REPORT ITU-R M.2041

Sharing and adjacent band compatibility in the 2.5 GHz band between the terrestrial and satellite components of IMT-2000

(2003)

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NOTE – Concerning the satellite component of IMT-2000, this Report covers some current and potential IMT-2000 satellite radio interfaces.

1 Introduction

WRC-2000 identified three different blocks of additional spectrum for IMT-2000, including the band 2 500-2 690 MHz. The band 2 500-2 690 MHz is currently allocated on a primary basis to several space services, the fixed service and the mobile service. This Report restricts its scope to the interference between the MSS and terrestrial component of IMT-2000.

This Report uses the relevant parameters needed in interference studies 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 IMT-2000 CDMA direct spread/CDMA TDD (referred to hereafter in this Report as T-IMT-2000); no other terrestrial IMT-2000 radio interfaces have been considered because the current studies only consider that interface. The interference problems are investigated by deterministic and statistical approaches, for the different scenarios. This Report gives technical conclusions regarding the necessary guardbands between T-IMT-2000 and the MSS in the band 2 500-2 690 MHz. Since these conclusions are based on parameters correct at the date of publication and predicted deployment scenarios, it should be noted that any changes in parameters, for example, in the T-IMT-2000 emission masks, would require the conclusions of this Report to be reconsidered.

2 Sharing and adjacent band compatibility methods

2.1 Interference mechanisms

2.1.1 Interference paths for S-IMT-2000/T-IMT-2000 sharing and compatibility assessments

The various interference paths can be categorized 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 satellite IMT-2000 (S-IMT-2000) direction (uplink or downlink) determines the approach to modelling.

The result is four main interference paths, as shown in Table 1 and Figs. 1 to 4.

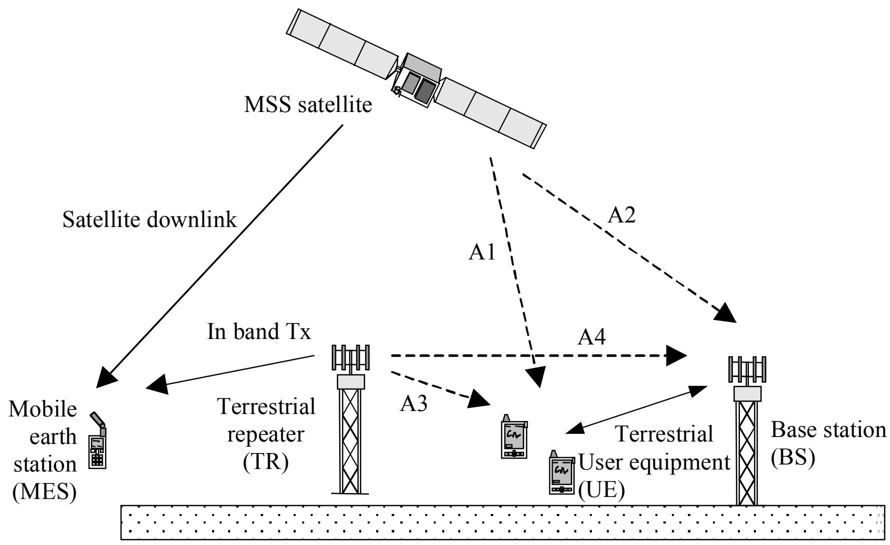
TABLE 1

Interference paths

Interference path	MSS downlink at 2 520 MHz	MSS uplink at 2 670 MHz
T-IMT-2000 wanted MSS interfering	A	B
T-IMT-2000 interfering MSS wanted	D	C

FIGURE 1

Interference path A
2 500-2 520 MHz



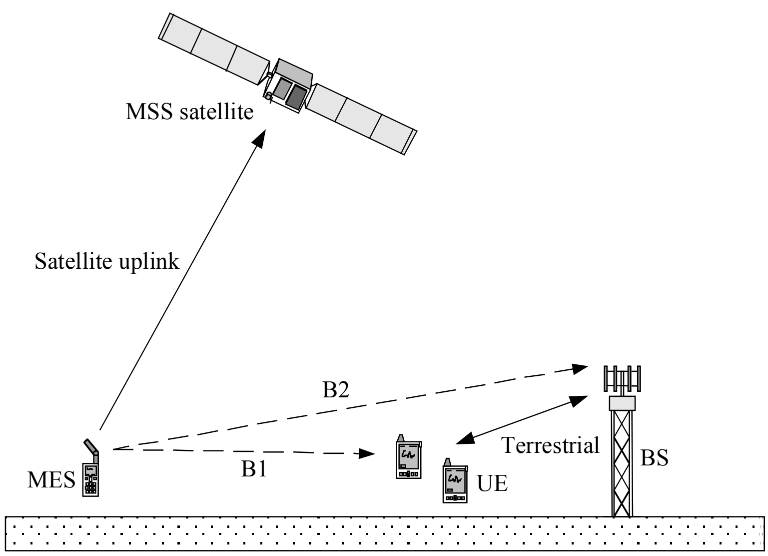
Interference path:

A1: MSS → UE
A2: MSS → BS
A3: TR → UE
A4: TR → BS

Rap 2041-01

FIGURE 2

Interference path B
2 670-2 690 MHz



Interference path:

B1: MES → UE
B2: MES → BS

Rap 2041-02

FIGURE 3

Interference path C
2 670-2 690 MHz

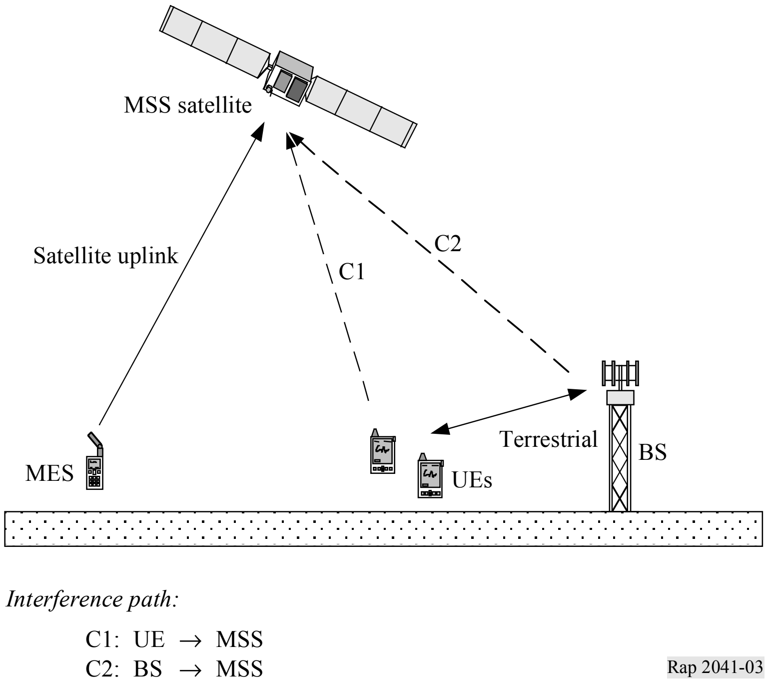
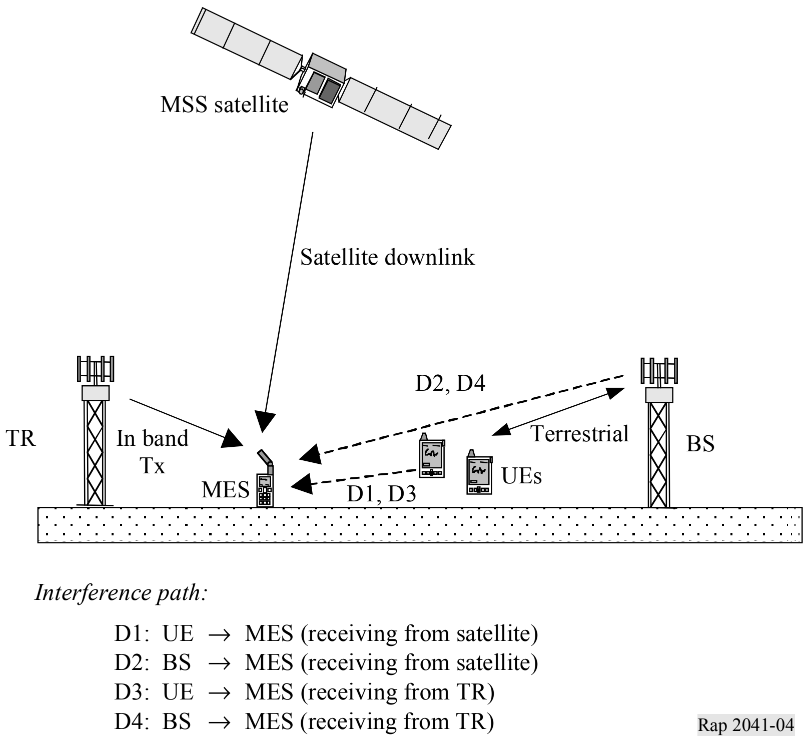


FIGURE 4

Interference path D
2 500-2 520 MHz



2.2 Minimum coupling loss (MCL) and Monte Carlo approaches

In this Report, two approaches have been used so far to assess interference between two systems.

a) 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 derivation of the minimum separation distance) and/or the minimum adjacent band isolation (and hence derivation of the minimum guardband). For 3GPP compliant systems (terrestrial or satellite) operating with the same bandwidth, the adjacent band isolation is expressed by the adjacent channel interference ratio (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 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:

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

In the case of a minimum separation distance calculation, D_{min}:

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

In the case of a minimum guardband 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 the input filter) of the victim receiver.

However, in T-IMT-2000 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, such as for example, those involving user terminals as a victim.

b) The second approach is the Monte Carlo 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 IMT-2000 CDMA direct spread is considered to be 2%.

The Seamcat[1] Monte Carlo tool was used in most of the Monte Carlo simulations presented in that Report. The assumptions used in the Monte Carlo simulations are detailed in Annex 2, and are based on work in ITU-R. Additional information is also included alongside the reported compatibility studies.

It is understood that any one of the approaches described above is not sufficient alone to describe in detail the interference problem, and to conclude on the problem of guardbands. 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 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 Recommendation ITU-R P.676. 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 is used for MCL. It could be used for distances up to 100 km with some precautions. Typically this is used for co-located systems e.g. for frequency separation studies. This model is also implemented in SEAMCAT, adding a log-normal fading factor.

– For distances > 20 km, Recommendation ITU-R P.452 for smooth Earth. Typically this is used for non-co-located systems, e.g. for geographic separation.

3 Co-frequency sharing conclusions

When considering the sharing of the same frequency band between the terrestrial component of IMT-2000 and the MSS, the detailed analysis (see Annex 2) shows that such sharing is not feasible over the same geographical area. Consequently, Radiocommunication Study Group 8 came to the conclusion that co-frequency sharing is not feasible for networks operating in the same geographical area.

The feasibility of co-frequency sharing was reviewed as part the studies undertaken in this Report. The conclusions are summarized below for each of the two MSS systems considered:

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1 http://www.ero.dk/971f102b-c3b2-42d4-a186-82162f695ee9.W5Doc.

For SRI-E

In general, co-frequency sharing between the satellite radio interface (SRI)-E satellite component and the terrestrial component was found to be difficult, with some paths that would result in extremely high levels of interference.

In particular co-frequency operation of both satellite uplink and downlink in a band with terrestrial systems would not be feasible based on the assumptions and modelling in this study. This is primarily due to high levels of aggregate interference from T-IMT-2000 systems into the S-IMT-2000 uplink. There is some potential for S-IMT-2000 downlink operation co-frequency with T-IMT-2000 systems, but this would require large separation distances between the S-IMT-2000 service area and the T-IMT-2000 service area.

The most problematic paths were from T-IMT-2000 into S-IMT-2000, that is:

– path C: from T-IMT-2000 (either uplink or downlink) into S-IMT-2000 satellite at 2 670-2 690 MHz

– path D: from T-IMT-2000 (either uplink or downlink) into S-IMT-2000 MES at 2 500-2 520 MHz.

In general paths A and B, from S-IMT-2000 into T-IMT-2000 resulted in lower interference levels.

For S-DMB

As for SRI-E, the co-frequency sharing is not feasible over the same geographical area. When considering interference from the satellite, a satellite antenna discrimination over the T-IMT-2000 service area around 20-25 dB is necessary. Conversely, the co-channel protection of the satellite reception from terrestrial interference would require a satellite antenna discrimination of 25 to 40 dB over the T-IMT-2000 service area, depending on deployment assumptions, and the nature of the interferers (mobile station (MS) or BS). The interference of the satellite-digital multimedia broadcast (S-DMB) terrestrial repeaters into T-IMT-2000 is an additional factor which impedes co-frequency co-located operation of S-DMB and T-IMT-2000.

4 Adjacent band summary results

The adjacent band compatibility results are summarized in Table 2. The systems characteristics and study results are detailed in Annexes 1 and 2. In Table 2 results are given either in term of frequency carrier spacing or in term of frequency guardbands. A scenario is considered not feasible when guardbands exceed 15 MHz. Concerning IMT-2000 CDMA TDD simulations, results are highly dependent on the deployment assumptions.

TABLE 2

Adjacent band compatibility results

Scenario **Interferer → victim**	**S-DMB**	**SRI-E**
1 (Path A1) Sat down → UE IMT-2000 CDMA direct spread down @ 2 520 MHz	Feasible with standard 5 MHz carrier spacing	Feasible without any guardband
2 (Path A1) Sat down → UE Rx IMT-2000 CDMA TDD @ 2 520 MHz	Feasible with standard 5 MHz carrier spacing	Feasible without any guardband (1)
3 (Path A2) Sat down → BS IMT-2000 CDMA direct spread up @ 2 520 MHz	Feasible with a carrier spacing of 5.3 MHz (could be improved by optimized satellite filtering techniques)	Feasible without any guardband
4 (Path A2) (Sat down → BS Rx IMT-2000 CDMA TDD @ 2 520 MHz	Feasible with a carrier spacing of 5.3 MHz (could be improved by optimized satellite filtering techniques)	Feasible without any frequency guardband(1)
5 (Path A3) TR → IMT-2000 CDMA direct spread down @ 2 520 MHz	Feasible with standard 5 MHz carrier spacing (no guardband required)	Not applicable: No terrestrial repeaters with SRI-E
6 (Path A3) TR → MS Rx IMT-2000 CDMA TDD @ 2 520 MHz	Feasible with standard 5 MHz carrier spacing (no guardband required)	Not applicable: No terrestrial repeaters with SRI-E
7 (Path A4) TR → IMT-2000 CDMA direct spread up @ 2 520 MHz	Not feasible: required carrier spacing greater than 20 MHz	Not applicable: No terrestrial repeaters with SRI-E
8 (Path A4) TR → BS Rx IMT-2000 CDMA TDD @ 2 520 MHz	Required carrier spacing depends on IMT-2000 CDMA TDD deployment. T-IMT-2000 coexistence studies results apply	Not applicable: No terrestrial repeaters with SRI-E

TABLE 2 (*continued*)

Scenario **Interferer → victim**	**S-DMB**	**SRI-E**
9 (Path B1) MES Sat up → UE IMT-2000 CDMA direct spread down @ 2 670 MHz	The standard 5 MHz carrier spacing is appropriate	Feasible: does not require frequency guardband
10 (Path B1) MES Sat up → UE Rx IMT-2000 CDMA TDD @ 2 670 MHz	The standard 5 MHz carrier spacing is appropriate	Feasible: does not require frequency guardband
11 (Path B2) MES Sat up → BS IMT-2000 CDMA direct spread up @ 2 670 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 the following specific operating constraints apply: a 10 MHz carrier spacing (5 MHz guardband) shall apply, or the portable S-DMB terminal is 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 guardband
12 (Path B2) MES Sat up → BS Rx IMT-2000 CDMA TDD @ 2 670 MHz	Feasible with standard 5 MHz carrier spacing	Feasible: does not require frequency guardband
13 (Path C1) UE IMT-2000 CDMA direct spread up → Sat up @ 2 670 MHz	Feasible with a carrier spacing of 5 MHz (no guardband required)	Feasible with a 1 MHz guardband

TABLE 2 (*continued*)

Scenario **Interferer → victim**	**S-DMB**	**SRI-E**
14 (Path C1) UE Tx IMT-2000 CDMA TDD → Sat up @ 2 670 MHz	Feasible with a carrier spacing of 5 MHz (no guardband required)	Feasible: does not require frequency guardband
15 (Path C2) BS IMT-2000 CDMA direct spread down → Sat up @ 2 670 MHz	Feasible with a carrier spacing of 5 MHz	Guardband exceeds 7 MHz. See also Annex 2, § 5 for sensitivity analysis
16 (Path C2) BS Tx IMT-2000 CDMA TDD → Sat up @ 2 670 MHz	Feasible with a carrier spacing of 5 MHz	Feasible: does not require frequency guardband(2)
17 (Path D1) UE IMT-2000 CDMA direct spread up → MES down @ 2 520 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 guardband Vehicular macro: feasible without guardbands Rural: feasible without guardbands See also Annex 2, § 5 for sensitivity analysis
18 (Path D1) UE Tx IMT-2000 CDMA TDD → MES down @ 2 520 MHz	Not necessary to be studied if S-DMB terminals implement terrestrial IMT-2000 CDMA TDD: S-DMB terminals are dual mode and require a minimum duplex spacing of 20 MHz. Otherwise, T-IMT-2000 coexistence studies results apply	Suburban: guardband exceeds 8 MHz Urban: guardband exceeds 8 MHz See also Annex 2, § 5 for sensitivity analysis
19 (Path D2) BS IMT-2000 CDMA direct spread down → MES down (satellite reception mode) @ 2 520 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 2, § 5 for sensitivity analysis

TABLE 2 (*end*)

Scenario **Interferer → victim**	**S-DMB**	**SRI-E**
20 (Path D2) BS Tx IMT-2000 CDMA TDD → MES down (satellite reception mode) @ 2 520 MHz	Feasible with standard 5 MHz carrier spacing	Suburban: 6 MHz guardband Urban: 0.5 MHz guardband See also Annex 2, § 5 for sensitivity analysis
21 (Path D3) IMT-2000 CDMA direct spread up → MES down (terrestrial repeater reception mode) @ 2 520 MHz	Not necessary to be studied: S-DMB terminals are dual mode and would need a carrier spacing above 20 MHz between Tx and Rx bands	Not applicable: No terrestrial repeaters with SRI-E
22 (Path D3) MS Tx IMT-2000 CDMA TDD → MES down (terrestrial repeater reception mode) @ 2 520 MHz	Not necessary to be studied if S-DMB terminals implement terrestrial IMT-2000 CDMA TDD: S-DMB terminals are dual mode and require a minimum duplex spacing of 20 MHz. Otherwise, T-IMT-2000 coexistence studies results apply	Not applicable: No terrestrial repeaters with SRI-E
23 (Path D4) IMT-2000 CDMA direct spread down → MES down (terrestrial repeater reception mode) @ 2 520 MHz	Feasible with standard 5 MHz carrier spacing	Not applicable: No terrestrial repeaters with SRI-E
24 (Path D4) BS Tx IMT-2000 CDMA TDD → MES down (terrestrial repeater reception mode) @ 2 520 MHz	Feasible with standard 5 MHz carrier spacing	Not applicable: No terrestrial repeaters with SRI-E

(1) The results for IMT-2000 CDMA TDD scenarios have been derived from the results obtained for IMT-2000 CDMA direct spread in the same direction of transmission. In general, compatibility is facilitated when using IMT-2000 CDMA TDD parameters with respect to using IMT-2000 CDMA direct spread parameters.

(2) For scenarios 14 and 16, IMT-2000 CDMA TDD is deployed in specific environments as proposed in Table 9.

5 Adjacent band conclusions and discussions

5.1 Overall conclusions

Table 3 offers an overview of the impact of the sharing studies on systems compatibility considerations together with spectrum implementations contexts.

For each possible combination of IMT-2000 CDMA direct spread and IMT-2000 CDMA TDD/MSS adjacent band sharing, the overall requirements in terms of the frequency carrier spacing or guardbands between these systems will need to ensure protection of both T-IMT-2000 and MSS victim stations in both systems, or compatible operation of these systems.

Table 3 presents all possible combinations of T-IMT-2000 versus MSS adjacent band sharing. In order to keep to two-dimensional reading of the Tables and reflect that T-IMT-2000 versus S-DMB and T-IMT-2000 versus SRI-E compatibility results can be different due mainly to different implementation schemes[2], Table 3 is split into Tables 3a) to 3d) (these Tables present the overall compatibility assessment for T-IMT-2000 versus S-DMB and T-IMT-2000 versus SRI-E respectively).

The results have been grouped in parts of Table 3 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.

All the results presented in this Table were obtained using the agreed baseline assumptions for MSS and T-IMT-2000 systems, as recorded in Annex 1.

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

TABLE 3

a) S-DMB down @ 2 520 MHz and T-IMT-2000 above 2 520 MHz

	IMT-2000 CDMA TDD	**IMT-2000 CDMA direct spread down**	**IMT-2000 CDMA direct spread up**
T-IMT-2000 victim	MSS↓→IMT-2000 CDMA TDD MS&BS guardband = the maximum value among 0.3 MHz and T-IMT-2000 results(1)	MSS↓→ IMT-2000 CDMA direct spread MS No guardband(2)	MSS TR ↓→ IMT-2000 CDMA direct spread BS S-DMB terrestrial repeaters and T-IMT-2000 BS collocation remain difficult with carrier frequency spacing up to 15 MHz(3)
MSS victim	MS&BS→ MES Similar to IMT-2000 CDMA TDD/ IMT-2000 CDMA direct spread results(4) if IMT-2000 CDMA TDD mode is not implemented in S-DMB terminals(5)	IMT-2000 CDMA direct spread BS→ MES No guardband	IMT-2000 CDMA direct spread 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 IMT-2000 CDMA TDD/ IMT-2000 CDMA direct spread results if IMT-2000 CDMA TDD mode is not implemented in S-DMB terminals(5)	No guardband	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

(1) Possible combination of guardband and separation distances with regard to MS/terrestrial repeaters (see also Report ITU-R M.2030).

(2) No additional guardband between the two 5 MHz blocks. Since adjacent carriers are of 3.84 MHz, in 5 MHz blocks, a guardband already exists.

(3) Scenario A2 (S-DMB satellite down → terrestrial IMT-2000 CDMA direct spread BS) would require 0.3 MHz guardbands.

(4) Possible combination of guardband and separation distances with regard to MS/MES (see also Report ITU-R M.2030).

(5) If IMT-2000 CDMA TDD mode was implemented in S-DMB terminals, a guardband of greater than 20 MHz would be needed.

TABLE 3 (*continued*)

b) S-DMB up @ 2 670 MHz and T-IMT-2000 below 2 670 MHz

	IMT-2000 CDMA TDD	**IMT-2000 CDMA direct spread down**	**IMT-2000 CDMA direct spread up**
T-IMT-2000 victim	MES →IMT-2000 CDMA TDD MS&BS No guardband	MES → IMT-2000 CDMA direct spread MS No guardband	MES → IMT-2000 CDMA direct spread BS No guardband 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 guardband is required
MSS victim	IMT-2000 CDMA TDD MS&BS→ Sat No guardband	IMT-2000 CDMA direct spread BS→ Sat No guardband	IMT-2000 CDMA direct spread MS → Sat No guardband
Compatibility result combining lines 1 and 2	No guardband	No guardband	No guardband 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 guardband is required

TABLE 3 (*end*)

c) SRI-E (down) @ 2 520 MHz and T-IMT-2000 above 2 520 MHz

	IMT-2000 CDMA TDD	IMT-2000 CDMA direct spread down	IMT-2000 CDMA direct spread up
T-IMT-2000 victim	(Sat↓→IMT-2000 CDMA TDD MS&BS) No guardband	(Sat↓→ IMT-2000 CDMA direct spread MS) No guardband	(Sat↓→ IMT-2000 CDMA direct spread BS) No guardband
MSS victim	IMT-2000 CDMA TDD MS&BS→ MES Not feasible if MESs and T-IMT-2000 operate in the same environment	IMT-2000 CDMA direct spread 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	IMT-2000 CDMA direct spread MS→ MES Not feasible for MES in pedestrian-micro environment. For the other scenarios it is feasible with no guardband (rural, vehicular macro)
Compatibility result combining lines 1 and 2	Not feasible if MESs and T-IMT-2000 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

d) SRI-E up @ 2 670 MHz and T-IMT-2000 below 2 670 MHz

	IMT-2000 CDMA TDD	IMT-2000 CDMA direct spread down	IMT-2000 CDMA direct spread up
T-IMT-2000 victim	MES →IMT-2000 CDMA TDD MS&BS No guardband	MES →IMT-2000 CDMA direct spread MS No guardband	MES →IMT-2000 CDMA direct spread BS No guardband
MSS victim	IMT-2000 CDMA TDD MS&BS →Sat No guardband	IMT-2000 CDMA direct spread BS →Sat guardband exceeds 7 MHz.	IMT-2000 CDMA direct spread MS →Sat guardband 1 MHz
Compatibility result combining lines 1 and 2	No guardband	Guardband exceeds 7 MHz	Guardband 1 MHz

In order to refine the analysis of difficult compatibility study results for SRI-E downlink in Table 3c), and SRI-E uplink with regard to IMT-2000 CDMA direct spread downlink in Table 3d) (due to a high sensitivity of the SRI-E MES to interference), some additional interference assessment of the related worst scenarios involving SRI-E stations as a victim were undertaken with more optimistic assumptions than the baseline, mainly by a review of the T-IMT-2000 parameters (giving 6 to 12 dB relaxation: see Annex 2, § 5). These additional evaluations reveal a noticeable enhancement of the compatibility results in some cases. In the case of interference from the T-UTMS IMT-2000 CDMA direct spread downlink into the SRI-E uplink, the guardbands reduces from greater than 7 MHz to 1.5 MHz. In the case of interference from the terrestrial IMT-2000 CDMA direct spread 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.

5.2 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 system are deployed:

– If IMT-2000 CDMA TDD systems are deployed in the adjacent band, it would not be feasible to operate MESs in the same geographical areas.

– If IMT-2000 CDMA direct spread downlink 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 IMT-2000 CDMA direct spread uplink 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 IMT-2000 CDMA TDD operates in the adjacent band, no guardband or a small guardband are necessary.

– If IMT-2000 CDMA direct spread downlink 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 IMT-2000 CDMA direct spread uplink operates in the adjacent band, a guardband of 1 MHz may be necessary.

5.3 Feasibility of adjacent band compatibility for S-DMB

5.3.1 Adjacent band compatibility with terrestrial IMT-2000 CDMA direct spread

In the downlink 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 IMT-2000 CDMA direct spread BSs.

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 BSs, although not necessary, enhances the compatibility situation.

In the uplink 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.

5.3.2 Adjacent band compatibility with terrestrial IMT-2000 CDMA TDD

In the downlink direction (around 2 520 MHz):

a) If S-DMB terminals implement terrestrial IMT-2000 CDMA TDD:

In general terms, dual-mode implementation issues within the S-DMB terminal will prevent adjacent band operation with IMT-2000 CDMA TDD. As for IMT-2000 CDMA direct spread, a 20 MHz guardband will not be sufficient to solve this issue.

b) If S-DMB terminals do not implement terrestrial IMT-2000 CDMA TDD:

The compatibility (with 5 MHz carrier spacing) of IMT-2000 CDMA 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 IMT-2000 CDMA TDD deployment. The required carrier separation distance is likely to be the same as the one between IMT-2000 CDMA TDD and IMT-2000 CDMA direct spread. The outcome of the T-IMT-2000 coexistence studies carried-out by Radiocommunication Study Group 8 may provide further guidance.

The adjacent band compatibility (with 5 MHz carrier spacing) of IMT-2000 CDMA 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 T-IMT-2000 with respect to S-DMB is possible with a standard carrier spacing of 5 MHz.

6 Glossary and abbreviations

Co-channel sharing

Co-channel sharing is the case where the terrestrial and the satellite components are 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.

ACI_{max}	maximum adjacent channel interference
ACIR	adjacent channel interference ratio
ACLR	adjacent channel leakage ratio
ACS	adjacent channel selectivity
BS	base station within T-IMT-2000
CBD	central business district
DL	downlink. In the case of terrestrial: BS transmit, UE receive
IMT-2000 CDMA direct spread	an IMT-2000 radio interface, also called frequency division duplex
IMT-2000 CDMA TDD	an IMT-2000 radio interface, also called time division duplex
MCL	minimum coupling loss
MES	mobile earth station within the satellite system
MS	mobile service
MSS	mobile-satellite service
Sat	satellite station
S-DMB	satellite digital multimedia broadcasting
S-IMT-2000	IMT-2000 satellite radio interface
SRI-E	satellite radio interface E
T-IMT-2000	IMT-2000 CDMA direct spread/IMT-2000 CDMA TDD terrestrial radio interface
TR	terrestrial repeater
UE	user equipment within T-IMT-2000
UL	uplink. In the case of terrestrial: UE transmit, BS receive

Annex 1

System parameters

1 T-IMT-2000 system parameters

1.1 Base station

The reference text for the parameters of the terrestrial system components is Report ITU-R M.2039.

1.1.1 Base station as wanted system

TABLE 4

IMT-2000 base station receive parameters

Cell type	Rural
Antenna type	120° sector
Maximum antenna gain (dBi) including feeder loss	17
Downtilt angle (degrees)	2.5
Antenna height (m)	30
Polarization	Linear
Receiver noise figure (dB)	5
Receiver thermal noise (dB(W/MHz))	–139
Interference criteria (I_{sat}/N_{th}) (dB)	–10
Adjacent channel selectivity	FDD: TS 25.104 [3] TDD: TS 25.105 [4]

1.1.2 Base station as interfering system

TABLE 5

IMT-2000 base station transmit parameters

Cell type	Rural (IMT-2000 CDMA direct spread)	Vehicular-macro (IMT-2000 CDMA direct spread)	Pedestrian-micro (IMT-2000 CDMA direct spread)	Pico-CBD (IMT-2000 CDMA direct spread)	Suburban and urban (IMT-2000 CDMA 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(1)
Operating bandwidth (MHz)	5	5	5	5	5
Antenna type	120° sector	120° sector	120° sector	Omni-directional	Omni-directional
Maximum antenna gain (dBi) including feeder loss	17	17	5	0	0
Downtilt angle (degrees)	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 [3]				25.105 [4]

(1) 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 IMT-2000 CDMA TDD mode. In the analysis, a 50% duty cycle is assumed, giving reduction in the typical transmitter power of 3 dB.

1.2 Mobile station

Mobile station parameters, for all environments, are given in Tables 6 and 7.

1.2.1 Mobile station as wanted station

TABLE 6

IMT-2000 mobile station receive parameters

Antenna type	**Isotropic**
Maximum antenna gain (dBi)	0
Antenna feed loss (dB)	0
Antenna height (m)	1.5
Polarization	Linear
Receiver noise figure (dB)	9
Receiver thermal noise (dB(W/MHz))	–135
Interference criteria (I/N_{th}) (dB)	–10
ACS	IMT-2000 CDMA direct spread: 25.101 [1] IMT-2000 CDMA TDD : 25.102 [2]

1.2.2 Mobile station as interfering station

TABLE 7

IMT-2000 mobile station transmit parameters

Maximum transmit power (dBm)	**21 or 24**			
Average transmit power (dBm) in IMT-2000 CDMA direct spread (from [6])	Rural	Vehicular-macro	Pedestrian-micro	Pico-CBD
	8.3 dBm	7.5 dBm	6.6 dBm	–2.5 dBm
Average transmit power (dBm) in IMT-2000 CDMA TDD	1.6 dBm(1)			
Operating bandwidth (MHz)	5			
Antenna type	Isotropic			
Maximum antenna gain (dBi)	0			
Antenna feed loss (dB)	0			
Antenna height (m)	1.5			
Polarization	Linear			
ACLR	IMT-2000 CDMA direct spread: 25.101 [1] IMT-2000 CDMA TDD: 25.102 [2]			

(1) Including 50% activity factor.

1.3 Traffic characteristics

Table 3 of Report ITU-R M.2039 gives IMT-2000 traffic model characteristics for a mature network, as derived from Report ITU-R M.2023. Some of these characteristics are key parameters when modelling interference from T-IMT-2000 uplinks (MS transmitting) into MSS systems. They are summarized in Tables 8 and 9.

TABLE 8

Terrestrial parameters in IMT-2000 CDMA direct spread

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	10 km
	Macro – vehicular	1 km
	Micro – pedestrian	315 m
	Pico – in-building	40 m
Percentage of terrestrial surface	Macro – rural	57%
	Macro – vehicular	2%
	Micro – pedestrian	2%
	Pico – in-building	0.02%
	No coverage	38.98%

TABLE 9

Terrestrial parameters in IMT-2000 CDMA TDD

Coverage	Urban and suburban indoor
Average number of UE/cell	53.42 users/cell
Cell range	200 m
Percentage of terrestrial surface	30% of urban and suburban, indoor deployment as described in Table 8

2 Satellite radio interface E (SRI-E) system parameters

This section presents the parameters of a satellite system, based on SRI-E defined in Recommendation ITU-R M.1457. These parameters have been updated where necessary based on the IMT-2000 satellite radio interface E specifications in Recommendation ITU-R M.1455.

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 Tables 10 and 11.

Where applicable, GSO longitudes of 54° W, 65° E and 109° E were used in the analysis.

2.1.1 Satellite as wanted system

TABLE 10

MSS satellite receive parameters

Gain pattern (Recommendation ITU-R S.672)	L_s = –25 dB
Maximum antenna gain (dBi)	43.1
Relative gain at EOC (dB)	–3
EOC satellite *G*/*T* (dB/K)	12
System noise temp (dB/K)	28.1
Receiver noise temp (K)	638.3
Bandwidth (kHz)	200
Receiver thermal noise (dB(W/MHz))	–140.6
Interference criteria (dB) for purposes of this study	$\Delta T/T$ = 6% in-band $\Delta T/T$ = 3% out-of-band

2.1.2 Satellite as interfering system

TABLE 11

MSS satellite transmit parameters

Gain pattern (Recommendation ITU-R S.672)	L_s = –25 dB
Maximum antenna gain (dBi)	43.1
Beam pattern	Hexagonal
Number of active beams	19
Frequency reuse	7-beam clusters
e.i.r.p. per carrier (dBW)	43
Bandwidth (kHz)	200
Unwanted emissions	RR, Appendix 3

2.1.3 Satellite beam parameters

The characteristics of the satellite beam pattern are shown in more detail in Table 12.

TABLE 12

Satellite beam characteristics

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 11)
Beamwidth	1.2°
Peak gain	43.1 dBi (from Table 11)
Roll-off (Recommendation ITU-R S.672)	L_s = –25 dB (from Table 11)

2.2 MES

The parameters of the S-IMT-2000 MES are based on the Class 2 terminal described in Recommendation UIT-R M.1455, configured for data use. This terminal is assumed to have a directional antenna with peak gain of 14 dBi and e.i.r.p. of 15 dBW.

The MES parameters depend on the interference scenario under consideration, and hence vary depending on whether the S-IMT-2000 component is the wanted or interfering system.

2.2.1 MES as wanted system

TABLE 13

MES receive parameters

Gain pattern	Recommendation ITU-R M.1091
Maximum antenna gain (dBi)	14
Antenna height (m)	1.5
Minimum elevation (degrees)	10
Maximum MES G/T (dB/K)	–13.5
System noise temp (dB/K)	27.5
Receiver noise temp (K)	562.34
Bandwidth (kHz)	200
Receiver thermal noise (dB(W/MHz))	–141.1
Interference criteria (dB) for purposes of this study	$\Delta T/T$ = 6% in-band $\Delta T/T$ = 3% out-of-band (when used in Monte Carlo methods, the criteria may be exceeded for up to 20% time or 20% MES locations)

2.2.2 MES as interfering system

TABLE 14

MES transmit parameters

Typical transmit power (dBW)	1
Operating bandwidth (kHz)	200
Gain pattern	Recommendation ITU-R M.1091
Maximum antenna gain (dBi)	14
Maximum transmit e.i.r.p. (dBW)	15
Antenna height (m)	1.5
Polarization	Right-hand circular (RHC)
Unwanted emissions	Recommendation ITU-R M.1343

2.3 User density

The density of MES users can be derived from Recommendation ITU-R M.1457.

TABLE 15

User density key parameters

MSS allocation	20 MHz/direction
Reuse between satellite beams	7
Carrier bandwidth	200 kHz
Beam separation	1°

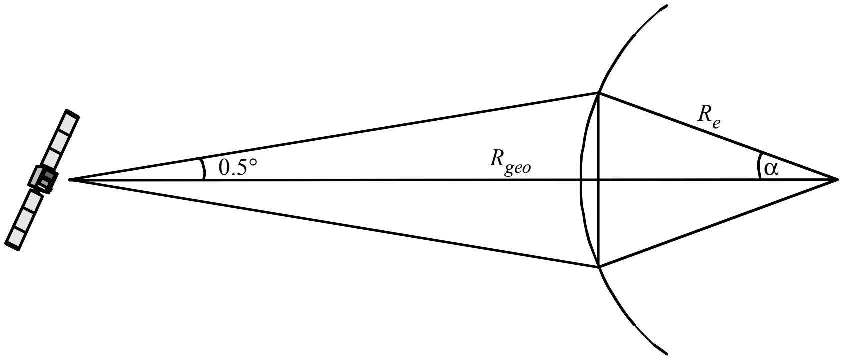
From the MSS allocation and the reuse, the average capacity per beam can be calculated as 20 MHz/7 = 2.86 MHz. With a carrier bandwidth of 200 kHz, this can be rounded to 14 carriers, total bandwidth 2.8 MHz.

Assuming an active data user occupies a single carrier[3], 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 Fig. 5.

[3] It should be noted that the SRI-E interface uses for this study 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.

FIGURE 5

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:

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

This equates to a square area with sides of 40 km.

3 S-DMB system parameters

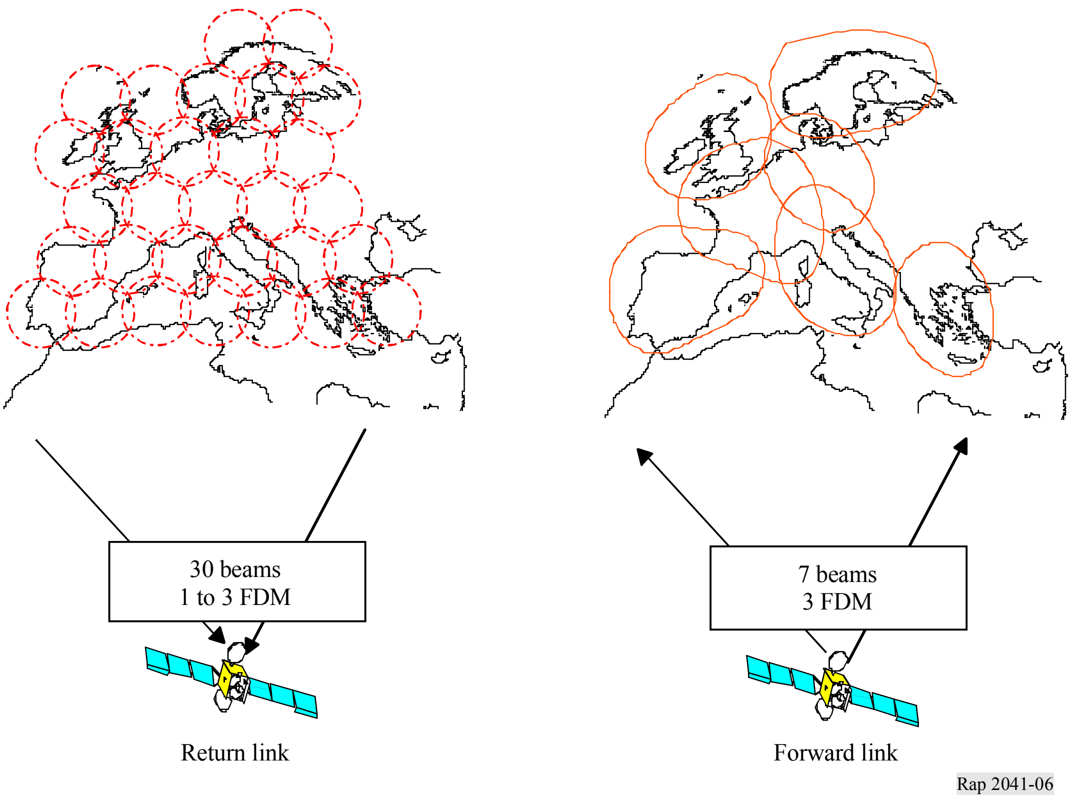
This section presents the parameters of S-DMB satellite system.

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 Fig. 6.

FIGURE 6

S-DMB satellite configuration



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

3.2 S-DMB forward link

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

3.2.1 RF performance

RF performance are summarized in Table 16.

TABLE 16

S-DMB forward link RF performance

Downlink frequency (satellite to S-DMB UE) (MHz)	2 170-2 200/2 500-2 520
Downlink polarization	Left-hand circular (LHC) or RHC
Number of spot beam (downlink)	7
e.i.r.p. maximum (dBW)	76
Useful bandwidth (MHz)	4.68 (3.84 Mchip/s, 1.22 roll-off factor)

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 Fig. 7. This mask takes into consideration:

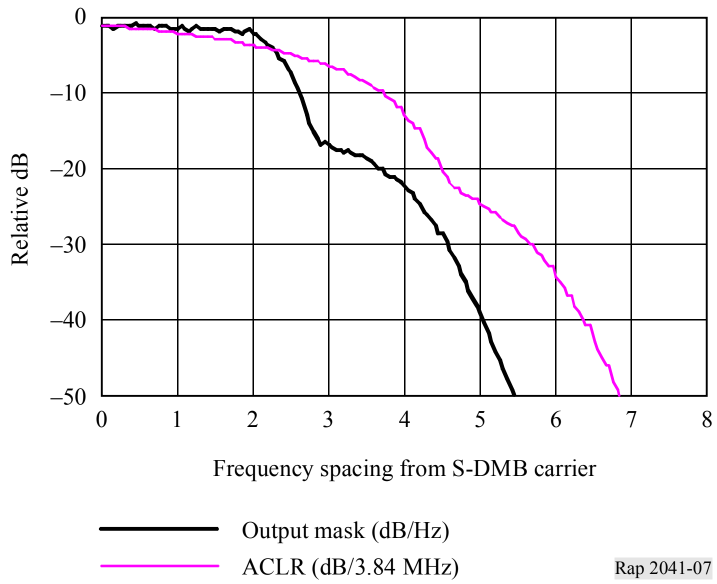
– the payload thermal noise contribution;

– 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-offs which are not finalized at this stage.

FIGURE 7

S-DMB satellite spectrum mask



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

Figure 7 also shows the ACLR 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

3.3 S-DMB return link

The satellite will implement a spot-beam/frequency reuse pattern as shown in Fig. 6. The satellite RF characteristics for the return link is given in Table 17.

TABLE 17

S-DMB return link RF performance

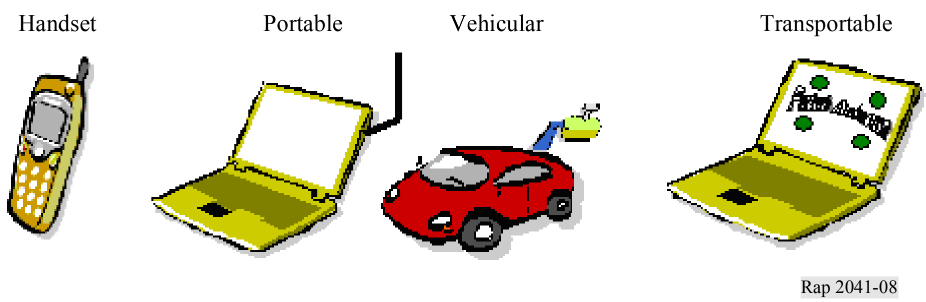
Useful bandwidth per FDM (MHz)	4.68 (3.84 Mchip/s, 1.22 roll-off factor)
Protection requirement at the satellite receiver	$\Delta T/T < 50\%$
System noise temperature (K)	550

3.4 User terminal

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

FIGURE 8

S-DMB UE configurations



3G standardized handset

This type of terminal is composed of a single multi-mode 2G/3G handset able to in parallel receive the S-DMB broadcast signal (T-IMT-2000 radio interface) and to establish point-to-point terrestrial connections for either the interactive S-DMB link or independent unicast services (e.g. 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-IMT-2000/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.

Portable

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

Vehicular

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

Transportable

The transportable configuration is built with a notebook which has a cover containing 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 summarized in Table 18.

TABLE 18

S-DMB UE maximum transmit power, antenna gain and e.i.r.p.

S-DMB UE type	Maximum transmit power	Maximum antenna gain (dBi)	Maximum e.i.r.p. (dBW)
3G handset			
Class 1	2W (33 dBm)	0	3
Class 2	500 mW (27 dBm)	0	–3
Class 3	250 mW (24 dBm)	0	–6
Portable	2 W (33 dBm)	2	5
Vehicular	8 W (39 dBm)	4	13
Transportable	2 W (33 dBm)	14	17

The S-DMB UE RF performances are given in Table 19.

TABLE 19

S-DMB UE RF performances

Receive frequency (MHz)	2 170-2 200/2 500-2 520	
Transmit frequency (MHz)	1 980-2 010/2 670-2 690	
Receive polarization	Linear	
Transmit polarization	Linear	
Noise figure (dB)	9	
Receiver noise floor (dBm)	–99	
Maximum output power (dBm)	24/27/33/39	
Antenna gain (dBi)	0/2/4/14	
Transmission mask	Compliant with the 3GPP UE requirements (see TS 25.101)	
ACLR as a function of carrier separation (from TS 25.101)	5 MHz	10 MHz
	33 dB	43 dB
ACS as a function of carrier separation (compliant with UE requirements in [2])	5 MHz	10 MHz
	33 dB	43 dB

Protection requirements of S-DMB UE reception against external interference

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

– 64 kbit/s: 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 provision of the S-DMB service while the terrestrial repeaters are not yet deployed.

– 1 Mbit/s: 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 kbit/s using orthogonal codes.

Table 20 gives protection requirements in terms of $C/(N + I)$ for test services to be used in sharing studies:

TABLE 20

Protection requirements for S-DMB UE

Test service	E_b/N_t [(1)]	$C/(N + I)$ [(2)]
64 kbit/s – outdoor	11.92 dB	–5.86 dB
1 Mbit/s (3 × 384 kbit/s) – outdoor	13.77 dB	3.77 dB
64 kbit/s – indoor	16.62 dB	–1.16 dB
1 Mbit/s (3 × 384 kbit/s) – indoor	17.77 dB	7.77 dB

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

(2) $C/(N + I) = (E_b/N_t)$ – processing gain (dB).

It has to be noted that these protection criterion 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.

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 using terrestrial repeaters.

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 80 dB (to avoid self oscillation) and offer narrow coverage.

– *"Non-on-channel" repeaters* use different frequency bands for signal reception and retransmission. They enable the achievement of 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:* 30/20 GHz to 2 GHz band.

  – *Node B 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 standardized equipment.

  – *Radio network subsystem package:* in this configuration, there is a single satellite access point shared by several Node B repeaters. The local distribution of the broadcast/multicast signal relies on the radio network control (RNC). This architecture is interesting for connecting several indoor pico-cells, or local outdoor islands.

The repeaters are always unidirectional, 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 collocated 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 are summarized in Table 21.

TABLE 21

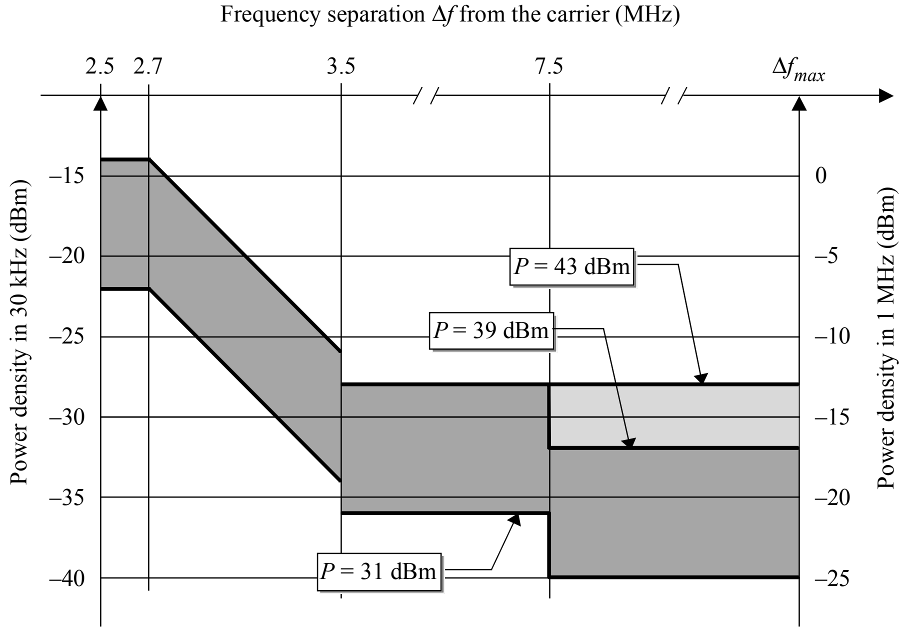
S-DMB terrestrial repeater – RF performance

Receive frequency (MHz)	FSS band		
Transmit frequency (MHz)	2 170-2 200/2 500-2 520		
Receive polarization	Linear		
Transmit polarization	Vertical		
Coverage area (degrees)	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 BS in [1] as illustrated in Fig. 9		
ACLR as a function of carrier separation (compliant with BS requirements in [1])	5 MHz	10 MHz	15 MHz
	45 dB	50 dB	67 dB

Terrestrial repeaters transmission masks:

FIGURE 9

Illustration of the terrestrial repeaters transmission mask



Note – This mask is similar to the BS transmission mask requirements in [3].

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References

[1] 3GPP 25.101 v530: Technical Specification Group Radio Access Networks. UE Radio Transmission and Reception (FDD).

[2] 3GPP 25.102 v510: Technical Specification Group Radio Access Networks. UE Radio Transmission and Reception (TDD).

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

[4] 3GPP 25.105 v510: Technical Specification Group Radio Access Networks. BS Radio Transmission and Reception (TDD).

[5] ERC Report 65: Adjacent band compatibility between UMTS and other services in the 2 GHz band.

Annex 2

Detailed sharing and compatibility analysis

1 Interference from MSS satellites into T-IMT-2000

This situation is occurs around 2 520 MHz and corresponds to path A.

In this configuration, the victim receiver is either a T-IMT-2000 BS or UE, which receives interference either from a S-IMT-2000 satellite (SRI-E or S-DMB) or from a S-IMT-2000 terrestrial repeater (S-DMB).

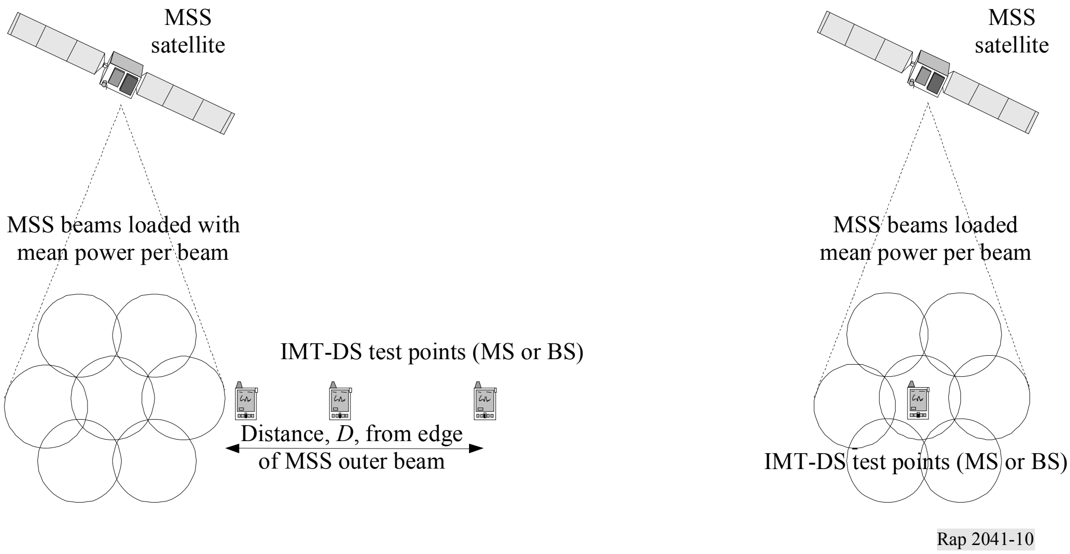
1.1 SRI-E

1.1.1 Methodology for path A

This interference path is between the S-IMT-2000 DL interfering into the T-IMT-2000, as shown in Fig 10.

FIGURE 10

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-IMT-2000 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.

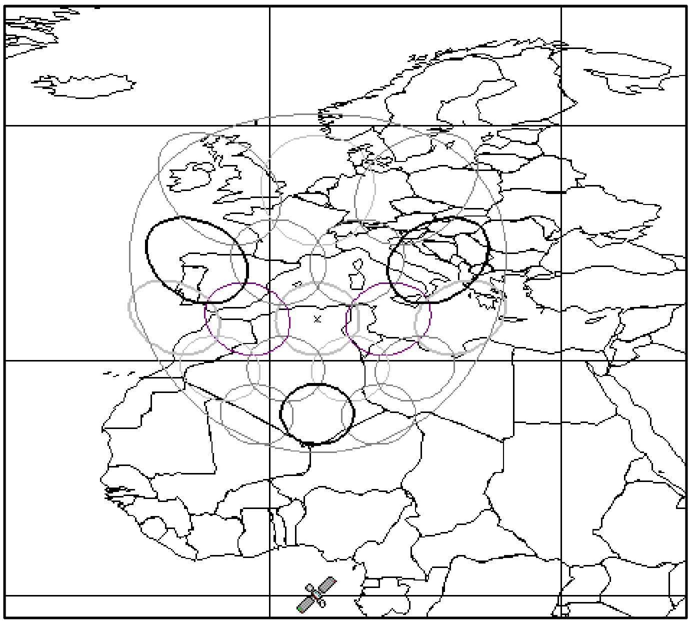
While a satellite can have hundreds of beams, not all will be active simultaneously – indeed power and frequency reuse constraints would make that infeasible.

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 Fig. 11. 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 11

Example GSO satellite beam pattern



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Interference into BSs

Interference into BSs was modelled in a similar way to that for MSs 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 (OoB) terms. The T-IMT-2000 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 T-IMT-2000 were activated with OoB term A. 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.

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

Co-frequency sharing considered the case where the S-IMT-2000 and T-IMT-2000 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 T-IMT-2000 was used for uplink or downlink.

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

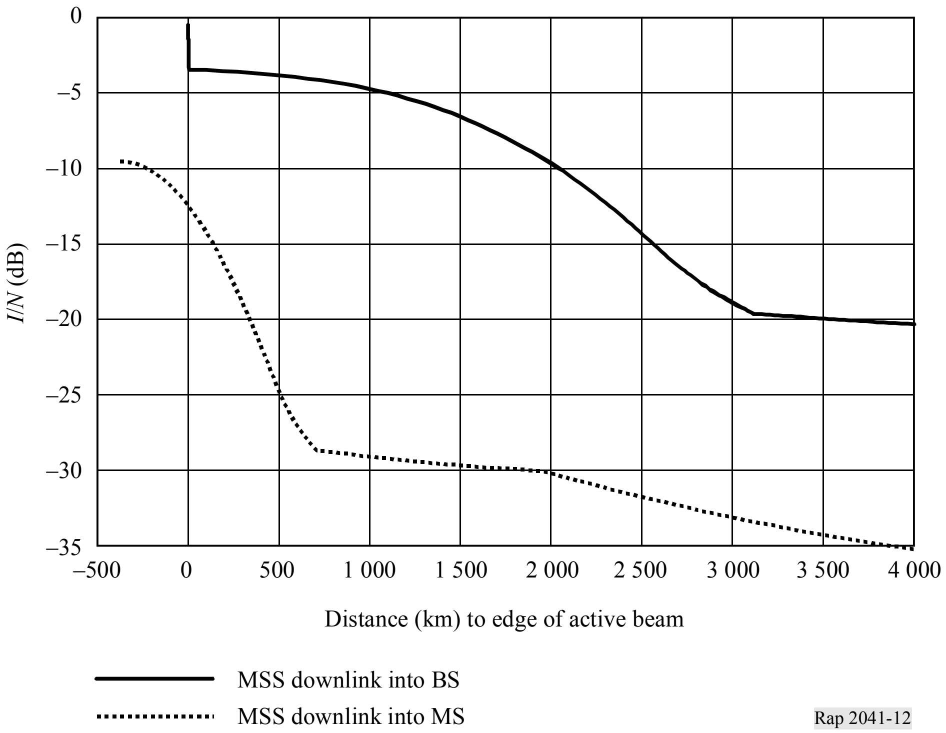
– for the MS Rx (downlink) the worst case was considered to be sub-satellite;

– for the BS Rx (uplink) 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 T-IMT-2000 location. The *I*/*N* vs. distance plots are shown in Fig. 12.

FIGURE 12

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).

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

Co-located sharing considered the case where the S-IMT-2000 and T-IMT-2000 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:

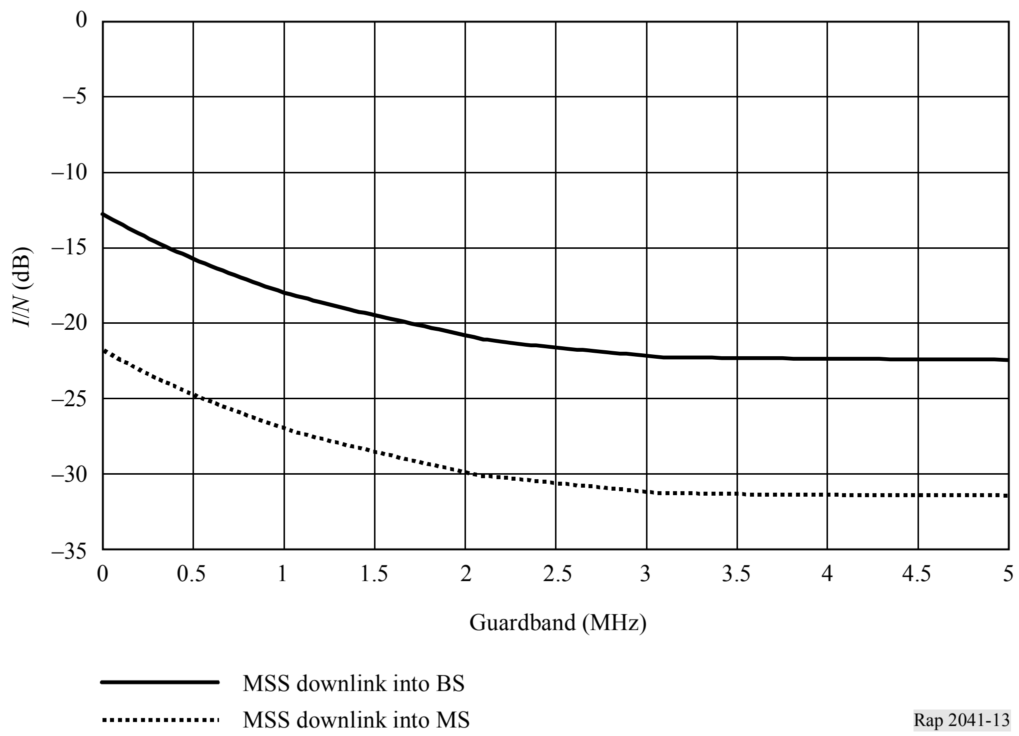
– for the MS Rx (downlink) the worst case was considered to be sub-satellite;

– for the BS Rx (uplink) the worst case was considered to be on the horizon.

The frequency of the T-IMT-2000 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 in Fig. 13.

FIGURE 13

Path A, frequency separation, *I*/*N* vs. guardband



1.2 Satellite-digital multimedia broadcasting (S-DMB)

1.2.1 Methodology for spacecraft interference (scenarios 1 to 4)

The interference assessment is conducted following a simple deterministic method, valid for IMT-2000 CDMA TDD and IMT-2000 CDMA direct spread 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:

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

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 [(6)] and [(9)] of Table 3 of Report ITU-R M.2039). A less stringent criterion may in practice be adequate for micro, or smaller cells.

1.2.2 Co-frequency analysis (S-DMB, Path A, scenarios 1 to 4)

Table 22 shows a calculation of the impact in a co-frequency situation, of the satellite emissions into the MS or BS reception.

TABLE 22

Satellite downlink interference (co-frequency)

		MS	BS	
Terrestrial	Maximum antenna gain	0.00	17.00	dB
	Feeder loss	0.00	1.00	dB
	Tilt angle	0.00	2.50	degrees down
	Antenna discrimination (Rec. ITU-R F.1336, $k = 0.2$, 10° elevation)		15.30	dB
	Rx noise figure	9.00	5.00	dB
	Rx noise level	–134.98	–138.98	dB(W/MHz)
	Required I/N	–10.00	–10.00	dB
	Maximum tolerable ACI	–144.98	–144.98	dB(W/MHz)
Satellite	Satellite altitude	3 6000.00	36 000.00	km
	Frequency	2 520.00	2 520.00	MHz
	Path loss	191.60	191.60	dB
	Maximum tolerable satellite e.i.r.p. density	46.62	41.92	dB(W/MHz)
	Satellite e.i.r.p.	74.00	74.00	dBW
	Bandwidth	3.84	3.84	MHz
	Maximum in-band e.i.r.p. density	68.16	68.16	dB(W/MHz)
	Required attenuation	21.54	26.24	dB

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/N_{th} criterion may be relaxed for small cells, etc.

However, these factor will not permit to enhance the situation enough to make the co-frequency sharing possible on 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 Table 22.

Effect of satellite elevation angle

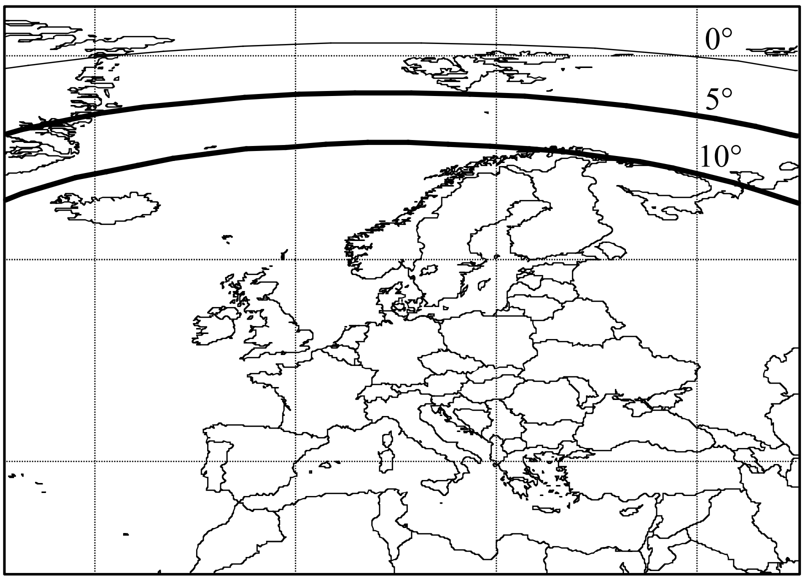
In the calculation shown in Table 22, an elevation angle of 10° is assumed.

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

Figure 14 shows the 0°, 5° and 10° elevation contours, for a satellite located at 10° E longitude.

FIGURE 14

Satellite elevation map



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As illustrated in Fig. 14, 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.

1.2.3 Adjacent band compatibility (S-DMB, path A, scenarios 1 to 4)

Figure 7 shows the S-DMB payload ACLR into an adjacent IMT-2000 channel, as a function of the channel spacing.

In order to meet the protection requirements of terrestrial 3G systems operating in adjacent band (see Table 22), the required channel spacing is:

– 4.6 MHz for protecting MSs (T-IMT-2000);

– 5.3 MHz for protecting BSs (T-IMT-2000).

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.

1.2.4 S-DMB TRs interfering T-IMT-2000 networks: methodology and results (scenarios 5 to 8)

1.2.4.1 Scenarios 7 and 8: Interference from S-DMB TRs into T-IMT-2000 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 Tables 23 and 24.

TABLE 23

Victim BS characteristics, as in [6]

	IMT-2000 CDMA direct spread BS macro	**IMT-2000 CDMA direct spread BS micro**	**T-IMT-2000 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 24

Interfering TR characteristics, as in [3]

TR 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

The minimum coupling loss requirement can be calculated as follows:

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

ACIR is calculated with:

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

(ACLR, ACS) = (45, 46) dB implies that ACIR = 42.5 dB.

It is assumed that the ACI_{max} is similar as proposed in Report ITU-R M.2030.

Cell type	Resulting maximum 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 forbids the co-location of S-DMB terrestrial repeaters with base stations.

From the MCL requirements it is also possible to derive the required separation distances between the TR and the BS (taking into account maximum TR and BS antenna gain):

The Hata-COST 231 modified propagation model is used.

TABLE 25

Separation distances between interfering TR and BSs (m)

	Wanted IMT-2000 CDMA direct spread BS macro	**Wanted IMT-2000 CDMA direct spread BS micro**	**Wanted T-IMT-2000 BS pico**
Interfering macro TR rural propagation	20 700	2 000	720
Interfering macro TR suburban propagation	7 200	650	235
Interfering micro TR suburban propagation	411	78	58
Interfering pico TR urban propagation	123	50	43

Some conclusions can be drawn from Table 25:

Macro TRs interfere BSs at such large distances, which will make the implementation of this type of repeaters impracticable.

Micro/Pico TRs 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 TR location will be highly constrained by prior BS deployment. Conversely, the presence of TRs 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 IMT-2000 CDMA direct spread BSs and S-DMB TRs is seen as essential for the S-DMB system deployment.

In the case of IMT-2000 CDMA direct spread BSs interfered by TRs, 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 IMT-2000 CDMA TDD BSs interfered by TRs is similar to the case of IMT-2000 CDMA TDD BSs interfered by IMT-2000 CDMA direct spread BSs. The separation distances for this case are given in Table 25 of Recommendation ITU-R M.1036, and vary a lot according to the IMT-2000 CDMA TDD deployment assumptions, and frequency separation (5, 10 or 15 MHz). As this is the most problematic case for T-IMT-2000 coexistence, it can be assumed that the frequency separation which will be implemented between IMT-2000 CDMA TDD and IMT-2000 CDMA direct spread (due to the BS-BS scenario), will also apply to the TR-BS (IMT-2000 CDMA 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 Annex 2, § 4.2.1, the dual mode nature of the S-DMB terminal will impose a carrier frequency separation of 20-30 MHz with terrestrial IMT-2000 CDMA direct spread uplink. This constraint needs to be considered in combination with the constraint arising from the TR-BS scenario.

1.2.4.2 Scenarios 5 and 6: interference from S-DMB TRs into T-IMT-2000 downlink

As already mentioned, the TRs are similar to IMT-2000 CDMA direct spread BSs, 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 BSs.

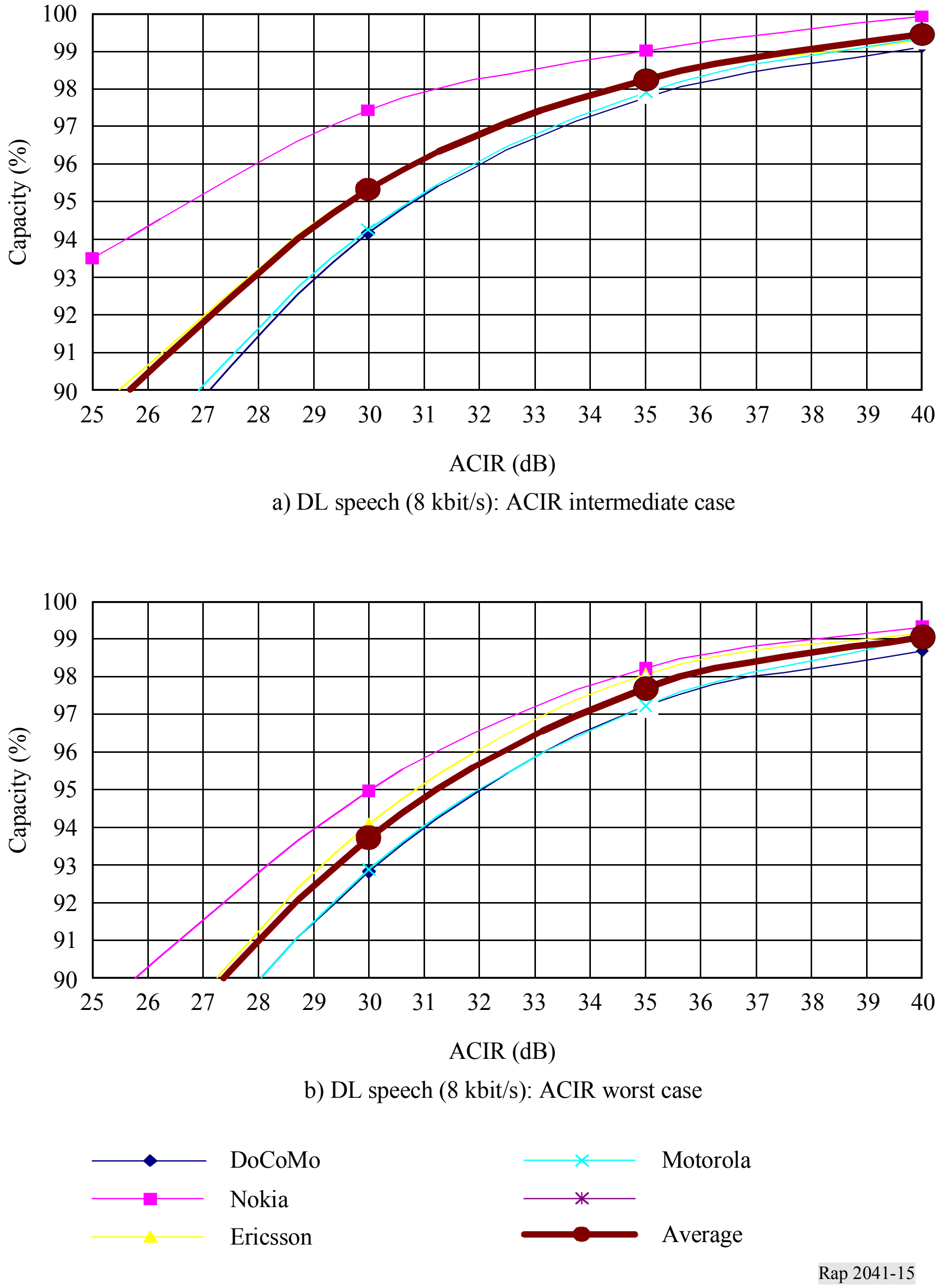
Another factor increases the similarity between BS and TRs: it is desirable in order to decrease the cost of the TR segment, and facilitate the integration, to reuse to the maximum extent possible 3GPP standardized equipment. This results, *inter alia*, in identical spectrum masks for TRs and BSs.

These similarities allow to reuse available studies which have been developed by 3GPP for assessing IMT-2000 CDMA direct spread/IMT-2000 CDMA direct spread coexistence in the downlink direction.

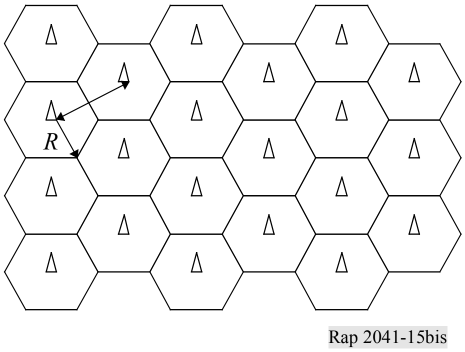
Figures 15a) and 15b) are extracted from 3GPP 25.942.v500 [7], and provide an estimate of the capacity loss of a IMT-2000 CDMA direct spread macro urban networks due to operation in the adjacent 5 MHz channel of a identical network, as a function of ACIR.

FIGURE 15

Capacity vs. ACIR for IMT-2000 CDMA direct spread/IMT-2000 CDMA direct spread coexistence (DL speech)



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



The worst case coexistence scenario corresponds to the case where the two networks are shifted by a cell radius (577 m 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 3GPP 25.942 study [7].

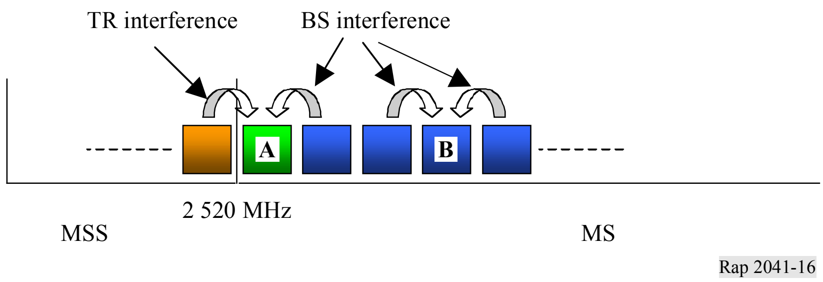
Extrapolation of results for TRs

In the 25.942 simulation for IMT-2000 CDMA direct spread/IMT-2000 CDMA direct spread coexistence, the impact is assessed in terms of loss of maximum number of users. The BSs 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 TRs with equivalent characteristics, the interference seen by the wanted network remains the same. Therefore the findings of the IMT-2000 CDMA direct spread/IMT-2000 CDMA direct spread coexistence studies, are also applicable to IMT-2000 CDMA direct spread/TR coexistence.

In the scenario studied in this section, the IMT-2000 CDMA direct spread downlink is in the lower part of the 2.5 GHz band. The 5 MHz carriers would be organized as follows:

FIGURE 16

Illustration of downlink adjacent channel interference



In Fig. 16, it can be seen that the interference experienced from adjacent blocks is equivalent for block A and for block B, provided that S-DMB TRs and BSs have similar deployment and RF characteristics.

Therefore the operation of TRs 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 IMT-2000 CDMA direct spread downlink carrier of a T-IMT-2000 network, compared to a terrestrial 5 MHz IMT-2000 CDMA direct spread 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 IMT-2000 CDMA TDD UE Rx (downlink) are similar to those regarding IMT-2000 CDMA direct spread UE Rx (downlink). However, the main compatibility issue for IMT-2000 CDMA TDD arises from IMT-2000 CDMA TDD BS Rx protection from TR interference, see above paragraph.

2 Interference from MSS MES into T-IMT-2000

This situation occurs around 2 670 MHz and corresponds to path B.

2.1 SRI-E

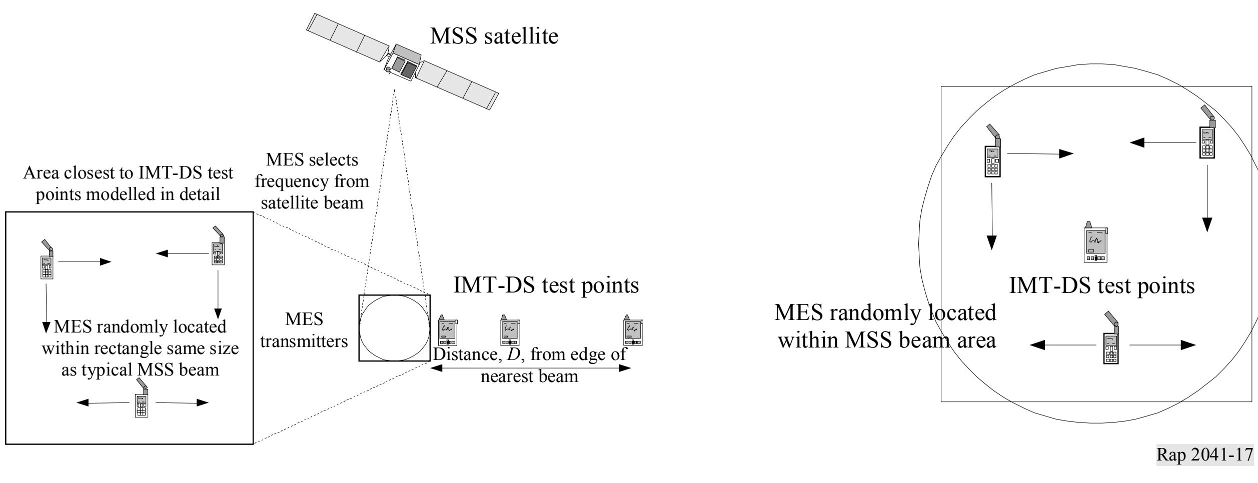
2.1.1 SRI-E (method 1)

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

This interference path is between the S-IMT-2000 uplink interfering into the T-IMT-2000, as shown in Fig. 17.

FIGURE 17

Interference path B: Geographic and frequency separation



Interference into mobile stations

In this case the interference is the summation of interference from multiple MESs. It was assumed that the MES in the satellite beam nearest to the T-IMT-2000 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 T-IMT-2000 deployment. Each MES was modelled as transmitting on mean power over a single S-IMT-2000 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 Recommendation ITU-R 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 ITU-R P.452 calculation for each MES.

For a given T-IMT-2000 location, these two distributions must be convolved together to produce an I/N distribution. A set of test T-IMT-2000 stations was therefore located at a set of distances from the edge of the S-IMT-2000 satellite beam, and the probability that the threshold is exceeded calculated.

Interference into BSs

Interference into BSs was modelled in a similar way to that for MSs 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 T-IMT-2000 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 T-IMT-2000 station is nearest in frequency, as there will be minimal OoB 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 T-IMT-2000 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.

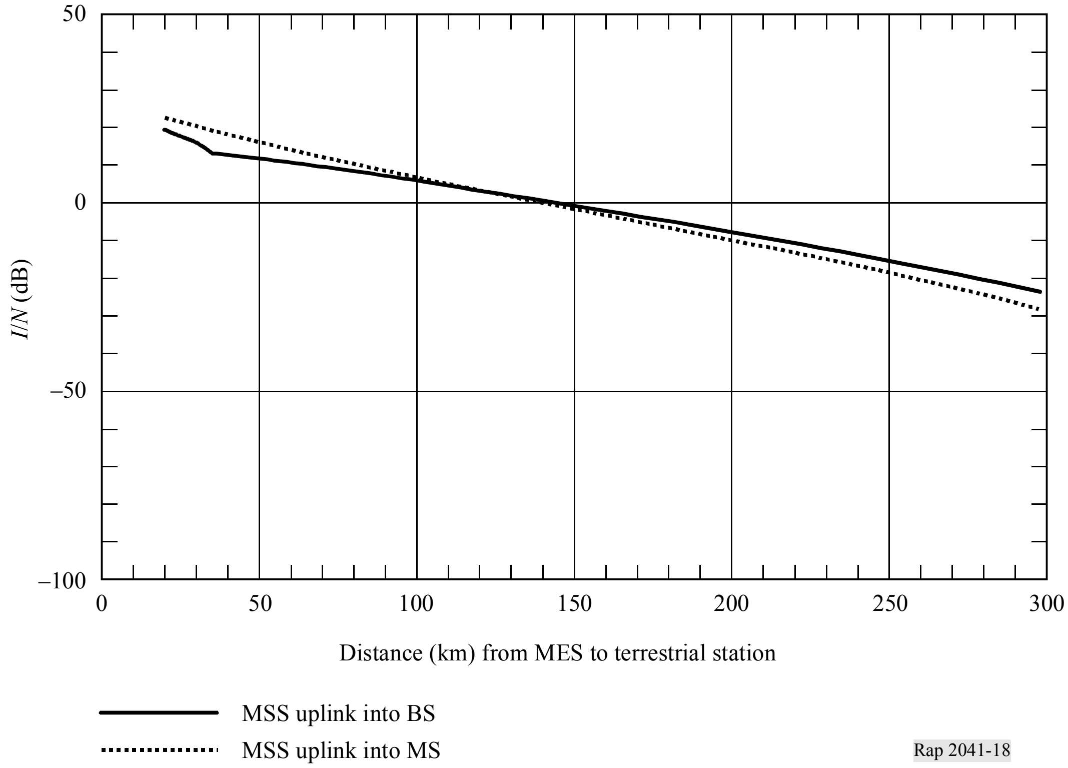
2.1.1.2 Co-frequency analysis (SRI-E, path B, scenarios 9 to 12)

Co-frequency sharing considered the case where the S-IMT-2000 and T-IMT-2000 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-IMT-2000 UL) into the T-IMT-2000 downlink (MS Rx) or uplink (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 Fig. 18.

FIGURE 18

Path B geographic separation, *I*/*N* versus distance



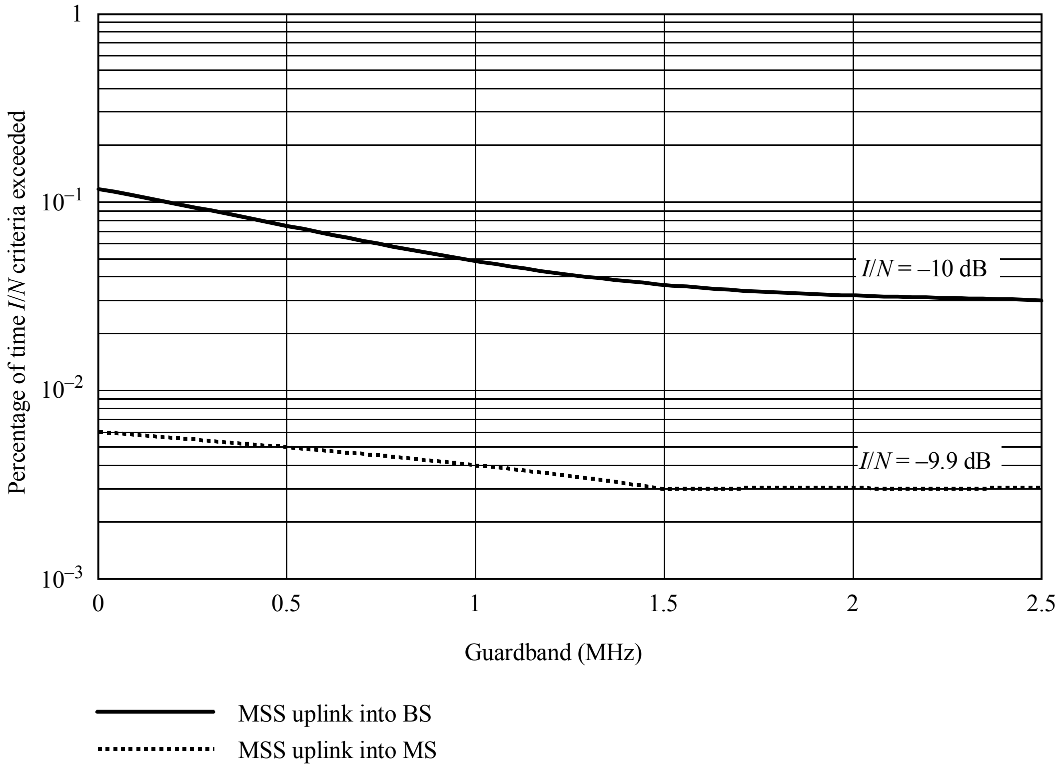
2.1.1.3 Adjacent band analysis (SRI-E, path B, scenarios 9 to 12)

Co-located sharing considered the case where the S-IMT-2000 and T-IMT-2000 systems were operating within the same geographic region but were separated in frequency. For path B, interference was considered from a single MES (S-IMT-2000 uplink) interfering into either the T-IMT-2000 downlink (MS Rx) or uplink (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 T-IMT-2000 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 percentage of samples the *I*/*N* criteria was exceeded for different guardbands from 0 to 2.5 MHz.

The results are shown in Fig. 19.

FIGURE 19

Path B, frequency separation, percentage of time *I*/*N* criteria exceeded vs. guardband



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

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2.1.2 SRI-E (method 2)

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

Results are calculated with ECC European tool SEAMCAT. The functional specifications of the SEAMCAT software are defined in the ERC Report 68 (ERC stands for the European Radiocommunications Committee, that has been since replaced by the ECC, Electronics Communications Committee of CEPT). 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 T-IMT-2000 simulation, a level around 2% of probability of interference is required to ensure the agreed 5% of outage.

SEAMCAT considers three different interference sources:

– OoB emissions;

– blocking effects;

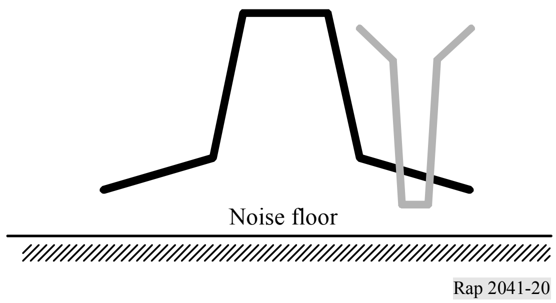
– intermodulation products effects.

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 $(2 \cdot f_1 \pm f_2)$ or $(2 \cdot f_2 \pm f_1)$[4]. 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.

OoB 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. 20).

FIGURE 20

OoB emissions impacting receiver of another technology

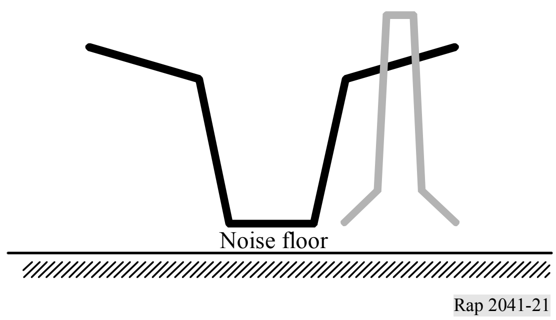


The result of such interference will be an effective reduction in the usable receiver sensitivity, which results in a reduced link budget margin. A receiver normally cannot do anything about this unwanted noise, however it is possible to reduce sideband emissions at the transmitter source through the 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 (see Fig. 21). 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 21

Desensitization of a receiver by an interferer in an adjacent channel



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4 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.

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.

2.1.2.2 Results

Internal interferences in IMT-2000 CDMA direct spread 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.

Scenario 9: effects of MES on IMT-2000 CDMA direct spread MS in 2 670-2 690 MHz

Results in urban areas with 315 m micro cell radius

The victim is the T-IMT-2000 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/km^2.

TABLE 26

Scenario 9 results (315 m radius, $C/(N+I) = -19$ dB)

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%

The victim is T-IMT-2000 UE which receives voice services and the interferer is MES UE for data services ($C/(N+I) = -11$ dB in urban).

TABLE 27

Scenario 9 results (315 m radius, $C/(N+I) = -11$ dB)

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%

The victim is T-IMT-2000 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 T-IMT-2000 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/km^2.

TABLE 28

Scenario 9 results (10 km radius, $C/(N+I) = -19$ dB)

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%

The victim is T-IMT-2000 UE, which receives voice services and the interferer is MES UE for data services ($C/(N+I) = -11$ dB in rural).

TABLE 29

Scenario 9 results (10 km radius, $C/(N+I) = -11$ dB)

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%

Scenario 11: effects of MES on IMT-2000 CDMA direct spread BS in 2 670-2 690 MHz

Results in urban areas in micro cell radius

The victim is T-IMT-2000 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.

TABLE 30

Scenario 11 results (315 m radius, $C/(N + I) = -21$ dB)

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%

The victim is T-IMT-2000 BS with 5 dBi gain and which receives voice services ($C/(N + I) = -12$ dB) and the interferer is MES UE for data services.

TABLE 31

Scenario 11 result (315 m radius, $C/(N + I) = -12$ dB)

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%

Results in rural areas with 10 km cell radius

The victim is T-IMT-2000 BS with 15 dBi gain and which receives data services ($C/(N + I) = -21$ dB) and the interferer is MES UE for data services.

TABLE 32

Scenario 11 results (10 km radius, $C/(N + I) = -21$ dB)

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%

The victim is T-IMT-2000 BS with 15 dBi gain, and which receives voice services ($C/(N + I) = -12$ dB) and the interferer is MES UE for data services.

TABLE 33

Scenario 11 results (10 km radius, $C/(N + I) = = -12$ dB)

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%

2.2 S-DMB

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

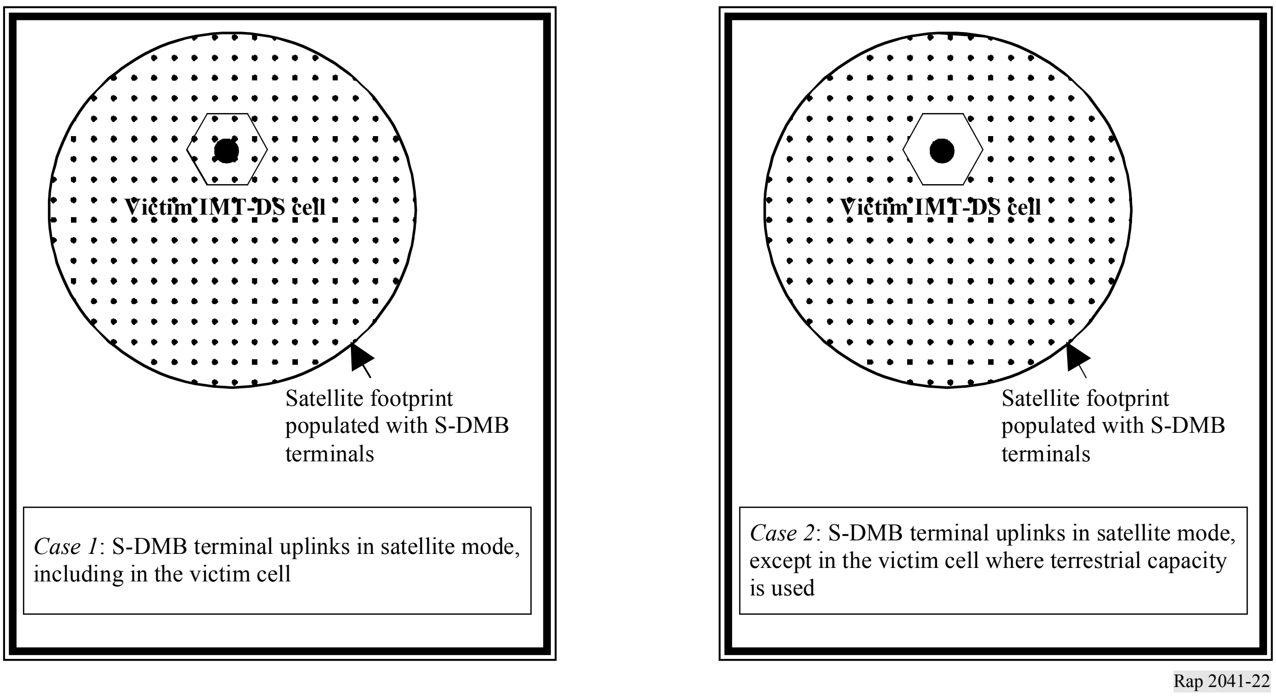
These scenarios were studied using SEAMCAT. The interfering S-DMB terminals are assumed to be uniformly spread across the simulation area. Their density is calculated from the maximum assumed uplink capacity, and the satellite beam footprint area. The S-DMB terminals will be able to use terrestrial capacity (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 22

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:

TABLE 34

Interfering S-DMB terminal characteristics

	Handheld	**Vehicular**	**Portable**
Maximum power (dBm) No uplink power control	24	33	39
Antenna maximum 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

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 (see Report ITU-R M.2039) are shown in Table 35.

TABLE 35

Victim terrestrial system characteristics

	IMT-2000 CDMA direct spread BS rural macro	**IMT-2000 CDMA direct spread UE rural macro**	**IMT-2000 CDMA direct spread BS suburban macro**	**IMT-2000 CDMA direct spread UE suburban macro**	**IMT-2000 CDMA TDD BS urban pico**	**IMT-2000 CDMA 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

The SEAMCAT simulations resulted in the following interference probabilities, for a standard 5 MHz spacing between the S-DMB and T-T-IMT-2000 carriers.

TABLE 36

Case 1 results: S-DMB emissions authorized in the T-IMT-2000 coverage

	IMT-2000 CDMA direct spread BS rural macro	**IMT-2000 CDMA direct spread UE rural macro**	**IMT-2000 CDMA direct spread BS suburban macro**	**IMT-2000 CDMA direct spread UE suburban macro**	**IMT-2000 CDMA TDD BS urban pico**	**IMT-2000 CDMA 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 37

Case 2 results: S-DMB emissions not authorized in the victim cell

	IMT-2000 CDMA direct spread BS rural macro	**IMT-2000 CDMA direct spread UE rural macro**	**IMT-2000 CDMA direct spread BS suburban macro**	**IMT-2000 CDMA direct spread UE suburban macro**	**IMT-2000 CDMA TDD BS urban pico**	**IMT-2000 CDMA 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

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. For example, there is only one handheld terminal per area of 1 500 km^2 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 T-IMT-2000 receivers. In general, the areas where S-DMB terminals would transmit are expected to be somewhat separated from the areas of dense T-IMT-2000 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 37 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 of Tables 28 and 29. Since the interference will be experienced by a limited number of cells, a criterion of –6 dB could have been used (see note [(6)] of Table 2 of Report ITU-R M.2039).

– *Mixture of terminals types*: Table 36 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 extremes 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.

3 Interference from T-IMT-2000 into MSS satellites

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

3.1 SRI-E

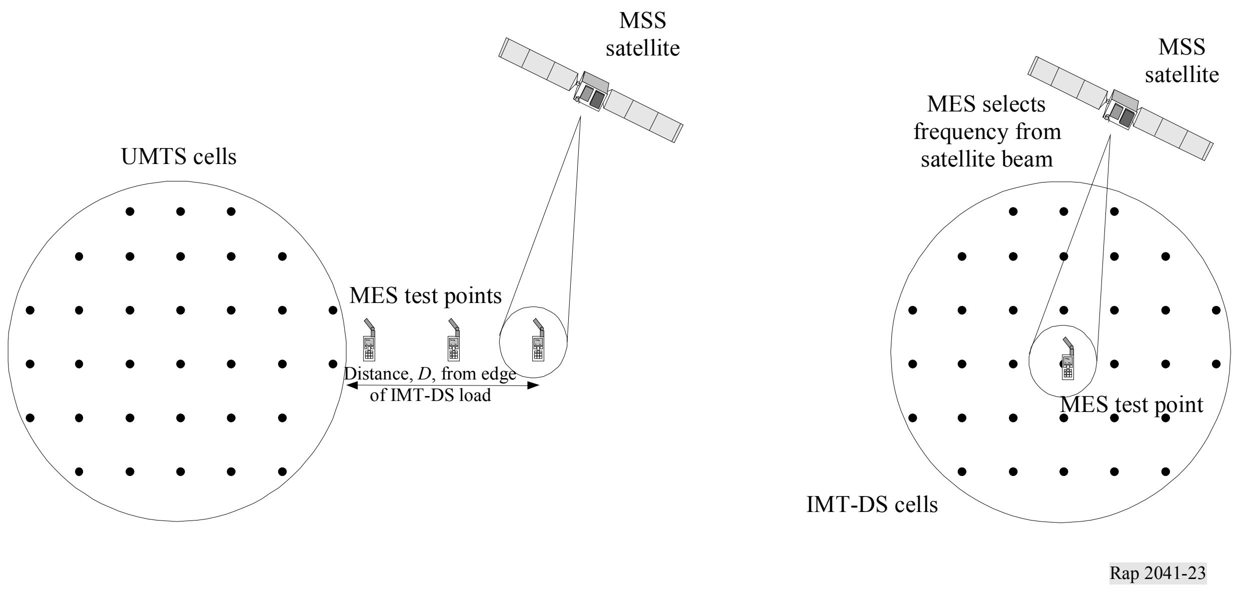
3.1.1 SRI-E (method 1)

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

This interference path is between the T-IMT-2000 (either BS or MS Tx) interfering into the S-IMT-2000 uplink, as shown in Fig. 23.

FIGURE 23

Interference path C: geographic and frequency separation



Interference from mobile stations

This scenario involves interference from large numbers of T-IMT-2000 transmitters into the satellite uplink. As it is not feasible to model each one individually, all the 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 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

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

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 T-IMT-2000 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 T-IMT-2000 deployment area and move it linearly in longitude to get the *I*/*N* for a range of geographic separations.

Interference from BSs

A similar approach was used to calculate aggregate interference from T-IMT-2000 BSs 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 nine antennas (three antennas per environment, each with three sectors):

Sector 1: three antennas for rural environment;

Sector 2: three antennas for suburban-macro environment;

Sector 3: three 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 BSs of specified environment into each antenna

P_c: mean transmit power of BSs 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 in 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 an MES, geographically separated from the T-IMT-2000 deployment, can then be calculated. A GSO satellite beam was pointed at a station located at the edge of the T-IMT-2000 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-IMT-2000 beam was pointed at a test MES located in the centre of the T-IMT-2000 deployment. The two T-IMT-2000 carriers nearest in frequency were then included in the summation.

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

Co-frequency sharing considered the case where the S-IMT-2000 and T-IMT-2000 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 T-IMT-2000 transmitters (either MS or BS) into the S-IMT-2000 uplink. The geometry varied depending on the sub-path considered:

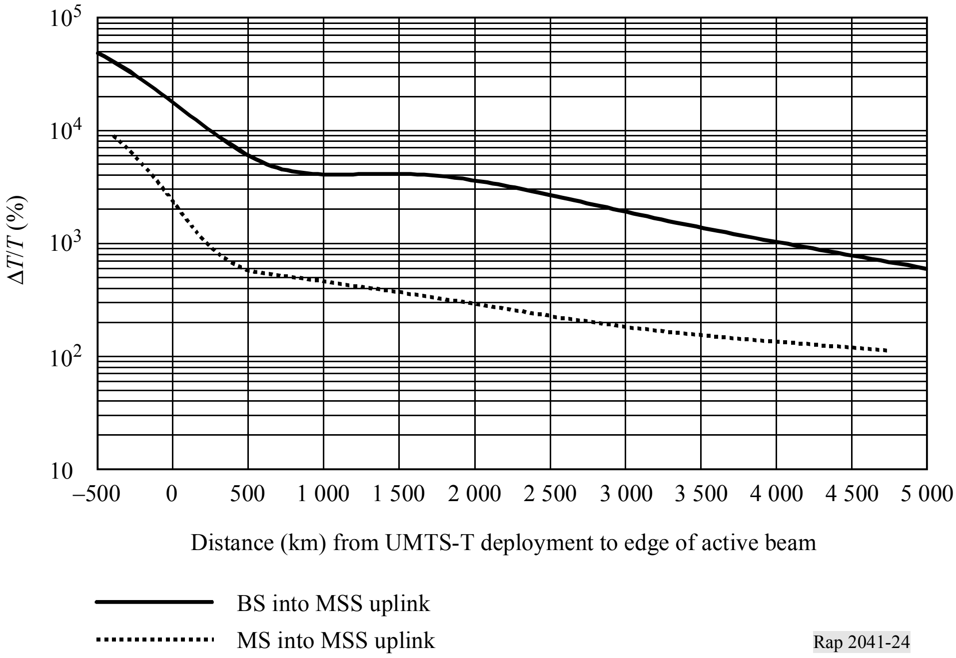
– for the MS Tx (uplink) the worst case was considered to be sub-satellite;

– for the BS Tx (downlink) 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 Δ*T*/*T* against distance from T-IMT-2000 deployment to the edge of active beam, as shown in Fig. 24.

FIGURE 24

Path C, geographic separation, Δ*T*/*T* vs. distance from T-IMT-2000 deployment



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

Co-located sharing considered the case where the S-IMT-2000 and T-IMT-2000 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 (uplink) the worst case was considered to be sub-satellite;

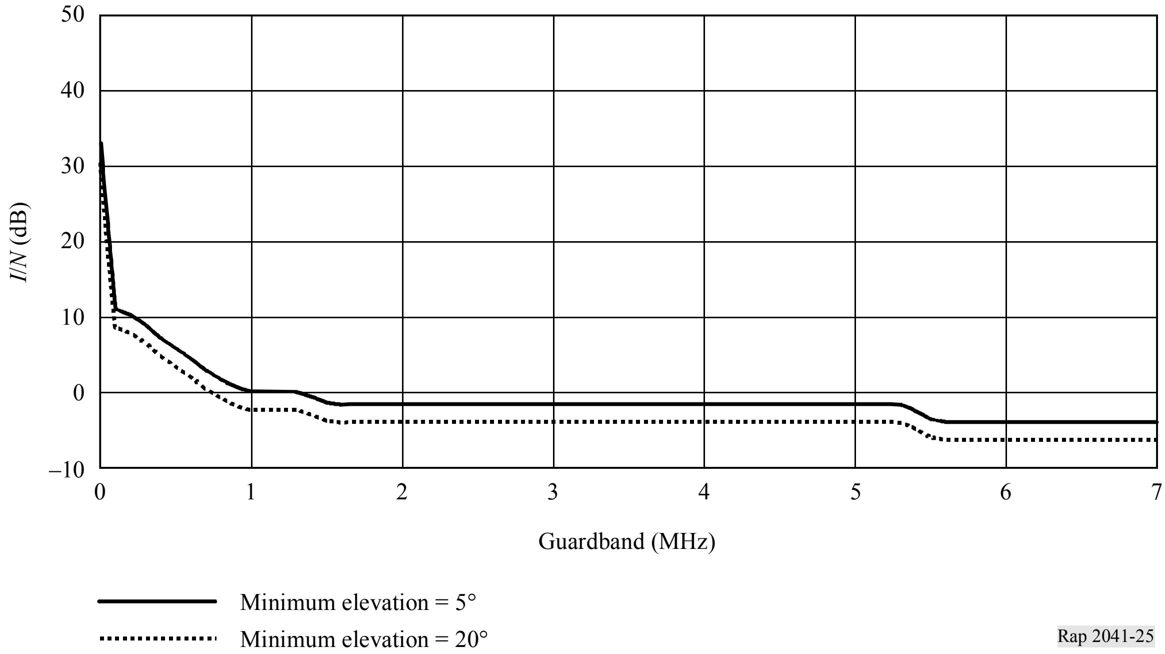
– for the BS Tx (downlink) the worst case was considered to be when the BS deployment and MES are on the horizon.

The results for scenario 15 are shown in Fig. 25. The Figure shows 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.

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

FIGURE 25

Results for scenario 15 (*I*/*N* versus guardband)



3.1.2 SRI-E (method 2)

3.1.2.1 Methodology (SRI-E, path C, scenarios 13 to 16)

The methodology is the same as the one used with S-DMB system and described in § 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.

3.1.2.2 Results with adjacent band compatibility issues

Concerning the methodology for assessing interference to the MSS space segment, the total interference at the satellite is calculated by summing up the contributions from each terrestrial visible cell following the ECC Report 65 method. In the calculations, vertical radiation pattern of BS antennas come from Recommendation ITU-R F.1336 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.

Table 38 gives the simulation results in adjacent band.

TABLE 38

OoB interfering power density at satellite receiver (dBm/Hz) to compare to –173.55 dBm/Hz ($\Delta T/T = 50\%$) and –185.78 dBm/Hz ($\Delta T/T = 3\%$)

Satellite 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 $\Delta T/T$)	–181.9 (14% of $\Delta T/T$)	–183 (11.3% of $\Delta T/T$)	–183 (11.3% of $\Delta T/T$)
10° E; 50° N	–182.2	–183.1	–184.2	–184.2
10° E; 60° N	–183.3	–185.2	–185.3	–185.3

The criteria of $\Delta T/T$ of 3% is exceeded whatever the guardband proposed. This scenario is examined further in § 5 of this Annex.

3.2 S-DMB

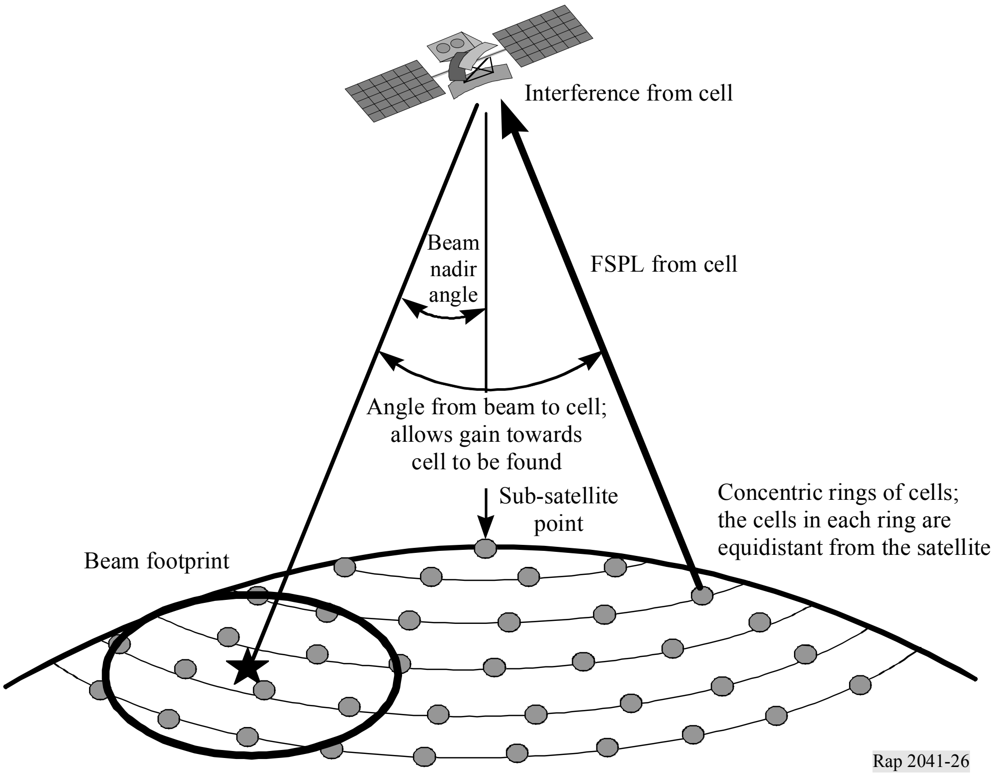
3.2.1 Methodology (S-DMB, path C, scenarios 13 to 16)

The methodology described in the ERC Report 65 (§ 3.2.1 of this Annex) 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 1.

FIGURE 26

ERC Report 65 methodology for evaluating interference into satellite reception



Based on the methodology described above and in [7], the average MS e.i.r.p. per cell, and the average BS power per cell are calculated, for both IMT-2000 CDMA TDD and IMT-2000 CDMA direct spread modes.

The resulting terrestrial 3G average parameters are given below:

	IMT-2000 CDMA direct spread	**IMT-2000 CDMA 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 cumulated BS emission level at the satellite, an average BS maximum gain of 13 dBi is assumed for IMT-2000 CDMA direct spread, and 5 dBi for IMT-2000 CDMA TDD. The BS gain towards the satellite is derived from the satellite elevation angle, and the BS maximum gain. The BS gain pattern obeys to Recommendation ITU-R 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 [1], [2], [3], [4]).

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.

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 Table 39.

TABLE 39

In-band interfering power density at satellite receiver (dBm/Hz)

	Interfering system		
Satellite beam boresight	**IMT-2000 CDMA direct spread UEs**	**IMT-2000 CDMA direct spread BSs**	**IMT-2000 CDMA 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

For IMT-2000 CDMA direct spread, 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 IMT-2000 CDMA 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 IMT-2000 CDMA TDD deployment. The sharing with IMT-2000 CDMA TDD, when deployed outdoors, would not be feasible.

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 40. The equivalent percentage of the satellite thermal noise, N_{th}, is given in parenthesis:

TABLE 40

Adjacent channel interfering power density at satellite receiver (dBm/Hz)

	Interfering system		
Satellite beam boresight	**IMT-2000 CDMA direct spread UEs**	**IMT-2000 CDMA direct spread BSs**	**IMT-2000 CDMA TDD (UE and BS)**
10° E; 40° N	–177.5 (23.4% of N_{th})	–180.8 (11.0% of N_{th})	–218.1 (29.5% of N_{th})
10° E; 50° N	–176.0 (33.5% of N_{th})	–176.5 (29.8% of N_{th})	–215.8 (45.7% of N_{th})
10° E; 60° N	–174.9 (43.1% of N_{th})	–171.4 (95.4% of N_{th})	–214.5 (64.6% of N_{th})

Assuming a standard 5 MHz channel spacing, the satellite reception is adequately protected from IMT-2000 CDMA direct spread mobile emissions. The same conclusion is applicable for interference coming from IMT-2000 CDMA direct spread BSs, 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 IMT-2000 CDMA TDD are anticipated. If there was a limited outdoor deployment of IMT-2000 CDMA TDD, the adjacent band compatibility would certainly still be feasible, due to the very high available margin.

4 Interference from T-IMT-2000 into MSS MES

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

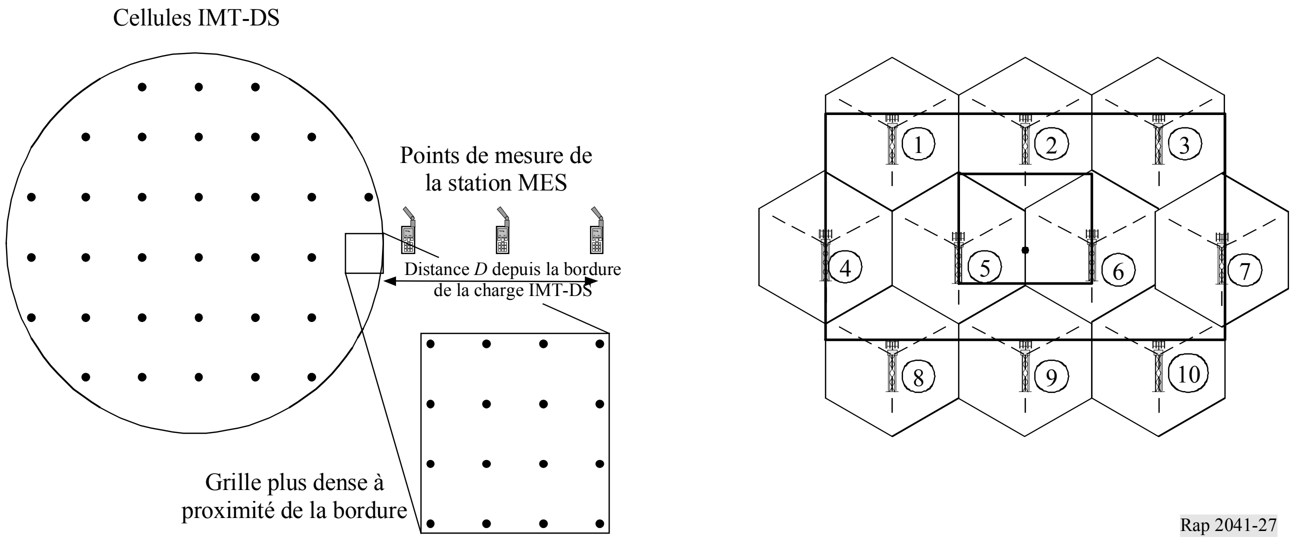
4.1 SRI-E

4.1.1 Methodology (SRI-E, path D, scenarios 17 to 20)

This interference path is between the T-IMT-2000 (either BS or MS Tx) interfering into the S-IMT-2000 downlink, as shown in Fig. 27.

FIGURE 27

Trajet de brouillage D: Espacements géographique et de fréquences



Interference from MSs

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 T-IMT-2000 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 T-IMT-2000 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. 27);

– 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 BSs

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 T-IMT-2000 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.

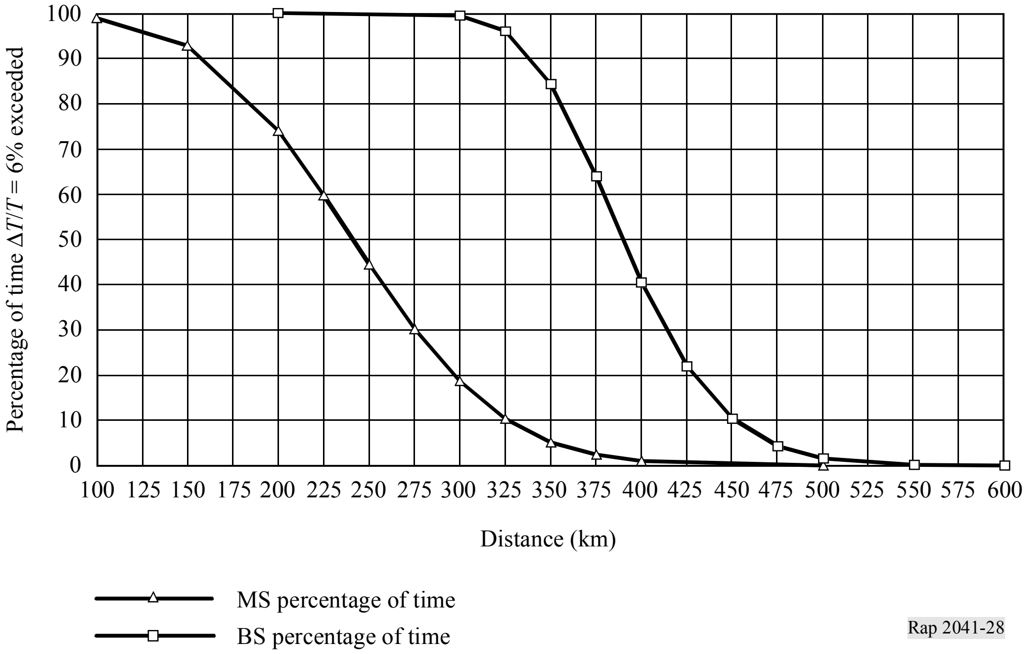
4.1.2 Co-frequency analysis (SRI-E, path D, scenarios 17 to 20)

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

The result after 100 000 samples was CDFs of $\Delta T/T$ vs. percentage of time $\Delta T/T$ exceeded. These were used to determine the percentage of time for which the threshold of $\Delta T/T = 6\%$ was exceeded for various distances, as shown in Fig. 28.

FIGURE 28

Percentage of time that Δ*T*/*T* = 6% is exceeded vs. distance

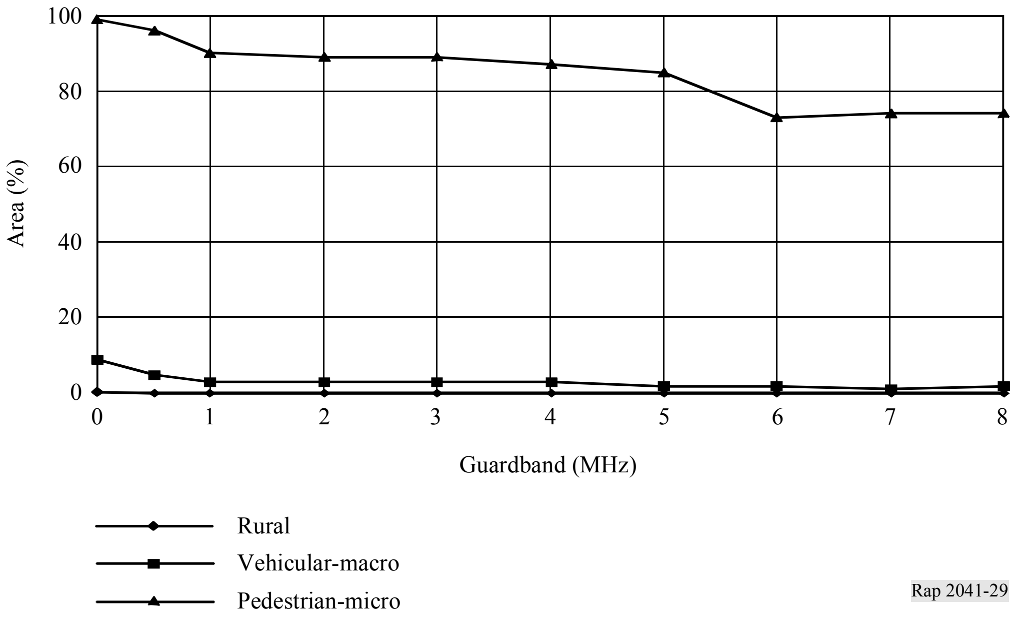


4.1.3 Adjacent band analysis (SRI-E, path D, scenarios 17 to 20)

Co-located sharing considered the case where the S-IMT-2000 and T-IMT-2000 systems were operating within the same geographic region but were separated in frequency. The interference levels vary depending upon the T-IMT-2000 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 29

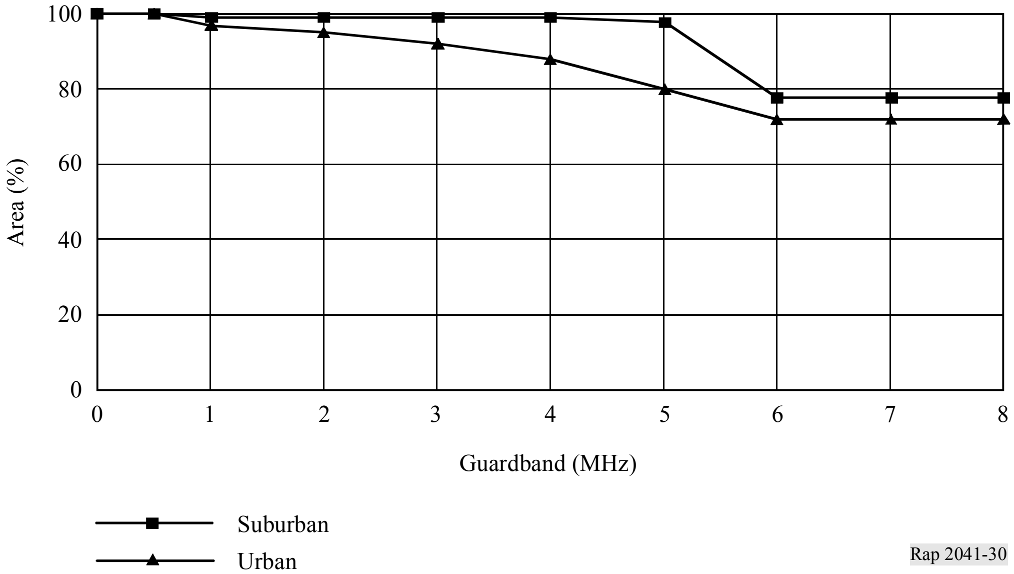
Percentage of MES locations for which criterion is exceeded for interference MS (IMT-2000 CDMA direct spread) to MES for various environments (scenario 17)



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

FIGURE 30

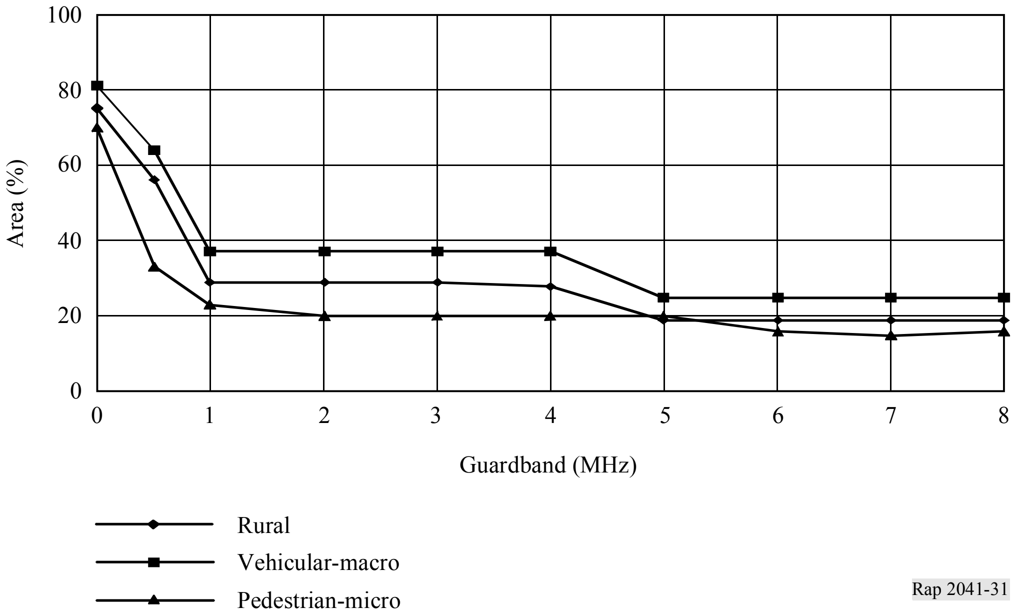
Percentage of MES locations for which criterion is exceeded for interference MS (IMT-2000 CDMA TDD) to MES for various environments (scenario 18)



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

FIGURE 31

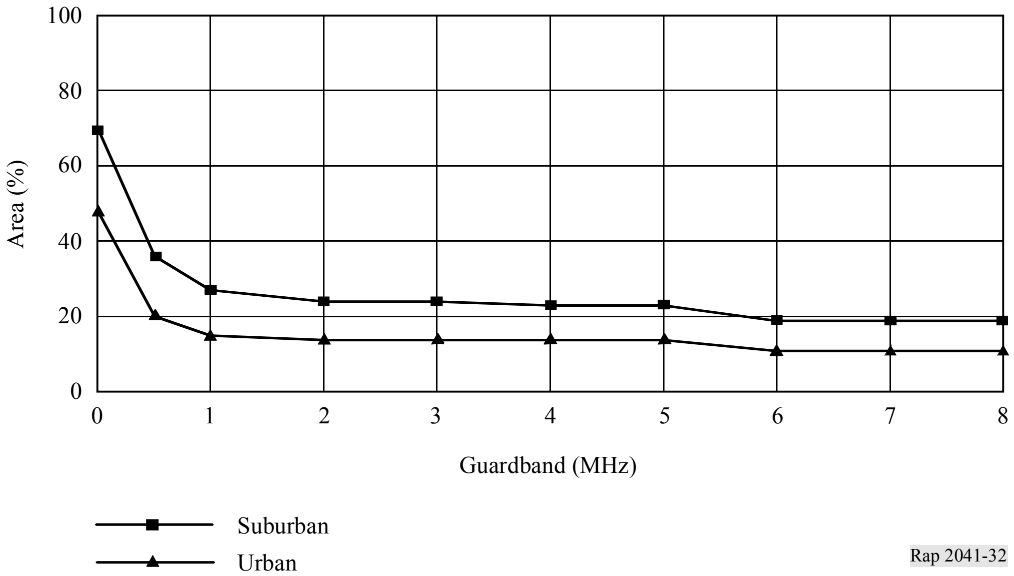
Percentage of MES locations for which criterion is exceeded for interference BS (IMT-2000 CDMA direct spread) to MES for various environments (scenario 19)



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 32

Percentage of MES locations for which criterion is exceeded for interference BS (IMT-2000 CDMA TDD) to MES for various environments (scenario 20)

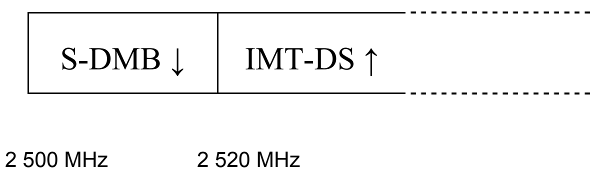


In each of these four scenarios, large guardbands are required in particular environments. Hence these scenarios are examined further in § 5 of this Annex.

4.2 S-DMB

4.2.1 Scenarios 17 and 21: Interference from IMT-2000 CDMA direct spread UE uplink into S-DMB terminals

This case corresponds to a situation where IMT-2000 CDMA direct spread 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-IMT-2000 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, 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 IMT-2000 CDMA direct spread uplink allocation is necessary.

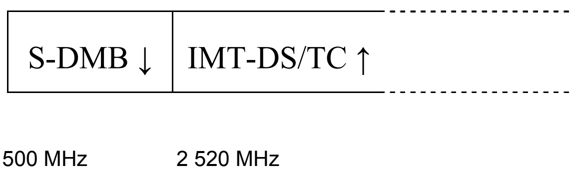
4.2.2 Scenarios 18 and 22: Interference from IMT-2000 CDMA TDD UE uplink into S-DMB terminals

Under this scenario, two cases need to be distinguished:

– The S-DMB terminal implements IMT-2000 CDMA 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.

– The S-DMB terminal *does not* implement IMT-2000 CDMA TDD capabilities in the upper adjacent frequency blocks to the 2 500-2 520 MHz MSS band, even though these blocks are identified for IMT-2000 CDMA TDD. In this case, the required frequency separation can be derived from T-IMT-2000 coexistence studies in a similar case. Nevertheless, the BS-to-BS case analysed in the T-IMT-2000 studies, which is known to be the most problematic, will determine the required frequency carrier separation.

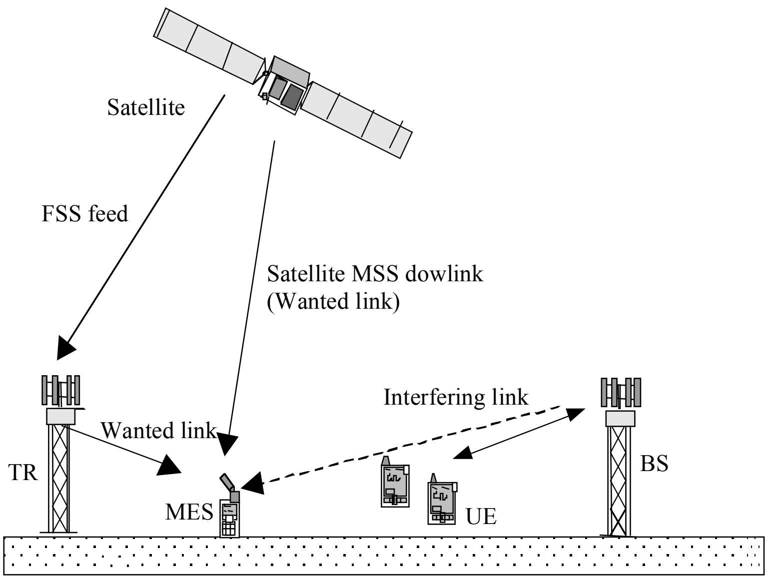
4.2.3 Scenarios 19, 20, 23, 24: Interference from BS T-IMT-2000 into S-DMB terminals



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 Fig. 33.

FIGURE 33

Wanted and interfering paths (S-DMB terminal victim)



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

TABLE 41

Envisaged S-DMB downlink bit rates

S-DMB terminal receive mode	Wanted Rx signal bit rate
From satellite	64 kbit/s
	3 × 384 kbit/s
From TRs	3 × 384 kbit/s

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 T-IMT-2000 standardized pedestrian environment:

$C/(N + I)$ @ 64 kbit/s = –5.86 dB

$C/(N + I)$ @ 384 kbit/s = 3.77 dB

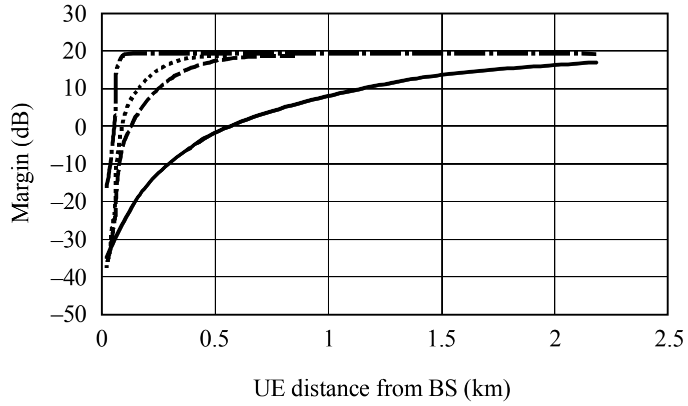
The Hata-COST 231 modified propagation model is used. The impact of the interference is calculated as a function of the distance between the wanted S-DMB user terminal (So called "S-DMB UE") and a single interfering BS.

Scenarios 19 and 20: S-DMB UE in satellite reception mode

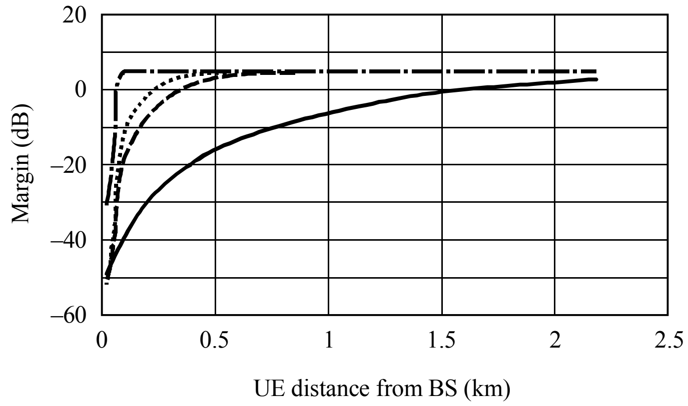
The following diagrams indicate the Rx margin in dB (relative to the objective $C/(N + I)$) at the S-DMB UE reception, for the 2 test bit rates proposed, and different interfering environments. A conventional 5 MHz carrier separation is assumed.

FIGURE 34

BS interference impact on S-DMB



a) S-DMB UE Rx margin (satellite mode) – 64 kbit/s



b) S-DMB UE Rx margin (satellite mode) – 3 × 384 kbit/s

43 dBm, *G* = 17 dBi, *h* = 30 m, rural environment
43 dBm, *G* = 17 dBi, *h* = 15 m, suburban environment
43 dBm, *G* = 17 dBi, *h* = 15 m, urban environment
33 dBm, *G* = 5 dBi, *h* = 5 m, urban environment

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Table 42 gives the corresponding separation distances (corresponding to 0 dB margin in Figs. 34a) and 34b) for 5 MHz carrier spacing, and 10 MHz carrier spacing).

TABLE 42

BS interference radius (m) (victim: S-DMB terminal)

	Carrier separation	5 MHz		10 MHz	
	S-DMB downlink rate	64 kbit/s	3 × 384 kbit/s	64 kbit/s	3 × 384 kbit/s
Interfering BS (power, gain, height, environment)	43 dBm, 17 dBi, 30 m, rural	580	1 650	310	860
	43 dBm, 17 dBi, 15 m, suburban	130	370	80	190
	43 dBm, 17 dBi, 15 m, urban	93	240	72	125
	33 dBm, 5 dBi, 5 m, urban	51	70	42	58

Assuming a terrestrial repeater cell radius of respectively 10 km, 2 km, 1 km and 315 m for the four environments envisaged in Table 42, the loss of coverage which results from BS interference is as follows:

TABLE 43

BS interference area (percentage of cell area)

	Carrier separation	5 MHz		10 MHz	
	S-DMB downlink rate	64 kbit/s	3 × 384 kbit/s	64 kbit/s	3 × 384 kbit/s
Interfering BS (power, gain, height, environment)	43 dBm, 17 dBi, 30 m, rural	0.34%	2.72%	0.10%	0.74%
	43 dBm, 17 dBi, 15 m, suburban	0.42%	3.42%	0.16%	0.90%
	43 dBm, 17 dBi, 15 m, urban	0.86%	5.76%	0.52%	1.56%
	33 dBm, 5 dBi, 5 m, urban	2.62%	4.94%	1.78%	3.39%

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 BS 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 Table 43, 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 (3 × 384 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 TR 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 TR segment. The TR 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.

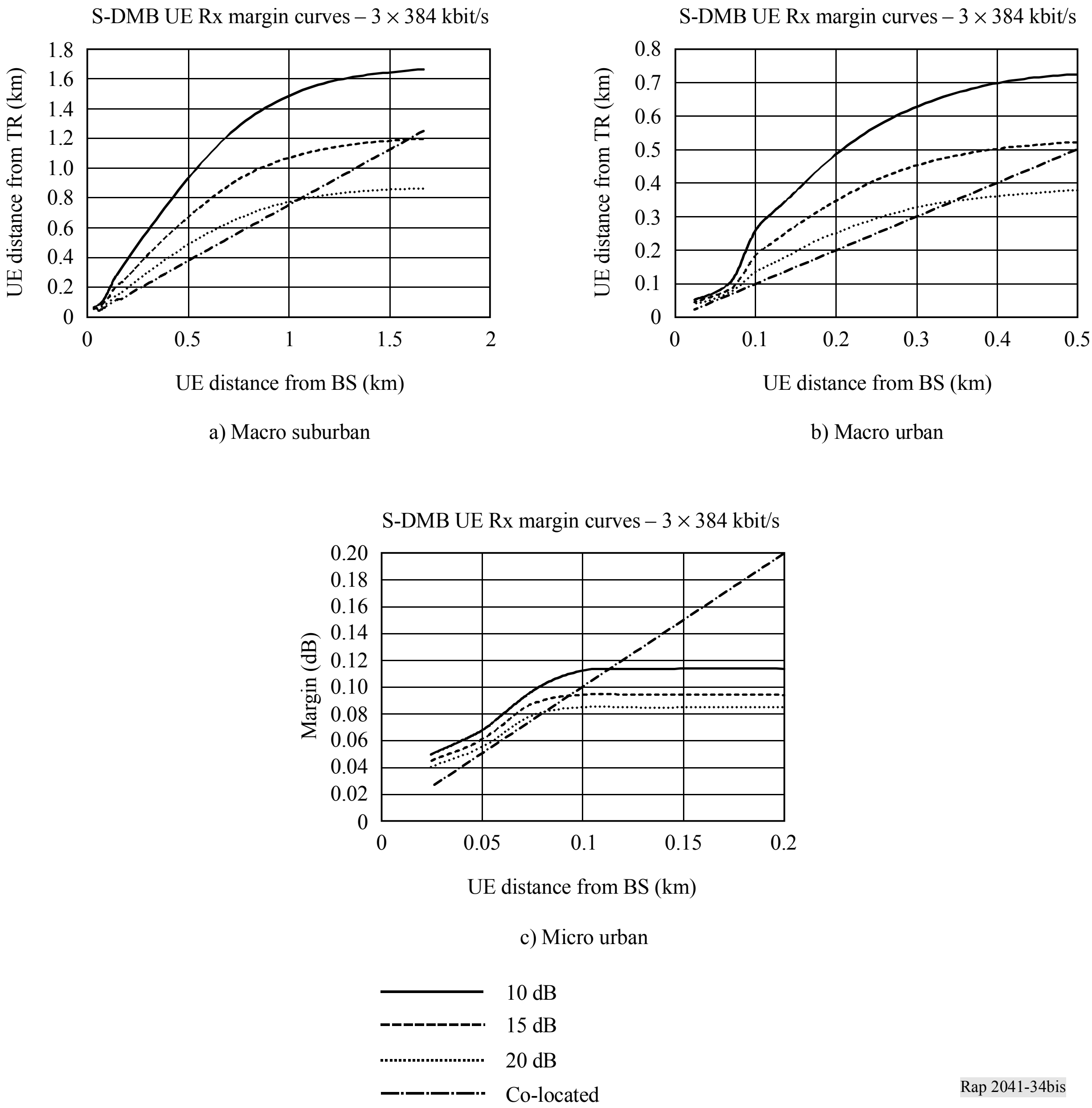
The assumed values for BS and TR deployment are:

TABLE 44

BS/TR assumptions

	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:



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In the above diagrams showing the $C/(\mathrm{N} + \mathrm{I})$ 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 TR and the minimum distance to the BS for a target Rx margin. When the TR and the BS are co-located, the curves show that it is possible to maintain an 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 TR and the BSs are co-located.

These distances correspond approximately to operational cell radii for these environments. Therefore, the S-DMB terminal receiving from the TR 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 coexistence 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.

5 Sensitivity analysis for the 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.

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.

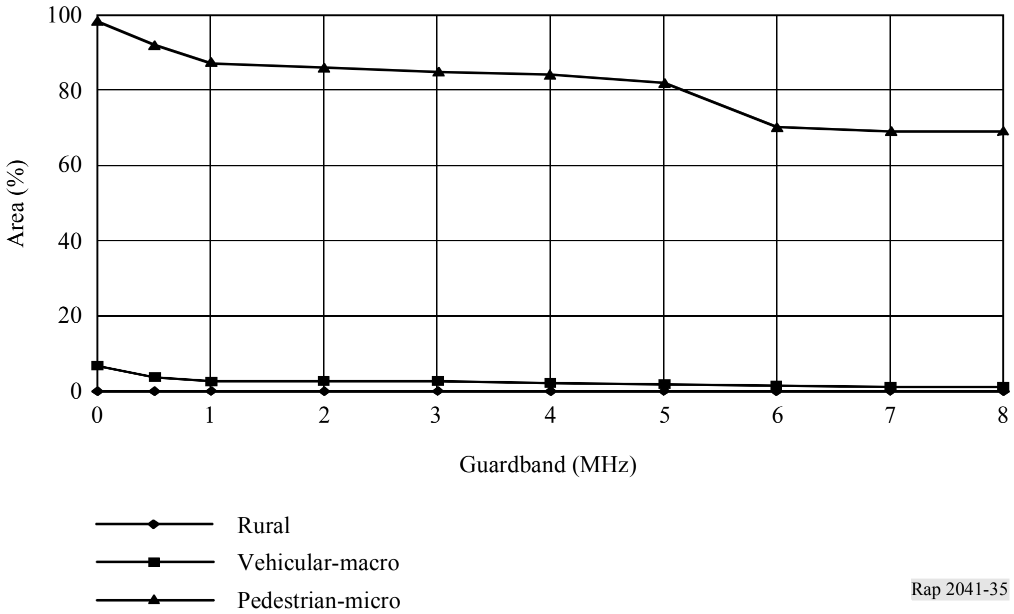
Path D

The baseline results for scenarios 17 to 19 (§ 4.1.4) 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 IMT-2000 CDMA 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 OoB emissions of the BS 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 35

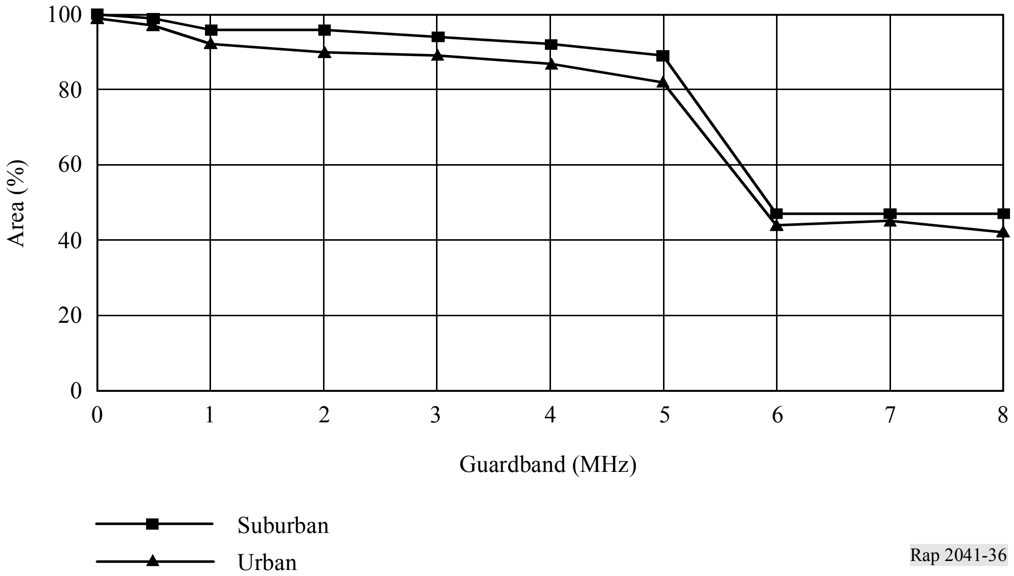
Improved results for scenario 17 (IMT-2000 CDMA direct spread UE interfering with MES)



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.

FIGURE 36

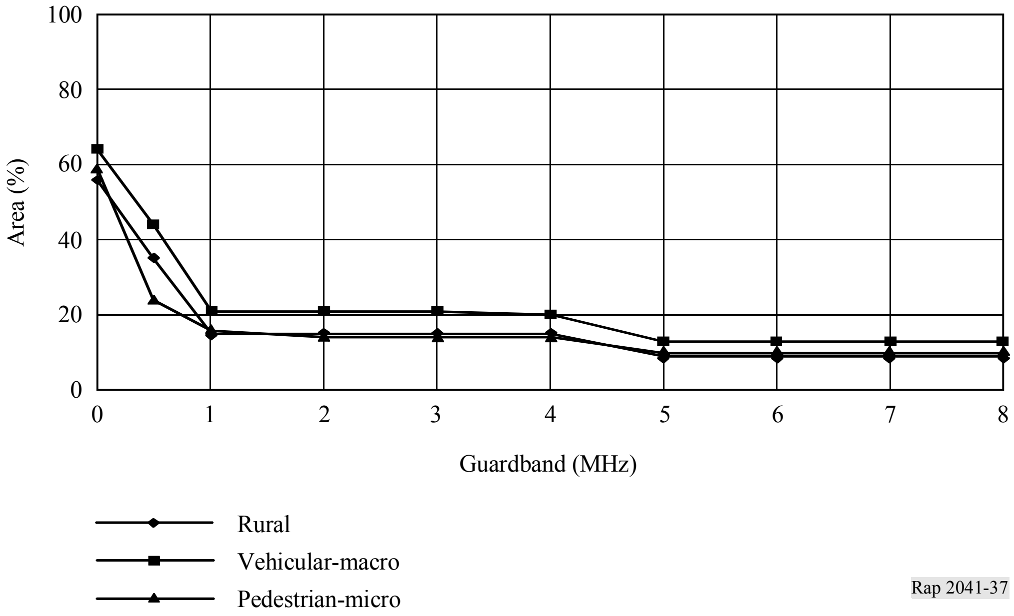
Improved results for scenario 18 (IMT-2000 CDMA TDD UE interfering with MES)



In both environments, the necessary guardband exceeds 8 MHz.

FIGURE 37

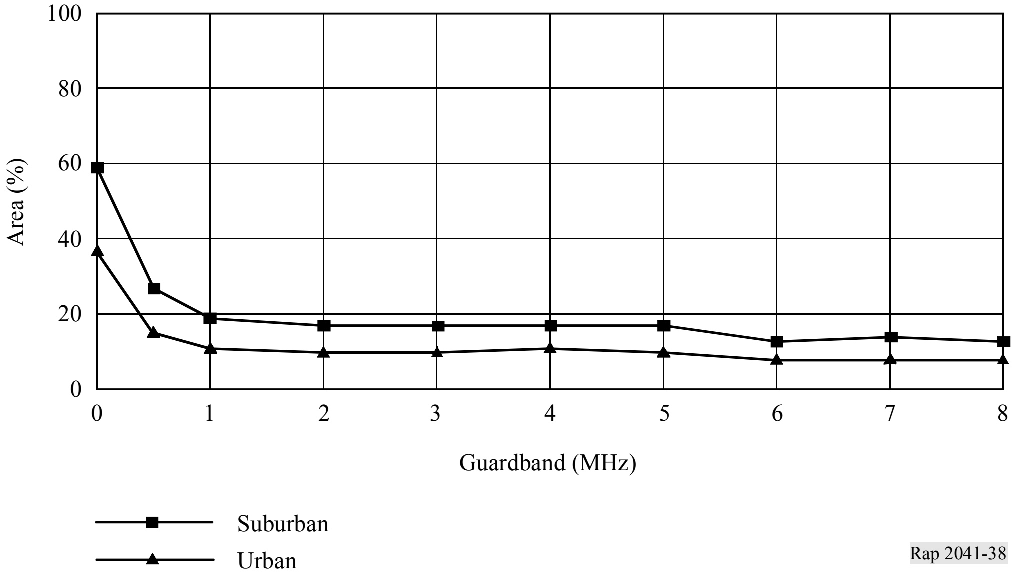
Improved results for scenario 19 (IMT-2000 CDMA direct spread BS interfering with MES)



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 $\Delta T/T$ 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.

FIGURE 38

Improved results for scenario 20 (IMT-2000 CDMA 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.

5.2 MSS UL band

Path B

The baseline analysis indicated that adjacent band operation in the MSS uplink 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 BSs 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 BS 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 BS OoB emissions just meet the limits in the standard at each point of the frequency scale. In reality, there is some margin between the actual OoB 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 OoB 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.

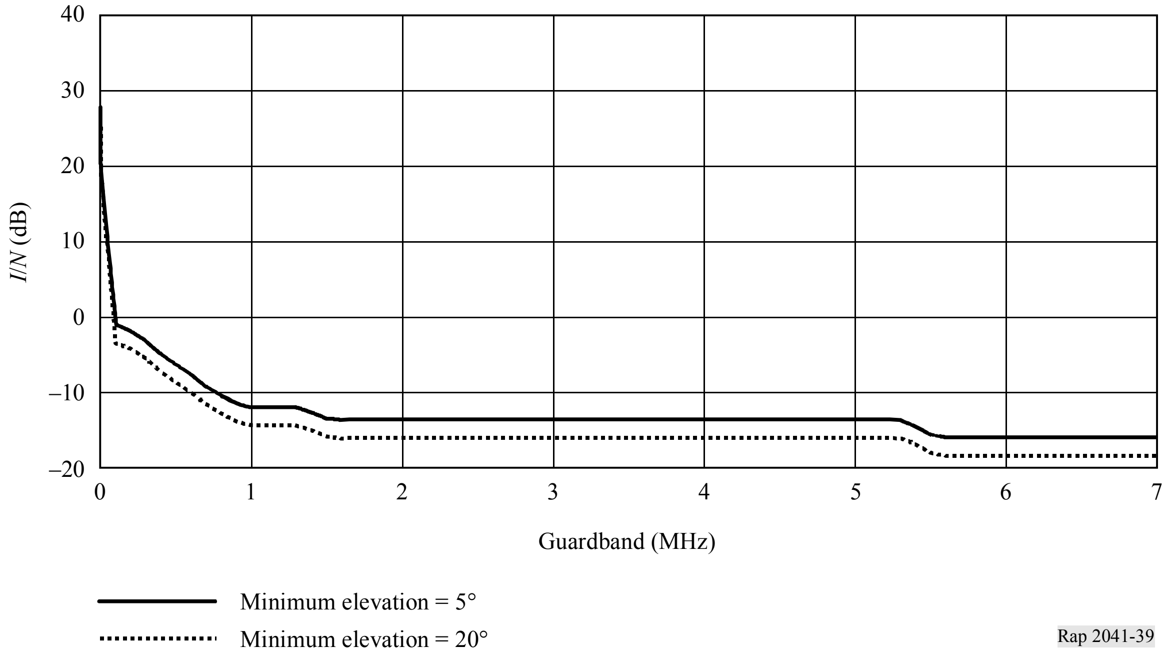
– The calculations assume that the BS antenna conforms exactly to the reference antenna pattern whereas in practice, the antenna may be expected to perform better, particular for the larger off-axis angles. Further, the baseline calculations do not include any terrain or building blockage between the BSs 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. Figure 39 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.

FIGURE 39

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, Table 45 gives the simulation results in the adjacent band.

TABLE 45

OoB interfering power density at satellite receiver (dBm/Hz) to compare to –185.78 dBm/Hz ($\Delta T/T = 3\%$)

Satellite beam boresight	Interferences without guardbands	Interferences with 1 MHz guardband	Interferences with 2 MHz guardbands
10° E; 40° N	–193 (14% of $\Delta T/T$)	–193.9	–194.9
10° E; 50° N	–194.3	–195.1	–196.1
10° E; 60° N	–196.5	–197.3	–198.3

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 the SRI-E satellite receiver.

References

[1] 3GPP 25.101 v530: Technical Specification Group Radio Access Networks. UE Radio Transmission and Reception (FDD).

[2] 3GPP 25.102 v510: Technical Specification Group Radio Access Networks. UE Radio Transmission and Reception (TDD).

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

[4] 3GPP 25.105 v510: Technical Specification Group Radio Access Networks. BS Radio Transmission and Reception (TDD).

[5] ERC Report 65: Adjacent band compatibility between UMTS and other services in the 2 GHz band.

[6] ETSI TC-SES TR 102 058 v004 (Draft): Satellite UMTS - Evaluation of the W-CDMA UTRA FDD as a satellite radio interface.

[7] 3GPP 25.942 v500: RF Systems scenarios.