RECOMMENDATION ITU-R M.1654*

A methodology to assess interference from broadcasting-satellite service (sound) into terrestrial IMT-2000 systems intending to use the band 2 630-2 655 MHz

(Question ITU-R 229/8)

(2003)

Summary

This Recommendation is an example methodology to assess the interference from BSS (sound) into terrestrial IMT-2000 systems intending to use the band 2 630-2 655 MHz and that could be used to determine the impact of BSS (sound) on terrestrial IMT-2000 in the context of co-frequency sharing through the development of pfd masks, where applicable. This methodology contains an algorithm that can be used to calculate a single entry pfd mask for BSS (sound) satellites for a given scenario to meet an *Isat*/*Nth* criterion within a tolerance of 1 dB at any location on the Earth. Attachment 1 to Annex 1 sets out an example of the application of a methodology assessing the possible impact in terms of a loss of coverage or cell size reduction. It has been recognized that the interference into a cellular network can be assessed in terms of coverage reduction (particularly in noise-limited networks such as in rural areas) as well as in terms of availability reduction (particularly in capacity-limited networks such as in urban areas). These approaches may be complementary, and additional study is required on these further aspects. Further study is required on alternative example methods assessing the possible impact. The use of this Recommendation to calculate pfd values in the context of co-frequency sharing should carefully take into account all parameters including operational constraints on BSS (sound) systems, as well as the likely different IMT-2000 sharing scenarios. In particular, it should be noted that if this Recommendation is used to derive pfd values to be applied as hard limits, worst-case assumptions are not deemed appropriate. As this Recommendation contains a methodology for assessing multiple satellite interference, its use is not advised in the process of coordination.

The ITU Radiocommunication Assembly,

considering

a) that a methodology is required to assess the possible aggregate interference from BSS (sound) into terrestrial IMT-2000 systems intending to use the band 2 630-2 655 MHz and for the development of pfd masks, where applicable, with a view to achieving the objectives in Resolutions 223 (WRC-2000) and 539 (WRC-2000),

* NOTE – The following countries – Saudi Arabia, Djibouti, Egypt, United Arab Emirates, Jordan, Kuwait, Morocco, Mauritania, Syrian Arab Republic, Tunisia and Yemen – object to the approval of this Recommendation and are not bound by it.

recognizing

a) that Resolution 539 (WRC-2000), *inter alia*, contains provisional pfd threshold levels for BSS (sound) systems using non-GSO satellites in the band 2 630-2 655 MHz;

b) that Resolution 539 (WRC-2000) invites ITU-R to conduct the necessary technical studies in time for WRC-03 relating to frequency sharing between systems in the BSS (sound) and terrestrial services in the band 2 535-2 655 MHz with a view to avoid placing undue constraints on either service,

recommends

1 that the example methodology described in Annex 1 of this Recommendation could be used to assess interference from, and possible impact of, BSS (sound) on terrestrial IMT-2000 systems intending to use the band 2 630-2 655 MHz in the context of co-frequency operation through the development of pfd masks.

NOTE 1 – The example methodology described in Annex 1 of this Recommendation may also be applied for assessing interference of co-frequency operation involving any satellite service system using various orbital configurations, including the geostationary orbit or highly elliptical orbit types.

Annex 1

A methodology to assess interference from BSS (sound) into terrestrial IMT-2000 systems intending to use the band 2 630-2 655 MHz

1 Input data and scenarios

1.1 Characteristics of the systems

A given scenario will consist of BSS (sound) satellite networks using non-GSO space stations employing highly-elliptical orbits (HEO) and/or space stations using the GSO interfering into terrestrial IMT-2000 systems (base and/or mobile stations). Sections 1.1.1[1] and 1.1.2 list the necessary parameters, respectively for terrestrial IMT-2000 stations and BSS (sound) systems, to assess aggregate interference from BSS (sound) to terrestrial IMT-2000 stations.

1.1.1 Terrestrial IMT-2000 stations

– Receiver characteristics:
  – thermal noise level;
  – noise factor.

[1] Additional system specific input parameters for terrestrial IMT-2000 stations would be required for usage of Methods 2a and 2b in § 3.1.2. The detailed list of these parameters is provided in Attachment 1.

– Antenna characteristics:
  – maximum gain;
  – polarization;
  – feed loss;
  – 3 dB beamwidth[2];
  – vertical and azimuthal antenna radiation patterns over a range of elevation angles[2];
  – downtilt of the antenna[2];
  – site sectorization[2].
– Location of the receivers (for example, an area bounded by latitude(s) and longitude(s) data).

1.1.2 BSS (sound) systems

The various combination of a constellation of BSS (sound) systems that could operate in the 2 630-2 655 MHz band should be in accordance with the expected number of co-frequency satellites visible at the same location on the surface of the Earth. These may include non-GSO and/or GSO satellites.

– GSO satellites, assumed equally spaced across the GSO arc:
  – nominal geographical longitude on the geostationary satellite orbit.
– For non-GSO HEO satellite systems, the following parameters are to be provided:
  – number of orbital planes, number of space stations per orbital plane and number of space stations simultaneously transmitting on the active arc, period of the space stations;
  – altitude and longitude of the apogee and perigee for each space station;
  – inclination angle for each orbital plane with respect to Earth equatorial plane;
  – start and end of the active arc for each space station.

Interference produced by BSS (sound) satellites is typically modelled by pfd masks as a function of elevation angle ($dB(W/(m^2 \cdot MHz))$)[3]. Information on the polarization used by the satellite transmitters would be required to assess polarization discrimination if needed (see factor P_i in equations (1) and (2) in § 3.1.1).

There are two approaches to the analysis. These are:

– static approach – the location of the satellite is fixed at a single point;
– orbital simulation approach – time variation of the satellite is included[4].

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[2] Only applies to base station receivers.

[3] The modelling by this method may result in a worst-case situation of interference from GSO BSS (sound) satellites.

[4] It is considered that this approach, while requiring more complex simulation tools, will produce more accurate results.

2 Presentation of the results

The results should be expressed in terms of *Isat*/*Nth* received at each receiver (in the case of sectoral base station receivers, one receiver per sector should be used). It is recognized that when assessing interference from satellite systems into an IMT-2000 network, the effect of this interference would be spread over large areas, thus leading to an interference assessment in terms of *Isat*/*Nth*[5].

It may also include results of *Isat*/*Nth* which take into account the combined impact for each base station sector coverage area of the receiver.

The results should be expressed in a transparent, simple and comprehensive manner.

3 Method of calculation and production of the results

3.1 Assessment of the interference into an IMT-2000 base station

3.1.1 Aggregation of the interference from multiple satellites into a given IMT-2000 base station receiver

The calculation steps for the aggregation of the interference from satellites is summarized below:

– considering a set of non-GSO and/or GSO satellites orbiting around Earth;

– considering assumed pfd masks at the Earth's surface used to model the emissions of each non-GSO and/or GSO satellite;

– considering an IMT-2000 base station with sectoral antenna, characterized by its latitude, longitude, orientation and tilt angle;

– calculate the azimuth, elevation and off-axis angles between the IMT-2000 base station and each satellite of the assumed constellation;

– calculate the aggregate interference at the receiver entrance from all visible satellites (i.e., whose elevation angle is positive) with an overlapping bandwidth with terrestrial IMT-2000 and the subsequent *Isat*/*Nth* IMT-2000 base station receiver (sector) at a given latitude and longitude (*lat*, *long*), and pointing in a given direction (*orientation, tilt angle*). The subsequent *Isat*/*Nth* is given by the following formula:

$$\frac{Isat}{Nth}\left(\begin{matrix} lat, long, orientation, \\ tilt\ angle \end{matrix}\right) = 10 \log\left(\frac{1}{Nth}\sum_{i=1}^{n\_sat} 10^{\,(pfd_i(elevation\_i) + G(r\_azimuth\_i,\, r\_elevation\_i) + 10\log(\lambda^2/4\pi) - FL - P_i)/10}\right) \quad (1)$$

[5] The use of $C/(N + I)$ interference assessment into IMT-2000 is only used in contexts where interference impacts only a limited numbers of cells. Such assessment is not suitable for situations involving satellite interference into large numbers of stations of different networks where wanted signal carrier power levels vary for each user with factors such as time, traffic loading, user location and power control.

where:

Isat/*Nth* (*lat*, *long*, *orientation*, *tilt angle*): is the resulting aggregate *Isat*/*Nth* from all visible space stations with an overlapping bandwidth with terrestrial IMT-2000 at the IMT-2000 receiver (dB)

$pfd_i(elevation\_i)$: pfd at the terrestrial IMT-2000 station from visible BSS (sound) space station *i* (dB(W/(m^2 · MHz)))

elevation_i: elevation of the space station *i* seen from the IMT-2000 base station (it is the angle of arrival of the space station *i* incident wave to the IMT-2000 base station, above the horizontal plane) (degrees)

G(*r_azimuth_i, r_elevation_i*): off-axis gain of the IMT-2000 base station sector towards the space station *i* (dBi)

r_azimuth_i: relative azimuth of the space station *i* seen from the IMT-2000 base station sector (it is determined by the difference between the azimuth of the space station *i* seen from the base station and the azimuth of the orientation of the IMT-2000 base station sector) (degrees)

r_elevation_i: relative elevation of the space station *i* (the angle of arrival of the space station *i* incident wave to the IMT-2000 base station, above the horizontal plane, plus the tilt angle of the IMT-2000 base station (a downtilt angle has a positive value)) (degrees)

λ: wavelength (m)

FL: terrestrial IMT-2000 receiver feeder loss (dB)

P_i: expected averaged polarization discrimination between transmitting antenna of space station *i* and the IMT-2000 base station receiving antenna (dB)

n_sat: number of satellites

Nth: terrestrial IMT-2000 station receiver thermal noise (W/MHz).

In the static approach, the non-GSO HEO type satellite(s) is (are) assumed to transmit at its (their) apogee.

In the orbit simulation approach, the HEO satellite is transmitting from its simulated location on the active arc at each time increment and equation (1) is computed for each time increment (t) and becomes equation (2):

$$\frac{Isat}{Nth}\begin{pmatrix} lat, long, orientation, \\ tilt\ angle, t \end{pmatrix} = 10 \log \left(\frac{1}{Nth} \sum_{i=1}^{n\_sat} 10^{\left(pfd_i(elevation\_i(t)) + G(r\_azimuth\_i(t), r\_elevation\_i(t)) + 10 \log(\lambda^2/4\pi) - FL - P_i(t) \right)/10} \right) \quad (2)$$

The notations in equation (2) have equivalent meaning to those in equation (1).

The static approach enables tables or figures recording *Isat*/*Nth* values at the terrestrial IMT-2000 receiver to be determined as a function of the relative longitude, latitude, tilt angle and orientation of the terrestrial IMT-2000 station for a given distribution of BSS (sound) satellites transmitting at their pfd mask.

The orbit simulation approach can produce further combined information on the received interference with the corresponding time duration, or the percentage of time a given *Isat*/*Nth* level of interference is experienced.

3.1.2 Assessment of the interference received at a given IMT-2000 site

In addition to the assessment of the interference received at an IMT-2000 individual sector, it may be of interest to consider also the impact of the interference into IMT-2000 sites, taking into account the combined impact on each sector area.

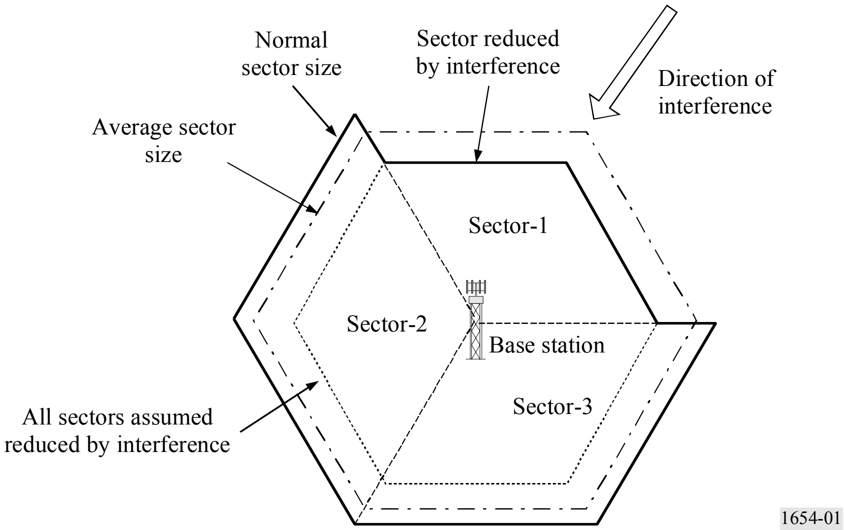
The combined impact of the satellite interference over a site is to be evaluated in regard to the particular concerns of the scenario envisaged. For example, in cases where rural areas are of special concern, the impact on the loss of coverage is of the more critical impact on the system, and additional base stations would be required to overcome the effect of the interference. In this case, the interference threshold can be specified as an *Isat*/*Nth* derived from a loss of coverage analysis. In other words, it is also an evaluation of the percentage of the number of base stations needed to overcome the effect of interference on an IMT-2000 site deployment scheme.

With single sector cells, using azimuth independent antennas, this *Isat*/*Nth* can be directly compared against the value determined during simulation. However, with three sectors/cell, and if each sector has its own receiver, then three *Isat*/*Nths* will be calculated.

Figure 1 shows the key elements that need to be considered:

FIGURE 1

Impact on three-sector cell of direction dependent interference



In Fig. 1, interference reduces the coverage of Sector 1 but not Sectors 2 and 3. The actual impact over a large area would depend upon cell planning.

Below, are three approaches suggested to calculate the *Isat*/*Nths*:

Method 1 (worst case): assumes cell planning is undertaken with the minimum base station (BS) spacing distance in all azimuths, i.e.:

$$\frac{Isat}{Nth} = \max\left\{\frac{Isat_{sector1}}{Nth}, \frac{Isat_{sector2}}{Nth}, \frac{Isat_{sector3}}{Nth}\right\} \tag{3}$$

where:

$Isat_{sectori}/Nth$: $Isat/Nth$ value calculated in sector i.

Method 2a (average): calculate the average loss of coverage over the three sectors and convert back into an *Isat*/*Nth*, which is equivalent to assuming cell planning optimizes the network such that the distance between BS varies by azimuth to exactly adjust for interference:

$$\Delta A_{cell}\left(\frac{Isat}{Nth}\right) = \frac{1}{3}\left(\Delta A_{sector1}\left(\frac{Isat_{sector1}}{Nth}\right) + \Delta A_{sector2}\left(\frac{Isat_{sector2}}{Nth}\right) + \Delta A_{sector3}\left(\frac{Isat_{sector3}}{Nth}\right)\right) \tag{4}$$

where ΔA_{cell} is the average cell site area in presence of interference, as a combination of each compounding sector areas $\Delta A_{sector1}$, $\Delta A_{sector2}$ and $\Delta A_{sector3}$, which are the sector areas for cells 1, 2 and 3 receiving interference $Isat_{sector1}$, $Isat_{sector2}$ and $Isat_{sector3}$ respectively. The detailed calculation steps can be found in Appendix 1.

Method 2b (weighted average): assumes that cell planning is between the worst and best values, and calculates the weighted average loss of coverage over the three sectors and converts back into an adjusted *Isat*/*Nth* (see also Attachment 1):

$$\Delta A_{cell}\left(\frac{Isat}{Nth}\right)=\frac{h}{3}\left(\Delta A_{sector1}\left(\frac{Isat_{sector1}}{Nth}\right)+\Delta A_{sector2}\left(\frac{Isat_{sector2}}{Nth}\right)+\Delta A_{sector3}\left(\frac{Isat_{sector3}}{Nth}\right)\right) \qquad (5)$$

h is the weighted average loss and can be determined by comparing the min/max values calculated using Method 1 and Method 2a. Typically, *h* is found to be approximately 1.7.

3.1.3 Polarization discrimination

In situations where the antennas of IMT-2000 base stations use different polarizations (e.g. linear) to those employed by BSS (sound) systems (i.e. circular), polarization discrimination may be available in the case of mainbeam-to-mainbeam coupling of the IMT-2000 base station antenna and the BSS (sound) space station antenna (up to 3 dB). In the case of side lobe into main beam coupling, polarization discrimination may also be available to some extent, but this aspect has not yet been studied in detail in ITU-R and could be taken to be less than 1.5 dB in average.

3.1.4 Further additional attenuation

In case this methodology is to be used for assessing interference into a specific terrestrial IMT-2000 network deployment scheme using indoors receivers or base stations subject to blockage from the satellite signals, additional attenuation may be considered under 3.1.1 (in-building penetration losses for example).

3.2 Assessment of the interference into an IMT-2000 mobile station

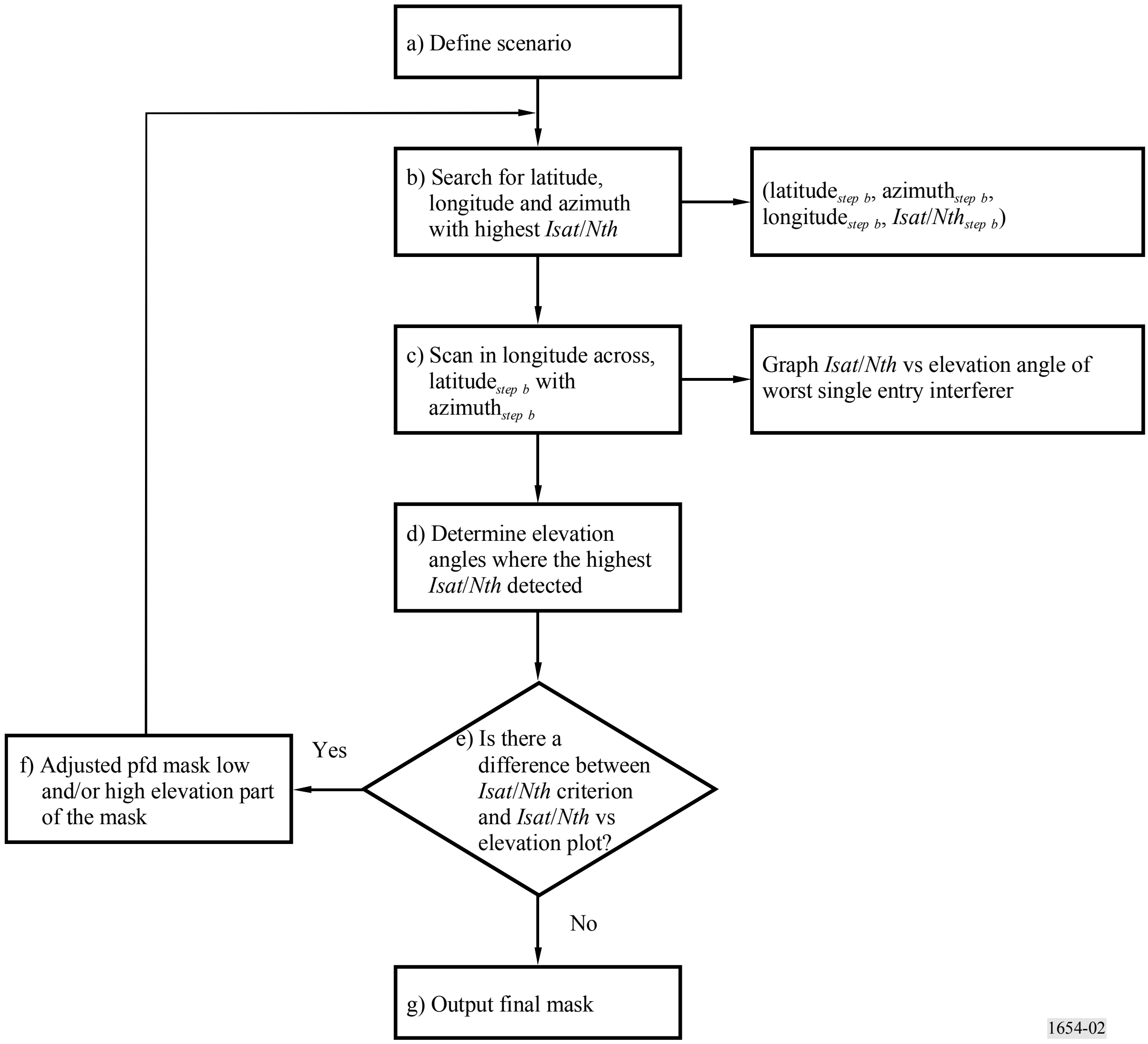
The same approach as in the previous § 3.1.1, 3.1.3 and 3.1.4 can be used to assess the interference into IMT-2000 mobile stations, taking into consideration the omnidirectional nature of the antennas and the different value of the receiver noise level.

3.3 Algorithm to calculate single entry pfd masks

The algorithm in Fig. 2 can be used to calculate a single entry pfd mask for BSS (sound) satellites for a given scenario to meet an *Isat*/*Nth* criterion within a tolerance of 1 dB at any location on the Earth. This algorithm assumes that all the satellite emissions are modelled with the same pfd mask, but in principle the algorithm could be adapted to consider different break points as well as different pfd masks for the non-GSO or the GSO satellite emissions.

FIGURE 2

Steps in algorithm to calculate single entry pfd mask



The steps in the calculation are:

Step a: Define scenario – This is the BSS (sound) constellation, the pfd mask for the initial trial, and the terrestrial IMT-2000 characteristics such as gain pattern, peak gain, feed loss, noise figure, antenna tilt angle etc. In addition, an *Isat*/*Nth* criterion is required so that at Step e it can be used to identify where the pfd mask could be adjusted.

Step b: Search for latitude, longitude and azimuth with highest *Isat*/*Nth* – This involves checking every combination of latitude, longitude, and azimuth. Test points are evenly spaced in latitude and longitude, and then the base station antenna azimuth is scanned between 0° and 360°. The interference into the antenna is calculated using equation (1).

In cases where the antenna is not azimuth independent, the station is configured with two additional antennas, pointing ±120° from the first antenna. The adjusted *Isat*/*Nth* for all sectors of the base station is calculated using (Method 2b).

The output from the simulation is the highest *Isat*/*Nth* calculated, the latitude and longitude of the location that suffered that level, and the azimuth of the antenna that produced the highest *Isat*/*Nth* level ($\text{latitude}_{Step\ b}$, $\text{azimuth}_{Step\ b}$, $\text{longitude}_{Step\ b}$, $Isat/Nth_{Step\ b}$).

Note that for azimuth independent antennas (and in the case of the mobile station) it is not necessary to scan in azimuth.

Step c: Scan in longitude across $\text{latitude}_{Step\ b}$ using $\text{azimuth}_{Step\ b}$ – A station is configured at the $\text{latitude}_{Step\ b}$, with one antenna pointing in the direction of the $\text{azimuth}_{Step\ b}$. In the case of analysis of base station with azimuth dependent antennas, two additional sector antennas should be included at ±120° from the antenna that suffers the highest interference.

The interference into each sector is again calculated using equation (1), and then, where necessary, the impact on the base station for all three sectors is calculated using (Method 2b).

The output is a plot of adjusted aggregate *Isat*/*Nth* against the elevation angle of the satellite that caused the highest single entry interference into the sector that suffered the highest levels of interference[6].

Step d: The plot of *Isat*/*Nth* vs. elevation angle is analysed to note if there is difference[7] between the *Isat*/*Nth* levels calculated and the criterion.

Step e: If it appears that the maximum *Isat*/*Nth* in the 0°-5° and/or 25°-90° segment(s) is (are) below or above the criterion by at least 1 dB, then the algorithm proceeds to Step f. If it appears that the maximum of the *Isat*/*Nth* plot in the 0°-5° segment and the 25°-90° segments are within 1 dB of the criterion then the algorithm continues at Step f.

Step f: The pfd mask is then adjusted in either the low elevation segment (0°-5°) or high elevation segment (25°-90°) or both, and the algorithm returns to Step b. It is assumed that pfd masks would be integer in dB values.

Step g: The output is the pfd mask that meets the *Isat*/*Nth* criterion within a tolerance of 1 dB.

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[6] In case more than one space station could be identified under this procedure (e.g. two space stations are visible from an IMT-2000 base station antenna, and both space stations produce the same and higher level of interference into this base station antenna), only one of these space stations needs to be retained for the following steps of the algorithm.

[7] The difference here can be a positive value (calculated *Isat*/*Nth* is below the criterion) or a negative value (calculated *Isat*/*Nth* is above the criterion) (dB).

Appendix 1
to Annex 1

Impact of interference on terrestrial IMT-2000 cell coverage under Methods 2a and 2b in § 3.1.2 with the use of example W-CDMA parameters

1 Overview

This Appendix describes the algorithm to derive *Isat*/*Nth* levels to protect terrestrial IMT-2000 systems from interference from BSS (sound) systems, based upon an *Isat*/*Nth* criterion. This Appendix addresses terrestrial IMT-2000 systems employing CDMA standards. If other standards are to be used, then further study may be necessary.

This approach is based on the following assumptions:

– interference is particularly problematic in coverage-limited environments;

– a particularly sensitive environment as in the case of a lightly loaded rural uplink;

– typical base station heights for rural environments would be 30 m;

– a suitable propagation model that can be used for rural environments;

– an acceptable loss of coverage or requirement for additional base stations expressed respectively as ΔA_{cell} and $BS_{increase}$.

These assumptions are used in the following algorithm:

1) for the traffic levels of a typically lightly loaded rural cell, the uplink load factor is calculated and hence noise rise (dB);

2) using the load factor, and assuming a suitable propagation model that can be used for rural environments, calculate the coverage loss that would result from a range of *Isat*/*Nth*; the resulting table is then used to convert a cell coverage loss ΔA_{cell} obtained with Method 2a or Method 2b, back into the adjusted *Isat*/*Nth*.

These steps are described in the following sections.

2 Uplink case

Stage 1: Calculation of CDMA uplink noise rise

This section defines the algorithm to calculate the uplink noise rise (between thermal noise to system noise) as the baseline for lightly loaded rural cells. The uplink (UL) noise increase can be calculated using:

$$Noise\ rise\ (n_i) = \frac{I_{total}}{P_N} = \frac{1}{1-\eta_{UL}} \qquad \text{dB} \qquad (6)$$

where:

I_{total}: total received wideband intercell and intracell interference power (dB(W/MHz))

I_{total}: noise power (dB(W/MHz))

η_{UL}: uplink load factor, calculated using:

$$\eta_{UL} = (E_b/N_0)\frac{RN}{W}\nu\,(1+i) \tag{7}$$

where:

E_b/N_0: energy per bit divided by noise spectral density required to achieve required quality of service

R: average bit rate (Mbit/s)

N: number of users per cell

W: CDMA chip rate (Mchip/s)

ν: activity factor (the average time ratio during which the transmitter is active)

i: other cell interference to own cell interference ratio.

Assuming an E_b/N_0, activity factor, and other cell interference to own cell interference ratios, the cell throughput = RN can be varied to calculated the uplink load factor and hence the noise rise.

The following parameter sets are assumed:

TABLE 1

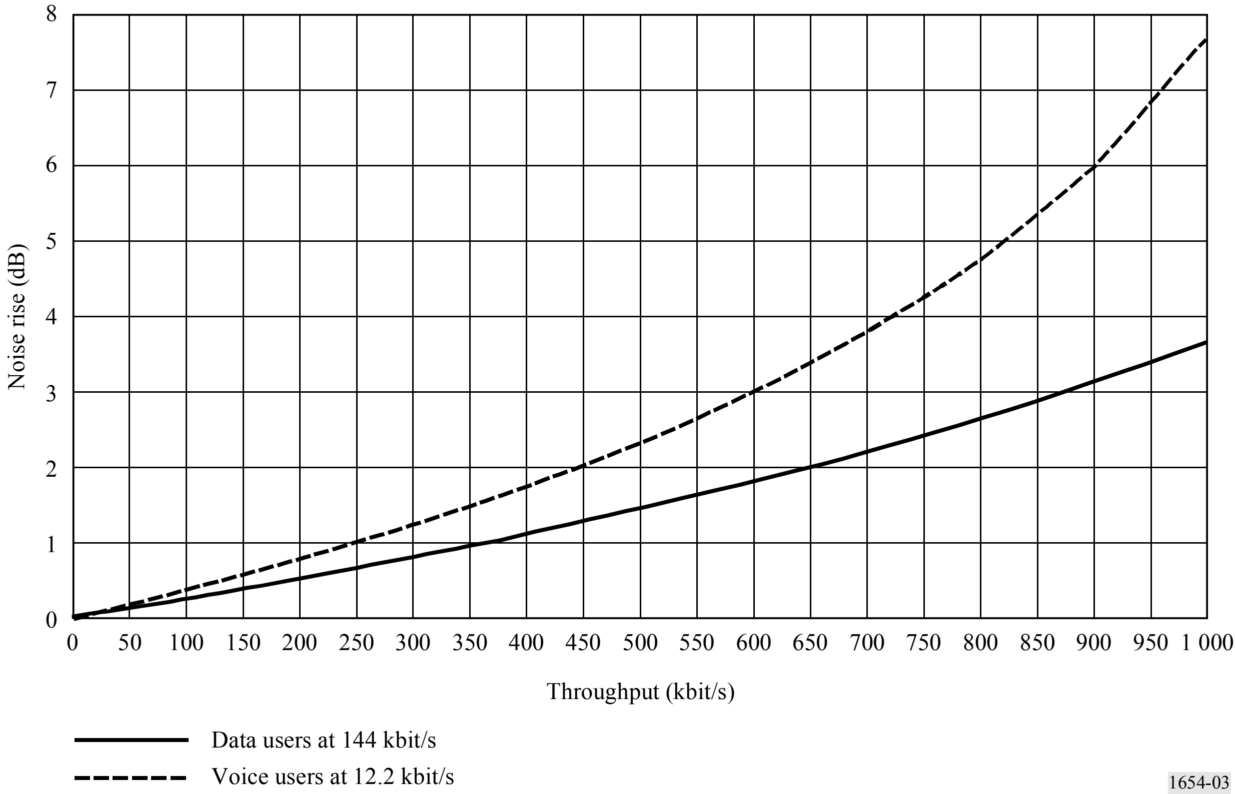
Terrestrial W-CDMA IMT-2000 uplink example parameters

Data set		
Traffic type	Voice	Data
Average bit rate R (Mbit/s)	0.0122	0.144
E_b/N_0 required (dB)	5.0	1.5
Activity factor, ν	0.67	1
Other cell to own cell interference ratio, i, for macro cell omni directional antenna (%)	55	55
CDMA chip rate, W (Mchip/s)	3.84	3.84

From these parameters, plots of noise rise against cell throughput were produced.

FIGURE 3

CDMA uplink noise rise as a function of data throughput



Noise rises of 0.5, 1.0 or 2.0 dB corresponds to the following number of users:

TABLE 2

Number of users to achieve noise rise

Noise rise, n_i (dB)	0.5	1.0	2.0
Voice users	10.7	20.5	36.5
144 kbit/s data users	1.3	2.5	4.5
Uplink load factor	0.1	0.2	0.4

For lightly loaded cells – for example in a rural area – there could be a handful of voice calls and a single data user. For these cells there would be a very low noise rise – for example in the range 0.5-1.0 dB. An alternative value that could be considered is 2 dB – however it should be noted that this would be a significant variation from the assumption of a lightly loaded rural cell.

Stage 2: Calculation of coverage loss

For coverage limited cells, such as would be the case for rural environments, the impact of interference is to decrease the range of a cell. This is a degradation in the propagation loss available in the link budget, Δ*L*, which can be calculated as:

$$\Delta L = 10 \log_{10} \left(1 + 10^{(Isat/Nth)/10}\right) \tag{8}$$

where the total noise *N* is dependent upon the thermal noise, N_{th}, and the noise generated by CDMA system (intracell and intercell) interference, N_{sys}, as follows:

$$N = N_{th} + N_{sys} \tag{9}$$

From the section above, the noise rise, n_i from thermal to total noise has been calculated, and hence the equation (8) becomes:

$$\Delta L = 10 \log_{10} \left(1 + 10^{((Isat/Nth) - n_i)/10}\right) \tag{10}$$

This loss in propagation margin, *L*, can be converted into a loss of range, *D*, using a suitable propagation model, such as the Hata model for open environments using base station height of 30 m, e.g.:

$$L = 106.2 + 35.2 \log_{10} D \tag{11}$$

Hence the change in range, Δ*D*, for a given degradation in the propagation loss is:

$$\Delta D = 10^{-\Delta L/35.2} \tag{12}$$

As the change in area, Δ*A*, is proportional to the square of the change in range, then:

$$\Delta A = \left(10^{-\Delta L/35,2}\right)^2 \tag{13}$$

Combining equations (8) and (13) we derive:

$$\Delta A\left(\frac{I_{sat}}{N_{th}}\right) = \left\{1 + 10^{((I_{sat}/N_{th}) - n_i)/10}\right\}^{-20/35.2} \tag{14}$$

Method 2a and Method 2b use equation (14) to evaluate the loss of coverage in each sector of an IMT-2000 base stations cell or site. For a tri-sectoral IMT-2000 base station site, the global loss of coverage of the cell/site is obtained by averaging the results obtained for each separate sector of the cell (see equations (4) and (5) in § 3.1.2 of Annex 1).

The increase in the number of required base stations is related to the area reduction due to interference. This is given by:

$$BS_{increase} = \frac{NumBS_{WithInterference}}{NumBS_{WithoutInterference}} \tag{15}$$

The number of base stations required can be estimated by:

$$NumBS_{WithoutInterference} = \frac{TotalArea}{AverageBSArea_{WithoutInterference}} \tag{16-1}$$

$$NumBS_{WithInterference} = \frac{TotalArea}{AverageBSArea_{WithInterference}} \tag{16-2}$$

If the coverage area of a BS reduces by factor Δ*A*, then the number of base stations will increase by the reciprocal of this factor.

For various *Isat*/*Nth* and n_i values we can derive the associated coverage area loss and hence requirement for additional base stations, as shown in Fig. 4 and Table 3. The Table is then used to convert back the global loss of coverage of an IMT-2000 cell/site to obtain the adjusted *Isat*/*Nth* values under Methods 2a and 2b.

FIGURE 4

Impact on coverage of base station *Isat*/*Nth* for noise rise = 0.5, 1 and 2 dB

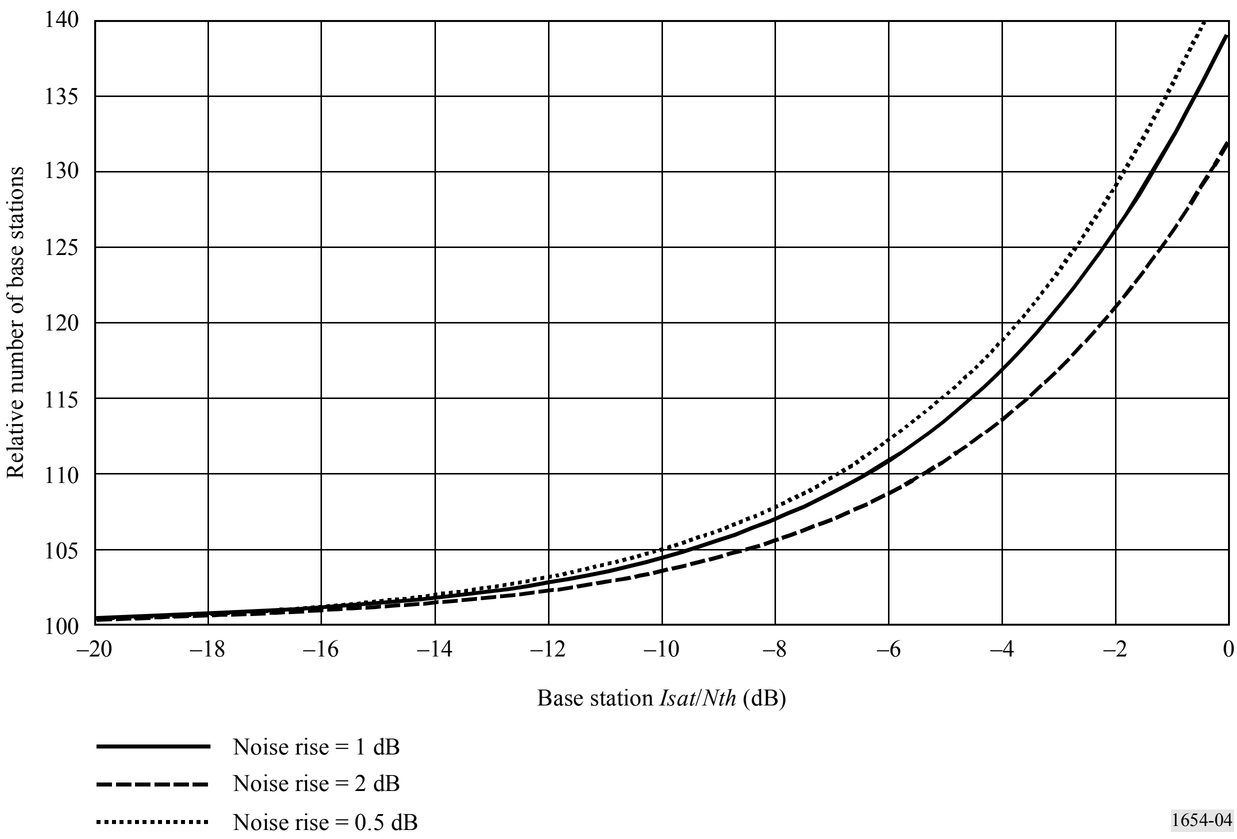


TABLE 3

Impact of *Isat*/*Nth* on coverage loss for base station

***Isat*/*Nth* (dB)**	**Noise rise = 0-5 dB**		**Noise rise = 1.0 dB**		**Noise rise = 2.0 dB**	
	BS required	**Coverage area loss (%)**	**BS required**	**Coverage area loss (%)**	**BS required**	**Coverage area loss (%)**
–100	100		100		100	
–20	100.5	0.5	100.5	0.5	100.4	0.4
–19	100.6	0.6	100.6	0.6	100.5	0.5
–18	100.8	0.8	100.7	0.7	100.6	0.6
–17	101.0	1.0	100.9	0.9	100.7	0.7
–16	101.3	1.3	101.1	1.1	100.9	0.9
–15	101.6	1.6	101.4	1.4	101.1	1.1
–14	102.0	2.0	101.8	1.8	101.4	1.4
–13	102.5	2.5	102.2	2.2	101.8	1.8
–12	103.2	3.2	102.8	2.8	102.2	2.2
–11	104.0	4.0	103.5	3.5	102.8	2.8
–10	105.0	5.0	104.4	4.4	103.5	3.5
–9	106.2	6.2	105.6	5.6	104.4	4.4
–8	107.8	7.8	107.0	7.0	105.6	5.6
–7	109.7	9.7	108.7	8.7	107.0	7.0
–6	112.2	12.2	110.9	10.9	108.7	8.7
–5	115.2	15.2	113.6	13.6	110.9	10.9
–4	118.8	18.8	116.9	16.9	113.6	13.6
–3	123.3	23.3	121.0	21.0	116.9	16.9
–2	128.9	28.9	126.0	26.0	121.0	21.0
–1	135.5	35.5	132.0	32.0	126.0	26.0
0	143.6	43.6	139.4	39.4	132.0	32.0