

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.

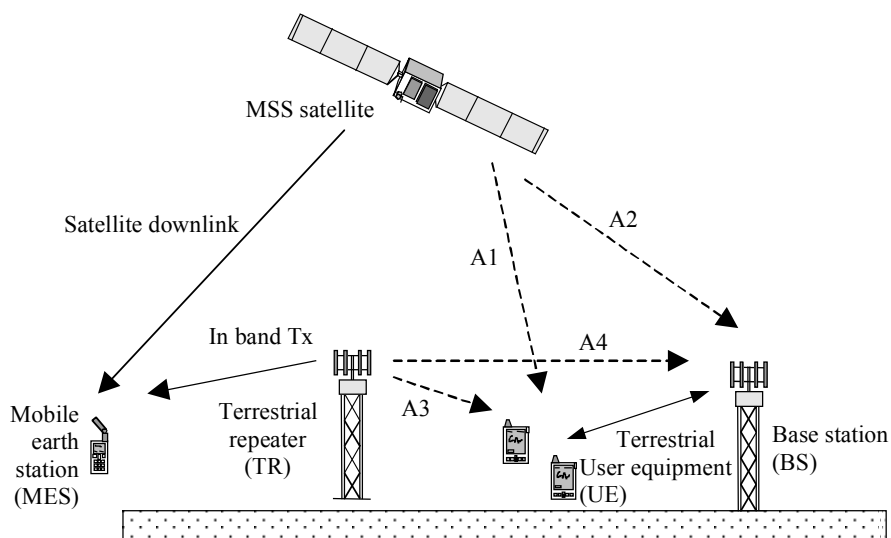
TABLE 1

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



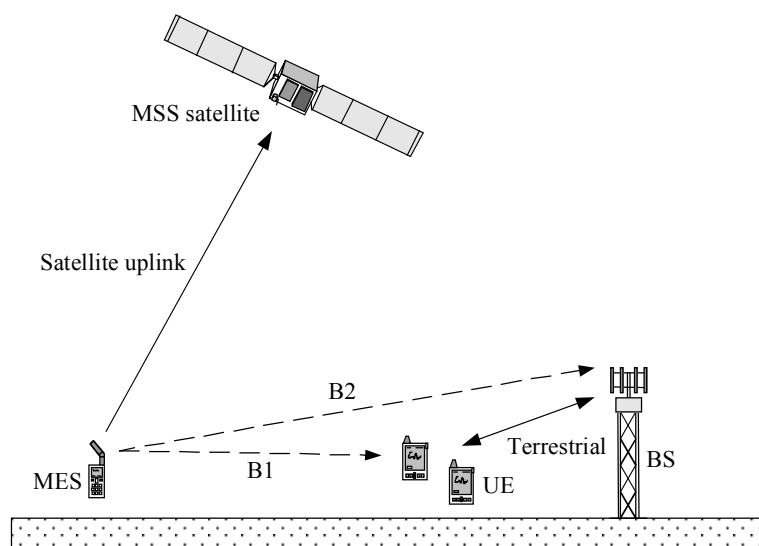
Interference path:

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

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FIGURE 2

Interference path B
2 670-2 690 MHz



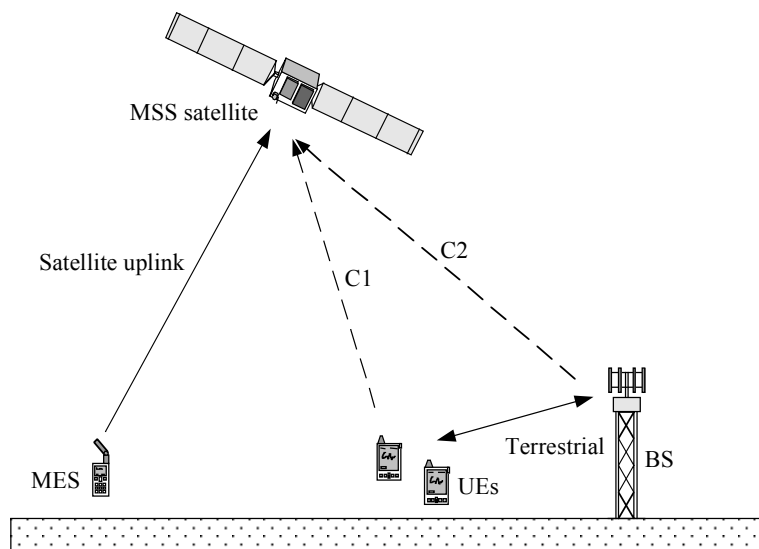
Interference path:

- B1: MES → UE
- B2: MES → BS

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FIGURE 3

Interference path C
2 670-2 690 MHz



Interference path:

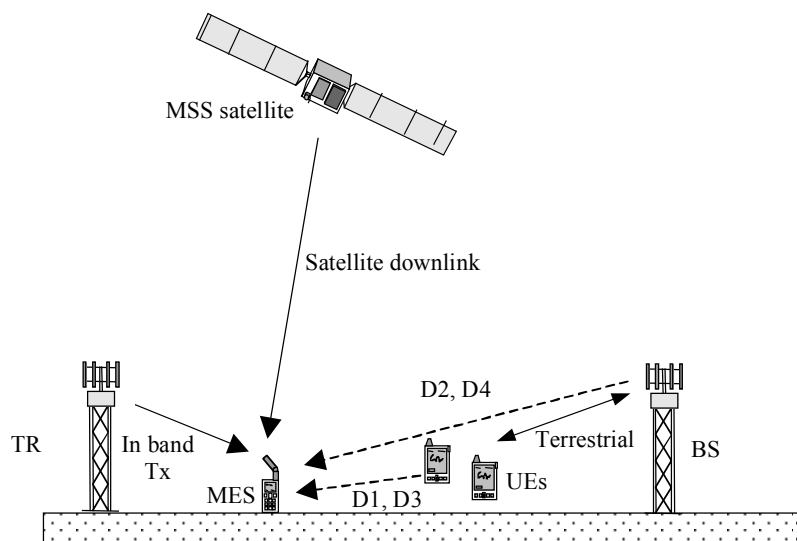
C1: UE → MSS

C2: BS → MSS

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FIGURE 4

Interference path D
2 500-2 520 MHz



Interference path:

D1: UE → MES (receiving from satellite)

D2: BS → MES (receiving from satellite)

D3: UE → MES (receiving from TR)

D4: BS → MES (receiving from TR)

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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:

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

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

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

In the case of a minimum guardband calculation, $f_{separation}$:

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

The ACIR is defined as:

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

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 Seamcat¹ 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:

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 schemes², 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.

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 $20 \text{ MHz}/7 = 2.86 \text{ MHz}$. 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 carrier³, then this represents 14 users/beam. The highest user density in users/km² 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.