Anlage 1/Anhang A

CEPT-Rec. 14-03 E

HARMONISED RADIO FREQUENCY CHANNEL ARRANGEMENTS AND BLOCK ALLOCATIONS FOR LOW AND MEDIUM CAPACITY SYSTEMS IN THE BAND 3400 MHz TO 3600 MHz

CEPT/ERC/RECOMMENDATION 14-03 E (Turku 1996, Podebrady 1997)

HARMONISED RADIO FREQUENCY CHANNEL ARRANGEMENTS AND BLOCK ALLOCATIONS FOR LOW AND MEDIUM CAPACITY SYSTEMS IN THE BAND 3400 MHz TO 3600 MHz

Recommendation adopted by the Working Group "Spectrum Engineering" (WGSE)

"The European Conference of Postal and Telecommunications Administrations,

considering

1. that CEPT has a long term objective to harmonise the use of frequencies throughout Europe,
2. that CEPT should develop radio frequency channel arrangements and block allocation rules in order to make the most effective use of the spectrum for point to point (P-P), point to multipoint (P-MP) and ENG/OB applications,
3. that CEPT/ERC Recommendation 25-10 designates this band as a tuning range for ENG/OB,
4. that the band 3400 MHz to 3410 MHz is used by land, airborne and naval military radars,
5. that the achievement of harmonisation requires the adoption of a limited number of channel arrangements and block allocation rules,

noting

a) that the table of frequency allocations in the Radio Regulations allocates the band 3400 MHz to 3600 MHz on a primary basis to the Fixed and Fixed - Satellite services and on a secondary basis to the Radiolocation and Mobile services,

b) that countries desire to deploy different combinations of P-P, P-MP and ENG/OB systems on a primary basis in this band,

c) that there is an ITU-R Recommendation (F-635) for P-P wide band applications incorporating this band for some administrations,

d) that frequency separation may be required for uncoordinated deployment of current and future systems,

e) that cellular deployment of P-MP systems preferably requires the allocation of continuous spectrum to the operator, *recommends*

1) that frequency assignments should in all cases be based on 0.25 MHz slots within the 3410 MHz to 3600 MHz band,

the frequency of the lower edge of any slot shall be defined by the general equation:

$f_s = 3410 + 0.25\,N$ MHz

where

$0 \leq N \leq 759$

2) that administrations should assign all or part of the band to any system or combination of the three systems in accordance with Annex A and/or B."

ANNEX A

50 MHz ARRANGEMENTS

A1 Point to multipoint systems

P-MP systems may be operated in the ranges 3410-3500 MHz and 3500-3600 MHz.

Where a frequency duplex allocation is required, the spacing between the lower edges of the paired sub-bands shall be 50 MHz. The edges of each sub-band are defined as follows:

3410 MHz - 3500 MHz

Lower sub-band:	$0.25\ N + 3410$ to $0.25\ (N + k) + 3410$	MHz
Upper sub-band:	$0.25\ (N + 200) + 3410$ to $0.25\ (N + k + 200) + 3410$	MHz MHz
$1 \leq k \leq 160,\ 0 \leq N \leq 159,\ k + N \leq 160$		

3500 MHz - 3600 MHz

Lower sub-band	$0.25\ N + 3410$ to $0.25\ (N + k) + 3410$	MHz
Upper sub-band	$0.25\ (N + 200) + 3410$ to $0.25\ (N + k + 200) + 3410$	MHz
$1 \leq k \leq 200,\ 360 \leq N \leq 559,\ k + N - 360 \leq 200$		

In the tables above, k defines the width of each sub-band and N defines the lower edge of each sub-band.

P-MP equipment may be used having a duplex spacing other than exactly 50 MHz. However, such equipment must conform to the limits of the block allocation as defined above.

A2 Point to point systems with a duplex spacing of 50 MHz

Channel centre frequencies are defined at the edges of 0.25 MHz slots as follows:

A2.1 Systems with 1.75 MHz channel spacing

3410 MHz - 3500 MHz

Lower sub-band	$f_{c,n} = 3410 + 1.75\ n$ MHz	$n = 1, 2, \ldots, 22$
Upper sub-band	$f_{c,n} = 3410 + 1.75\ n$ MHz	

3500 MHz - 3600 MHz

Lower sub-band	$f_{c,n} = 3500 + 1.75\ n$ MHz	$n = 1, 2, \ldots, 28$
Upper sub-band	$f_{c,n} = 3550 + 1.75\ n$ MHz	

A2.2 Systems with 3.5 MHz channel spacing

3410 MHz - 3500 MHz

Lower sub-band	$f_{c,n} = 3408.25 + 3.5\ n$ MHz	$n = 1, 2, \ldots, 10$
Upper sub-band	$f_{c,n} = 3458.25 + 3.5\ n$ MHz	

3500 MHz - 3600 MHz

Lower sub-band	$f_{c,n} = 3498.25 + 3.5\ n$ MHz	$n = 1, 2, \ldots, 14$
Upper sub-band	$f_{c,n} = 3548.25 + 3.5\ n$ MHz	

A2.3 Systems with 7 MHz channel spacing

3410 MHz - 3500 MHz

Lower sub-band	$f_{c,n} = 3406.5 + 7\ n$ MHz	$n = 1, 2, \ldots, 5$
Upper sub-band	$f_{c,n} = 3456.5 + 7\ n$ MHz	

3500 MHz - 3600 MHz

Lower sub-band	$f_{c,n} = 3496.5 + 7\ n$ MHz	$n = 1, 2, \ldots, 7$
Upper sub-band	$f_{c,n} = 3546.5 + 7\ n$ MHz	

A2.4 Systems with 14 MHz channel spacing

3410 MHz - 3500 MHz

Lower sub-band	$f_{c,n} = 3403 + 14\ n$ MHz	$n = 1, 2$
Upper sub-band	$f_{c,n} = 3453 + 14\ n$ MHz	

3500 MHz - 3600 MHz

Lower sub-band	$f_{c,n} = 3493 + 14\ n$ MHz	$n = 1, 2$
Upper sub-band	$f_{c,n} = 3543 + 14\ n$ MHz	

A3 ENG/OB systems

ENG/OB systems shall be assigned contiguous 0.25 MHz slots, as appropriate for the channel spacings and amount of spectrum required. Exact channel centre frequencies will be allocated within the slots depending on the equipment used.

Where the band 3410-3600 MHz is shared between ENG/OB and P-P or P-MP services by an administration, ENG/OB services will operate within either the range 3410-3500 or 3500-3600 MHz, with P-P and P-MP services in the other part of the band, to minimise co-ordination problems between the services.

ANNEX B

100 MHz ARRANGEMENTS

B1 Point to multipoint systems

P-MP systems may be operated in the range 3410-3500 MHz paired with 3500-3600 MHz.

Where a frequency duplex allocation is required, the spacing between the lower edges of each paired sub-band shall be 100 MHz. The edges of each sub-band are defined as follows:

Lower sub-band	$0.25\,N + 3410$ to $0.25\,(N + k) + 3410$	MHz
Upper sub-band	$0.25\,(N + 400) + 3410$ to $0.25\,(N + k + 400) + 3410$	MHz MHz
$1 \leq k \leq 360,\ 0 \leq N \leq 359,\ k + N \leq 360$		

In the table above, k defines the width of each sub-band and N defines the lower edge of each sub-band.

P-MP equipment may be used having a duplex spacing other than exactly 100 MHz. However, such equipment must conform to the limits of the block allocation as defined above.

B2 Point to point systems with a duplex spacing of 100 MHz

Channel centre frequencies are defined at the edges of 0.25 MHz slots as follows:

B2.1 Systems with 1.75 MHz channel spacing

Lower sub-band	$f_{c,n} = 3410 + 1.75\,n$ MHz	$n = 1, 2, \ldots, 50$
Upper sub-band	$f_{c,n} = 3510 + 1.75\,n$ MHz	

B2.2 Systems with 3.5 MHz channel spacing

Lower sub-band	$f_{c,n} = 3408.25 + 3.5\,n$ MHz	$n = 1, 2, \ldots, 25$
Upper sub-band	$f_{c,n} = 3508.25 + 3.5\,n$ MHz	

B2.3 Systems with 7 MHz channel spacing

Lower sub-band	$f_{c,n} = 3406.5 + 7\,n$ MHz	$n = 1, 2, \ldots, 12$
Upper sub-band	$f_{c,n} = 3506.5 + 7\,n$ MHz	

B2.4 Systems with 14 MHz channel spacing

Lower sub-band	$f_{c,n} = 3403 + 14\,n$ MHz	$n = 1, 2, \ldots, 6$
Upper sub-band	$f_{c,n} = 3503 + 14\,n$ MHz	

B3 ENG/OB systems

ENG/OB systems shall be assigned contiguous blocks of 0.25 MHz slots, as appropriate for the channel spacings and amount of spectrum required. Exact channel centre frequencies will be assigned within the slots depending on the equipment used.

Anlage 1/Anhang B

Funkschnittstellenbeschreibung FSB-RR039
(Entwurf vom 19.4.2004)

Schnittstelle Nr: FSB-RR039 (Entwurf 19.04.2004)

Schnittstellen – Parameter	Beschreibung	Bemerkung
Frequenzband	3410 – 3494 MHz 3510 – 3594 MHz	Unterband Oberband
HF-Leistung	max. +35 dBm	
HF-Strahlungsleistung	max. +18 dBW e.i.r.p. 1) +35 dBW e.i.r.p. 2)	1) für zentrale Funkstellen 2) für Teilnehmerfunkstellen
Kanalabstand	min. 1,75 MHz max. 14 MHz	
Paarfrequenzabstand	100 MHz	Anwendbar nur für FDD - Duplexverfahren
Belegte Bandbreite	entsprechend dem Kanalabstand	
Zulässige Aussendung	nur digitale Modulationsverfahren	
Übertragungsgeschwindigkeit	min. 2 Mbit/s bei Kanalabstand 1,75 MHz	
Funkdienst laut VO-Funk	Fester Funkdienst	
(Harmonisierte) Norm welche den Stand der Technik beschreibt	EN 301 753	
Sonstige Schnittstellenmerkmale	CEPT/ERC/REC 14-03 Annex B ECC Report 33 (Cavtat, May 2003)	
Geräteklasse entsprechend RL 99/5/EG	nicht festgelegt	
Bewilligungsart	Individuelle Bewilligung	Für Punkt-zu-Multipunkt Richtfunksysteme (Richtfunkverteilsysteme)
Grundlegende Anforderungen entsprechend RL 99/5/EG, Art. 3.3.	nicht festgelegt	

Anlage 1/Anhang C

ECC-Report 33
THE ANALYSIS OF THE COEXISTENCE OF FWA CELLS IN THE 3.4 - 3.8 GHz BAND

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

THE ANALYSIS OF THE COEXISTENCE OF FWA CELLS IN THE 3.4 - 3.8 GHz BAND

Cavtat, May 2003

EXECUTIVE SUMMARY AND CONCLUSIONS

Summary

The scope of this ECC Report is to provide up-to-date guidelines for efficient, technology independent deployment of 3.5 GHz (or 3.7 GHz) FWA systems.

The Report recognises that the current technology for FWA in bands around 3.5 GHz is in continuous extensive evolution since first ECC Recommendations 14-03 and 12-08 were developed. A detailed study on the coexistence of various technologies was needed in order to provide guidance to Administrations that wish to adopt an efficient and technology neutral approach to the deployment rules in these bands.

It is also noted that ETSI ENs in these bands are not presently designed for a technology neutral deployment (this is done only in the 40 GHz MWS EN 301 997) therefore do not contain system controlling parameters, in terms of EIRP, useful for the desired "technology neutral" and "uncoordinated" deployment. Not having any ECC harmonised guidance for such deployment, the ENS are still bound to a cell-by-cell "co-ordinated deployment" concept actually not used in most of the licensing regimes. This report might generate future feedback actions in revising also ETSI ENs accordingly.

Aspects that relate to sharing issues with FSS, radiolocation (in adjacent band) and ENG/OB are not considered in this Report. However they should be taken into account when applying any method of deployment suggested in this document.

The applicability limits of the current Report are as follows:
- Application is mostly devoted to "block assignment" licensing methods, rather than "channel assignment" method.
- The guidelines presented have been maintained, as far as possible, independent from the access methods described in the ETSI ENs (e.g. EN 301 021, EN 301 124, EN 301 744, EN 301 080 and EN 301 253).
- MP-MP (MESH) architectures are not yet considered. In order to include MESH architectures, a number of assumptions on "typical" application (e.g. on the omni-directional/directional antenna use) need to be defined in order to devise the typical intra-operators, mixed MP-MP/PMP interference scenarios for which simulations would have to be carried.
- Channel sizes and modulation schemes are also not specifically considered unless for defining "typical" system parameters. It should be noted that high state modulations (e.g. 64/128 QAM) have not been specifically addressed in the typical system parameters; nevertheless they would not change the general framework of this report. This may be considered during future update.
- FDD/TDD, symmetric/asymmetric deployments are considered.
- Additionally, system independent, EIRP density limits and/or guard-bands at the edge of deployed region (pfd boundary conditions) as well as at the edge of assigned spectrum (block edge boundary conditions) are considered as licensing conditions for neighbouring operators' coexistence (similarly to the latest principles in ECC Recommendation 01-04 in the 40 GHz band).

Presently, the spectrum blocks assigned to an operator vary widely from country to country - from 10 MHz up to 28MHz (single or duplex) blocks have been typically assigned. The block allocation size and the frequency re-use plan employed by the operator to achieve a multi-cell and multi-sector deployment drives the channel bandwidth of the systems presently on the market to be typically no greater than 7MHz. Conversely, the requirement for higher data throughputs is driving the need for wider channel widths (e.g. up to ~28 MHz) and therefore correspondingly wider spectrum blocks assignment in the future.

Therefore, system channel bandwidths and block sizes are not fixed, even if typical data for current technologies are used for feasibility analysis of the "block-edge" constraints.

The report considers two different aspects of deployment scenarios for two operators:

1. Operating in the same or partly overlapping area with adjacent bands assignment
2. Operating in adjacent or nearby areas and re-using the same band assignment.

A number of different methods have been used to assess the severity of interference. These are:

- Worst Case (WC) (generally used for CS to CS interference) and for PFD limits at geographical boundary for frequency (block) reuse
- Interference Scenario Occurrence Probability (ISOP) (for CS to TS interference between adjacent blocks)
- Monte Carlo simulations for CDF (cumulative distribution function) vs. C/I (e.g. for TS to CS interference between adjacent blocks).

For the above methods it has been possible to estimate the probability of interference between FWA systems. From these results, estimates have been made of the frequency and/or geographical spacing needed between these systems in order to reduce the level of interference to an acceptably low level. Absolute recommendations cannot be made because some system parameters are not defined by the available standards and because the effects of buildings and terrain are very difficult to model. The report therefore gives guidelines that will lead to acceptably low levels or low probability of interference in most cases.

For the above methods that might be described as:

- The **Worst Case (WC)** method derives system deployment parameters to ensure that interference is always below a set threshold for all cases.
- The **Interference Scenario Occurrence Probability (ISOP)** is defined as the probability that an operator places at least one terminal in the IA. ISOP is related to the number of terminals deployed by the operator, and possibly to the cell planning methodology. The ISOP method evaluates the NFD or the out-of-block rejection required in order to meet an interference probability lower than a certain value.
- The **Cumulative Distribution Function (CDF),** derived from Monte Carlo simulation of large number of "trial" TSs with a certain equipment/antenna/propagation model, is defined as the probability that a certain percentage of those trials would result in a C/I of the victim CS exceeding a predefined target limit.

The Report derives the following alternative parameters, useful for defining an "uncoordinated technology independent" deployment:

- The **Interference protection factor (IPF) and associated guard-band** method used to define the amount of isolation required from the interfering station to victim receivers in adjacent frequency block in terms of Net Filter Discrimination (NFD), obtained also by frequency separation (guard bands) and EIRP limitation.
- The **Block Edge EIRP Density Mask** (BEM) method is used for directly limiting the EIRP density in the adjacent block, and for assessing the CS to CS worst case interference, the CS to TS interference through acceptable ISOP value and the TS to CS through acceptable probability of exceeding a limit C/I to the victim CS.

An important finding of this Report is that stringent protection requirement (e.g. in terms of BEM or NFD) is required only for CS emissions; the protection factor for TS is far less stringent and reduces as the antenna directivity is improved.

Another important conclusion is a significant impact of CS antenna height on co-ordination distance for the frequency block reuse; due to the low LoS attenuation with distance, sensible size of co-ordination distance and associated PFD value are obtained only considering spherical diffraction attenuation. If the CS antenna height is not limited (or a down-tilt angle is required) as a licensing parameter, it is nearly impossible to tell how far away the block may be reused.

The example presented, made with typical system values, led to examples of BEM coherent with a "technology neutral" deployment of different systems in adjacent blocks. Receiver filters are assumed to be stringent enough to maintain the potential NFD implicit in the BEM (i.e. have sufficient out-of-block selectivity for avoiding non linear distortion in the RX front-end chain).

In some specific annexes technical background and studies for related issues are also reported. They include urban obstructed propagation (near-NLoS) models and examples of practical application of RF filtering for easing the CS absolute EIRP BEM fulfilment when using equipment-generic relative spectrum masks defined by ETSI.

Conclusions

This Report has considered a number of facts as initial considerations for deriving the coexistence study:

1. Presently ECC Recommendations 14-03 and 12-08 for the bands 3.6 GHz and 3.8 GHz do not give harmonised and detailed suggestion to administration for implementing FWA (such as those produced for 26, 28 and 40 GHz). Those ECC Recommendations offer only channel arrangements.
2. The band is limited and wasted guard-bands might drastically reduce the number of licensed operators, limiting the potential competition for new services.
3. Legacy systems (P-P and already licensed FWA) are present in these bands. "Block assignment" methods of different sizes (for different applications) are generally used for licensing FWA.
4. Sharing issues with FSS, radiolocation (in adjacent band), ENG/OB exist and should be taken into account.
5. At least for CSs, ETSI ENs in these bands are not presently designed for a technology neutral deployment (this is done only in the 40 GHz MWS EN 301 997) therefore do not contain system controlling parameters, in terms of EIRP, which would be useful for the desired "technology neutral" and "uncoordinated" deployment
6. The suggested guard-bands/mitigation(s) would depend on system bandwidth/characteristics. Presently, in this band, it is not possible to identify a "typical" system bandwidth on which base the definition of a guard-band. Symmetric/asymmetric, narrow/wide/broad band services[1], TDD/FDD, P-MP/Mesh architectures are already available on the market, each one with its own benefits and drawbacks, fitting to specific segments of the whole FWA market. It should be noted that e-Europe initiatives call for faster Internet applications (i.e. requiring relatively wide-band FWA) to be available on the whole European territory.
7. Typical block size ~ 7 to 14 MHz (e.g. from a block of channels based on 3.5 MHz raster) or ~10 to 15 MHz (e.g. when a basic 0.5 MHz raster is used) is considered practical for new wide/broad band services demand. Nevertheless the conclusions should be valid for wider block sizes (e.g. up to ~ 28/30 MHz) depending on the band availability in each country.
8. Also for "conventional" symmetric FDD the central-gap between go and return sub-bands do not exist in ECC Recommendations 14-03 and 12-08; therefore situation with TX/RX happening on adjacent channels exist (unless specifically addressed by single administrations in licensing rules).
9. It is also shown that, for PMP TSs, the antenna RPE plays a fundamental role in the coexistence; the more directive is the antenna of TSs, the less demanding might be their NFD (or the EIRP density BEM) required (offering a flexible trade-off to the market).
10. MP-MP (MESH) architectures have not been considered in this Report. In particular it is recognised that, for MESH architectures, a number of assumptions (e.g. on the omni-directional/directional antenna use) need to be defined in order to devise the typical intra-operator, mixed MP-MP/PMP interference scenarios for which simulations would habe to be carried.

Based on the above observations this Report recommended Interference Protection Factor/ isolation values ensuring acceptable coexistence levels between systems.

It has been shown that the required IPF levels can be achieved, depending on situations, by a combination of basic equipment NFD and appropriate additional isolation factor (e.g. suitable guard bands and/or mitigation(s) techniques)

In the case of a block assignment and where a guard band approach is not retained, these IPF levels can be ensured with additional EIRP BEM. This is deemed convenient for "technology independent" deployment and eventually feasible from a cost-effective equipment point-of-view. Especially when considering that the additional EIRP constraint (with respect to ETSI EN) might burden only CS design.

In addition, basic rules has been set for the co-ordination distance and PFD boundary levels between operators re-using the same block in adjacent geographical areas. In this field, the importance of limiting CS antenna height (or down-tilt angle) as possible licensing parameter is highlighted in order to have sensible co-ordination distances (i.e. limited by spherical diffraction attenuation).

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1 Narrow band services are considered here as < 64 kbit/s, wide-band from 64 to 1.5 Mbit/s and broadband above 1.5 Mbit/s

INDEX TABLE

THE ANALYSIS OF THE COEXISTENCE OF FWA CELLS IN THE 3.4 - 3.8 GHz BAND

1 INTRODUCTION

1.1 Scope

The scope of this report is to investigate the co-existence of Point to Multi-point systems. These systems are developed in accordance with the ETSI EN 301 021, EN 301 080, EN 301 124, EN 301 253 and EN 301 744. In conjunction with the CEPT channel plan defined by the ERC Recommendations 14-03 (sections A1 and B1) and 12-08 (sections B2.1.1 and B2.2.1).

Systems, owned by different operators, should be able to be deployed without mutual interference when operating in:

a) adjacent frequency blocks in the same area or,
b) the same frequency block(s) in adjacent areas.

This report aims to assist the administrations in the assignment of frequency blocks to the operators who operate FWA systems in the available bands between 3.4 GHz to 3.8 GHz.

These bands were subject to the previous ERC Recommendation 14-03, on harmonised radio frequency arrangements for Multipoint systems. Nowadays more experience has been gained from recent studies for the 26 and 28 GHz bands, finalised by ERC Report 99 and Recommendations 00-05 and 01-03, and most of all for the 42 GHz MWS band, finalised by ERC Recommendation 01-04.

ERC Report 97 qualitatively summarised requirements for modern licensing process and has also been taken into account in developing this report.

This report incorporates and enriches the information in earlier reports and recommendations.

Following the approach in this report, the goal might be the decoupling as much as possibles, of the ETSI equipment standards from the ECC licensing rules. For this purpose, the introduction of:

- "additional" EIRP density limits and/or guard-bands for regulating the mutual acceptable interference between adjacent frequency blocks, licensed to operators in the same area,
- borderline rules between operators re-using the same block,

would generally fulfil the requirements.

In order to cater for the mix of technologies and services to be delivered it is most appropriate that a block (or blocks) of spectrum is made available to a potential operator in a manner consistent with the technology and market that the operator may wish to address.

Medium size frequency blocks are considered and will depend to an extent on the applications foreseen. Presently, blocks would be tailored to systems on the market typically of small/medium bandwidth (e.g. < ~10 MHz), however the possibility that wider bandwidth (e.g. up to ~28 MHz) might become possible in future should be taken into account.

A key principle of the assignment guidelines is that even though a technology specific channelisation scheme is expected to operate within an assigned block this channelisation is not the basis for the assignment process. Operators are free to subdivide the assigned frequency block in the most efficient way for deploying or re-deploying the selected technology.

Due to the flexibility required in newly deployed services, it is important that the block assignment process supports systems for both symmetric and asymmetric traffic as well as systems that employ FDD and TDD techniques.

In principle no assumption has been made regarding the architecture of any FWA network; however MP-MP (MESH) architectures have not been considered in detail in this Report. Other ECC work has reported and concluded on MESH systems in higher frequency millimetric bands. It is recognised that whilst some of the results in this report might also be applicable to mixed PMP and MESH architectures, others may clearly need additional work. In particular, regarding the impact of MESH TS antenna patterns (e.g. some MESH systems use omni-directional/directional antennas). These studies might be carried on in due time if needed and when manufacturers will be in a position to offer the necessary information.

Measures are suggested for dealing with the issue of inter-operator coexistence both between adjacent frequency blocks and between neighbouring geographic areas. The basis for these measures is to allow deployment with the minimum of co-ordination although more detailed co-ordination is encouraged as an inter-operator issue.

In order to cope with the often-conflicting requirements of a number of technologies in terms of efficient and appropriate block assignments, some compromise is suggested in order to develop reasonable assignment guidelines, which balance constraints as far as possible on any specific technology.

Reasons in favour of seeking flexible assignment methods, either by introducing block edge mask or assuming specific Interference Protection Factors (IPF), are related to the fact that equipment is likely to exceed ETSI TM4 masks (e.g. through RF filters that might be adopted in these relatively low frequency bands). This is also supported by the experience in the 26/28 GHz CEPT approach for guard-bands, which were based on the fact that spectral emissions of practical equipment might generally be better than ETSI ENs masks.

1.2 The frequency licensing policy and the possible approaches

When considering the adjacent frequency blocks, same area scenario, the possible process of frequency licensing should guarantee, as far as possible, a "controlled interference" deployment. Emissions from one operator's frequency block into a neighbour block will need to be controlled. This can be done by different methodologies.

A first one, already recommended in other frequency bands, imposes, between the assignments, fixed guard bands evaluated around the most likely equipment to be deployed.

Alternatively, as recommended in the 42 GHz MWS band, a frequency block edge EIRP density emission mask is used. The block edge mask limits the emissions into a neighbouring operator's frequency block and it enables operators to place the outermost radio channels with suitable guard-bands, inside their assigned block, in order to avoid co-ordination with the neighbour's frequency blocks.

For further enhancing the spectrum efficiency, administrations might wish, after the block assignment procedure has been done, not to enforce the guard band or the block-edge mask to neighbour operators who will apply mutual co-ordination at the blocks edge in view to optimise the guard bands. In that case, the enforcing rules will apply only in a "mutually agreed" way or it would be flexibly changed according the actual interference scenario shared by both operators with theirs planning tools.

1.2.1 The Worst Case deployment scenario (derived from ERC Report 99)

In principle, the most efficient way of evaluating the guard bands would be through a "case by case" evaluation. This would imply that the administrations should, in the application phase, analyse the actual behaviour, the planned coverage range, the hubs location, the cellular structure and the cell planning aspects of the system operated by the operators in any particular area.

The administrations should therefore analyse all the possible interference combinations that the MP ETSI standards (EN 301 021, EN 301 080, EN 301 124, EN 301 253 and EN 301 744) make possible (i.e. different access schemes, modulation schemes, duplex schemes and capacity from few to ~ a hundred Mbit/s). Beside, they need to consider that operators could have different deployment requirements. They could have different BER threshold and availability requirements (typically, from 99.9 to 99.999%, sometime including and sometime excluding hardware reliability into their availability evaluation) and they could deploy systems with different system gains (up to several dB). This strongly impacts the coverage range, the cell planning and the frequency reuse allowed by the systems operated by different operators and it dramatically increases the number of interference scenario combinations.

Hence, the "case by case" evaluation is not likely to be a viable, or at least the most preferred, solution, due to the following reasons:

- The number of possible different deployment scenarios is so huge that it is unrealistic to think that administrations could look after all of them
- Operators could change their system or deployment after a period of time without warning the administration and the previous guard band evaluation could become wrong.

For the above reasons, a more realistic approach is necessary, and hereby only the two examples described in next sections 1.2.2 and 1.2.3 are explored in this report.

1.2.2 The "predefined guard band deployment"

In the first approach, here called *"predefined guard band deployment"*, the administration would aime to provide, to both operators and end users, a reasonably interference free environment. By limiting the Interference Scenario Occurrence Probability (ISOP) or Interference Area (IA) to a low level and by stating the guard band required between the assigned spectrum blocks.

Worstcases (typically co-sited or nearby by hub to hub) might happen, in few cases, and should be solved on a case by case basis by the operators concerned.

An administration could set a probability criterion, for the ISOP or IA, which is deemed to be acceptable and derive the corresponding guard bands (by estimation based on required NFD with the methods explained in following sections). In this case, the guard bands are explicitly outside the spectrum block assigned to the operator and would remain unused.

In addition, for maintaining good spectrum efficiency, this method asks for a quite good knowledge of the typical FWA system technologies used. The guard-bands are likely to be determined by the wider band systems therefore the method is most suited in case the differences among deployed technologies (e.g. channel spacing, NFD and modulation formats) are expected to be small or in bands already deployed where fixed channel arrangements are recommended. This approach tends to prevent spectrum efficiency improvement with the technology evolution and thus is not recommended as a preferred method.

1.2.3 The "guided unplanned deployment"

The second approach, here called *"guided unplanned deployment"*, implies that additional EIRP density limits are set in order to allow an "average" interference free scenario to the operators. In this case, the guard band is to be included in the blocks assigned to the operators; the blocks are to be made consequentially larger. In this case the "interference free environment" is ensured by the EIRP density limits set by the administration, evaluated for "average worst-case" interference scenarios.

With this approach, the operator is permitted to use the assigned block as much as the equipment filtering and actual EIRP allow operation close to the block-edge, leaving to him and the manufacturers the possibility to improve the spectral efficiency as far as possible.

This method is most suited when very different technologies are used. The EIRP density mask is designed on the basis of acceptable noise floor increase due to interference from adjacent block; therefore only the knowledge of typical victim receiver noise figure and antenna gain are necessary. The method is therefore quite independent from ETSI standards, and is effective for bands that do not have fixed channel arrangements as a deployment constraint.

For a sensible and cost-effective regulation, a block edge mask is generally designed on the basis of a small degradation in an assumed scenario with a low occurrence probability of a worst case (e.g. two directional antennas pointing exactly each other at close distance).

As for the first method described in section 1.2.2 above, it is not therefore excluded that in a limited number of cases specific mitigation techniques might be necessary; operators would still be asked to solve, with conventional site engineering methods, the "worst cases" that may happen in few cases. In particular when CSs are co-located on the same building or very close to each other, the statistical approach is not applicable and it is assumed that common practice of site engineering (e.g. vertical decoupling) is implemented for improving antenna decoupling as much as possible.

Moreover, for further enhancing the efficiency, administrations are not expected, after the block assignment procedure, to enforce the block-edge requirements to neighbour operators who will apply mutual co-ordination at the block edge in view to optimise the guard bands. In that case, only the maximum "in-block" EIRP/power density applies while the "out-of-block" noise floor will apply only from a "mutually agreed" starting point within the adjacent block.

It is up to operators to possibly further co-ordinate with other operators using adjacent blocks.

Also adjacent block receiver rejection concurs to a reduced interference scenario, however this is not in the scope of this Report to set limits for it; nevertheless it is expected that ETSI standards will adequately cover the issue.

2 "SAME AREA - ADJACENT FREQUENCY BLOCKS" INTERFERENCE SCENARIO

2.1 Analysis of the coexistence of two FWA cells in the 3.4 - 3.6 (3.6 – 3.8) GHz band

2.1.1 Typical System Parameters

Considering the scenario of a wide sub-urban area with relatively high traffic demand and a small amount of obstructing buildings, a medium bandwidth system (7 MHz) is analysed in LoS conditions.

The examples shown refer to the ETSI EN 301 021, only for defining a typical receiver BER thresholds. However, the considerations made are not too sensitive to the multiple access method, provided that all have similar spectral and link-budget characteristics. These data are then "technology independent", nevertheless for defining typical cell coverage sizes also real modulation formats should be used; in Table 1 data for two systems types only are referred. Different modulation are obviously possible (e.g. 64 states) but, they would not, in principle, lead to different conclusions on the regulatory framework objective of this report.

	System Type (according typical ETSI definitions)	
	Type A (typical 4 state)	**Type B (typical 16 state)**
Channel bandwidth MHz	7[2]	7[2]
Actual signal bandwidth $BW_{TX}=BW_{RX}$ (MHz)	6	6
Transmitted Power at section D' (dBm)[3]	30	30
Receiver Noise Figure at section D (dB)	8[4]	8[4]
Receiver Threshold for BER= 10^{-6} (dBm)[5]	-84	-76
System Gain D' - D (dB)	114	106
Critical C/I for BER= 10^{-6} (dB)	~14	~22
Hub (CS) antenna - 90° sector bore-sight gain (dB)	16	16
CS antenna azimuth and elevation radiation patterns	ETSI EN 302 085	ETSI EN 302 085
Terminal (TS) antenna bore-sight gain (dBi) and RPE[6]	16 ETSI EN 302 085 ITU-R F.1336	16 ETSI EN 302 085 ITU-R F.1336
CS and TS EIRP density (dBW/MHz)	8	8

Table 1: Typical system data for typical cell size evaluation

The same system parameters will be initially used for both victim and interferer. The 3.5 GHz will be used as radio frequency throughout the calculations.

Due to the importance of Terminal Station (TS) antennas RPEs (and in particular of their main lobe) on the results shown in this Report, suggest that the use of ETSI RPE for TS antennas might give worst-case results that are not experienced in practice. ETSI RPEs are generally defined only for "type approval" purpose (i.e. 100% of RPE values shall be within the mask). Annex2 of ITU-R F.1336 gives typical "average" RPE that are more representative of the field situation; F.1336 recommends RPE for the bands below 3 GHz that here are considered appropriate also in the 3.5 and 3.7 GHz bands; Figure 1 show the difference between those RPE.

The antenna gain is the parameter used in the formulas of Annex 2 of ITU-R F.1336 for identifying different RPEs, therefore it has been used in Figure 1 to reference the different antenna RPEs; the gain range 16 to 20 dB is considered representative, from the ITU-R recommendation F.1336 point of view, of classes of antennas similar to ETSI TS 2 and TS 3. However the objective of this report would be mainly to consider the impact of different ETSI antenna RPEs for coexistence studies, not necessarily for studying the increase of cell size. Therefore, while the typical ITU-R F.1336 RPEs with gain 16 and 20 dBi will be generally used in all numerical evaluations, the Report will maintain a fixed gain of 16 dBi, reported in Table 1 as representative of the average value on the market.

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[2] This channel spacing is considered the most representative for being carried over in the calculation. It is considered that the larger channel systems would lead the coexistence rules. Nevertheless lover spacing channels (e.g. from 1.5 MHz up), also widely popular, should more easily fit in that possible framework

[3] CS and TS power are assumed equal for symmetric traffic. This value includes feeder losses for full indoor applications. The 35 dBm Maximum Power presently allowed in ETSI ENs (e.g. EN 301 021 and 301 080) is considered not realistic from the co-existence point of view.

[4] The Noise Figure estimated from EN 301 021 BER values and typical modulation formats would result in ~12 dB; however this seems too pessimistic and a value of 8 dB has been assumed, it should already give enough margin for the possible necessity of a selective RF channel filter of reduced size for TS

[5] This value includes feeder losses for full indoor applications.

[6] An antenna with relatively low gain is frequently used for transmitting and receiving signals at the out-stations or in sectors of central stations of P-MP radio-relay systems. These antennas may exhibit a gain of the order of 20 dBi or less. It has been found that using the reference radiation pattern given in Recommendation ITU-R F.699 for these relatively low-gain antennas will result in an overestimate of the gain for relatively large off-axis angles. As a consequence, the amount of interference caused to other systems and the amount of interference received from other systems at relatively large off-axis angles will likely be substantially overestimated if the pattern of Recommendation ITU-R F.699 is used. On the other hand ITU-R F.1336 gives low gain TS antenna patterns only for bands below 3 GHz, nevertheless it is considered more appropriate and will be used in this study."

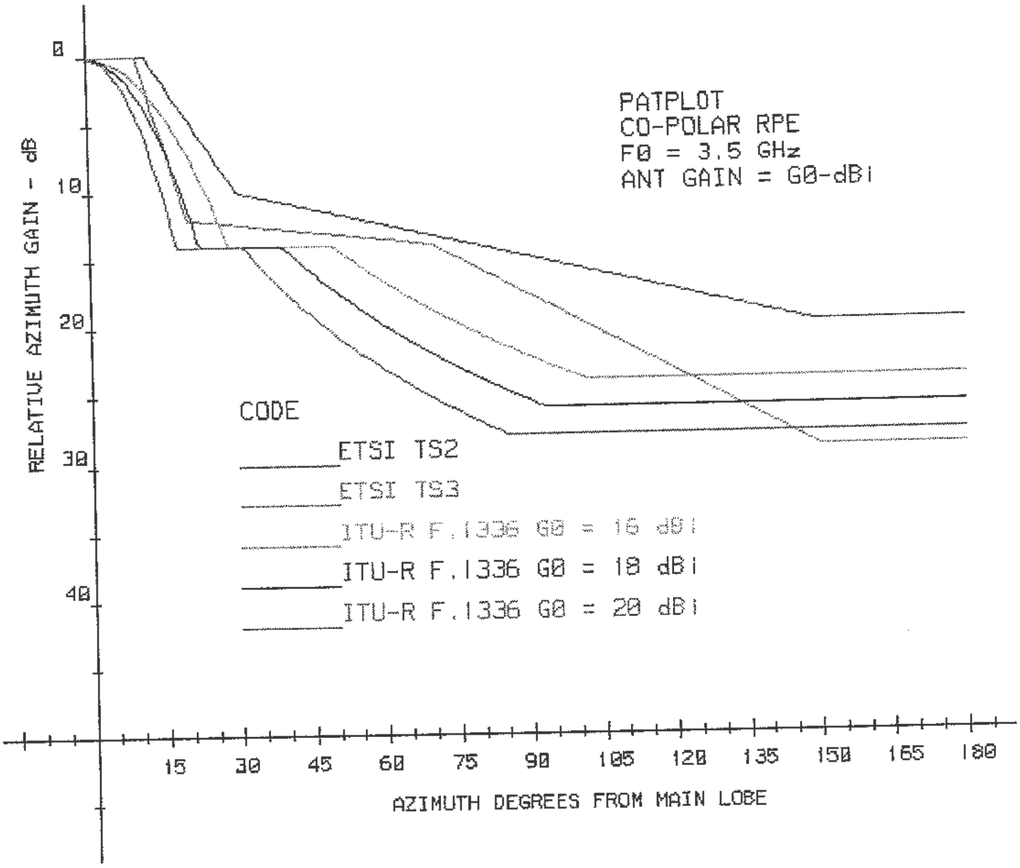

Figure 1: Antenna RPE Comparison

2.1.2 *Cell coverage.*

2.1.2.1 Rural scenario

The scenario examined is a LoS, relatively flat environment without significant obstructions, located in central Europe.

The main propagation modes are assumed to be free space and, possibly, spherical diffraction. The link availability will be affected by clear-air multipath.

The maximum cell radius R will be calculated from the link budget:

$$SG + G_{CS} + G_{TS} = FSPL + A_{sph} + FM \qquad (1)$$

where:

SG is the "system gain" (i.e. difference in dB of TX output power and RX threshold at given BER 10^{-6})

G_{CS} and G_{TS} are CS and TS antenna gains in dB. For this evaluation we will consider G_{TS}=16 dB as worst case (resulting in smaller cell size).

FSPL is the free space attenuation loss for f=3.5 GHz given by:

$$FSPL = 92.4 + 20\log(f\,D) = 103.28 + 20\log(D) \qquad (2)$$

A_{sph} is the spherical diffraction attenuation described in ITU-R Recommendation P.562 that depends on the height of CS and TS antennas, relative to the ground.

FM is the fade margin (excess attenuation) required to meet the yearly availability objective.

FM can be evaluated according to ITU-R P.530, which covers both the deep fade and shallow fade regions. For the purpose of the present analysis, it seems adequate to use the deep fade approximation or 10 dB, whichever is greater.

The 10 dB has been chosen as a safe value to ensure proper operation in "normal" clear air propagation.

From ITU-R P.530-8:

$$FM=-10 \log[P_{wm}/P_0], \qquad (3)$$

P_{wm} is the probability of exceeding the critical BER during the worst month. Scaling it to a yearly average, for the assumed geographical area and for 3.5 GHz radio frequency, with the conservative approach that the yearly unavailability ($un_{year}\%$) is spread over four "worst" months only, FM can be written as:

$$P_{wm}\% = 3 * un_{year}\% \qquad (4)$$

$$P_0\% = 5*10^{-7} * 10^{[-0.1*(Co-Clat-Clon)]} * pl^{(1.5)} * (1+\varepsilon)^{(-1.4)} * f^{(0.89)} * D^{3.6} \qquad (5)$$

Assuming C_0=3.5 (hilly terrain), C_{lon}=3 dB (Europe), C_{lat}=0 dB (medium latitude); pl=10%; ε=0;

$$P_0\% = 5*10^{-7} * 10^{[-0.1*(3.5-3)]} * 10^{(1.5)} * (1+0)^{(-1.4)} * 3.5^{(0.89)} * D^{(3.6)}$$

$$P_0\% = 4.2972*10^{-5} * D^{(3.6)}$$

$$P_0/P_{wm} = [4.2972*10^{-5} * D^{(3.6)}] / (3 * un_{year}\%)$$

Substituting (4) and (5) into (3) we obtain:

$$FM = -48.44+36*\log(D) - 10*\log(un_{year}\%) \qquad (6)$$

Spherical diffraction attenuation A_{sph} can be calculated by subtracting the free space attenuation from the output of the program GRWAVE (available from ITU). A sample output for two significant cases is shown in Figure 2. Neglecting the ripple at short distances, which comes from reflections in the plane earth model, A_{sph} is approximated as:

$$A_{sph} = 0 \qquad \text{(for } D < D_0) \qquad (7a)$$

$$A_{sph} = K_2 (D-D_0) \qquad \text{(for } D \geq D_0) \qquad (7b)$$

D_0 is taken as the point where the total attenuation equals the free space value (i.e. $A_{sph} = 0$ in Figure 2) where spherical diffraction attenuation starts to be significant. D_0 depends on the heights of hub and terminal antennas above ground (hc, ht). Values for a few significant cases are shown in the following Figure 2 that shows that $K_2 \cong 1.3$ dB/km is nearly invariant and that when different CS and TS antenna heights are considered, the mean height value could be used.

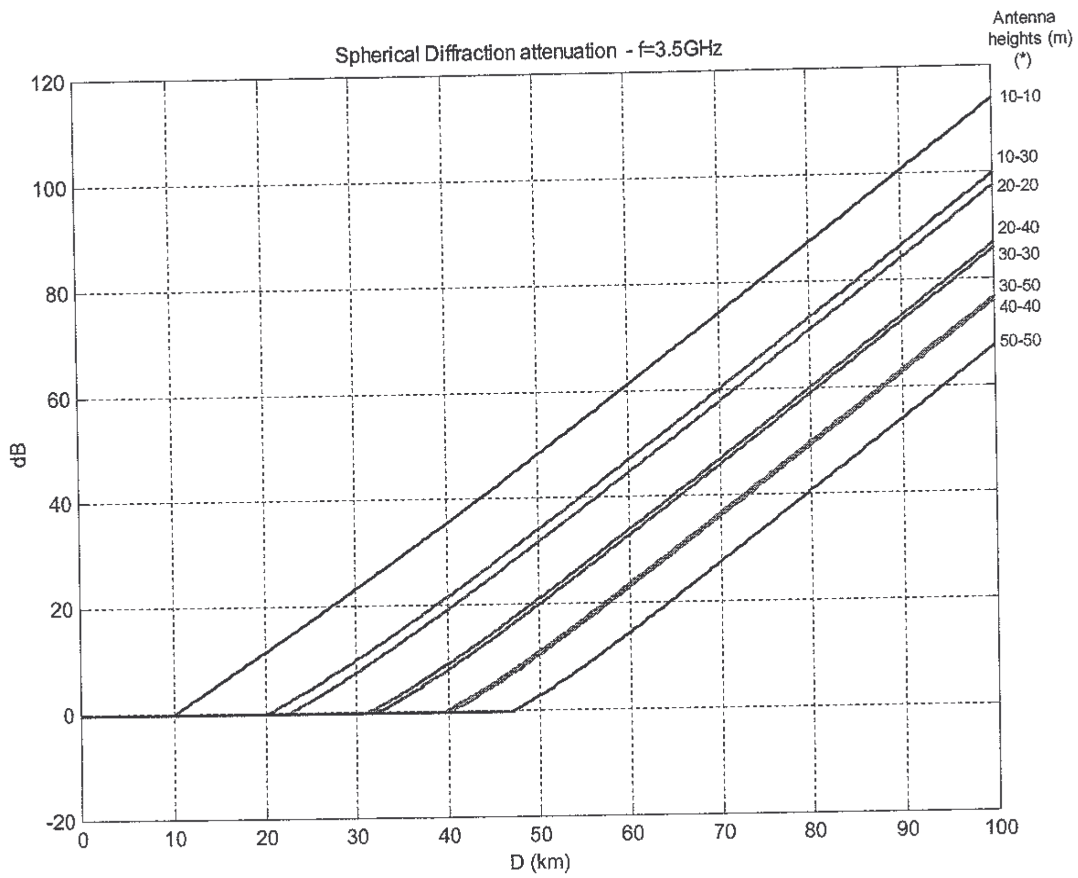

Figure 2: Additional attenuation due to spherical diffraction

Substituting (2), (6) and (7) into (1), the link budget at the cell edge (D=R) can be rewritten as:

$$SG + G_{CS} + G_{TS} = 54.84 - 10 \log(un_{year}\%) + 56 \log(R) + K_2 (R - D_0) \quad (8)$$

With the assumed equipment parameters, antenna heights, and yearly availability objectives 99.99 %, and 99.999%, the maximum cell radius values are shown in Table 2.

System type	Antenna heights	Availability							
		99.99%				99.999%			
		G_{TS}=16 dB		G_{TS}=20 dB		G_{TS}=16 dB		G_{TS}=20 dB	
		R [km]	FM [dB]	R [km]	FM [dB]	R [km]	FM [dB]	R [km]	FM [dB]
A	hc =40m ht = 20m	18.7	17.3	22	19.9	12.4	20.9	14.6	23.4
	hc =30m ht = 30m	18.7	17.3	22	19.9	12.4	20.9	14.6	23.4
	hc = 30m ht = 10m	18.7	17.3	(21.2)	(19.3)	12.4	20.9	14.6	23.4
	hc =20m ht = 20m	18.7	17.3	22	19.9	12.4	20.9	14.6	23.4
	(hc =10m ht =10m)	(14.7)	(13.6)	(16.2)	(15.1)	(11.4)	(19.6)	(12.9)	(21.5)
B	hc =40m ht = 20m	13.4	12.2	15.8	14.7	8.9	15.7	10.5	18.3
	hc =30m ht = 30m	13.4	12.2	15.8	14.7	8.9	15.7	10.5	18.3
	hc = 30m ht = 10m	13.4	12.2	15.8	14.7	8.9	15.7	10.5	18.3
	hc =20m ht = 20m	13.4	12.2	15.8	14.7	8.9	15.7	10.5	18.3
	(hc =10m ht =10m)	(12)	(10.4)	(13.5)	(12.2)	(8.7)	(15.4)	(10.5)	(18.3)
Note: Values in parenthesis denote the impact of spherical diffraction attenuation									

Table 2: Cell radius and FM vs. Availability (BER 10^{-6})

The conclusions of Table 2 show that, for most cases of practical antenna height, the cell radius is limited by the system gains considered and by the free space loss only. Hence spherical diffraction is not yet affecting the propagation; moreover, antenna heights are not affecting the area coverage. The cases with CS and TS antenna heights = 10 m (see Figure 2) are the only ones where spherical diffraction attenuation has some impact by reducing the cell size. The latter cases are shown only as explanatory example of the phenomenon, however, hc = 10m is not considered realistic and therefore will no longer be taken into account in further evaluations.

2.1.2.2 Urban scenario

For urban propagation models there are not consolidated ITU models. A number of empirical and physical models are used to characterise this behaviour at UHF frequencies, but unfortunately little is known about their application to the 3.5 GHz band. The associated path attenuation, in dB, shows a Gaussian probability distribution function (p.d.f.), with mean value (here called A_{50}) and standard deviation "σ".

Two of them, with quite different physical characteristics, are here used. They are the Hata-Okumura, here extrapolated up to~4 GHz and the one recently adopted by IEEE 802.16 for similar coexistence studies (see Annex 1).

In the Hata-Okumura the propagation mode is assumed to be free space with random attenuation due to diffraction over rooftops and multiple reflections from medium/high rise buildings (typical for Japanese cities). It gives the received field as a "locally random" variable with log-normal p.d.f. around a median value.

In IEEE 802.16 an "excess attenuation" for all TSs is introduced (mostly due to wooden/hilly areas among low rise buildings, typical for most US cities outside their relatively small downtown) increasing with distance from CS.

The following basic principles describe the IEEE model:

- The path loss (PL) can be seen as the summation of basic free space loss (FSL) and the excess loss (Lex) due to the local blockage conditions or reduction of antenna gains: PL(dB) = FSL (dB) + Lex (dB)
- The path loss can be modelled as follows: PL(dB) = A0(dB) + 10 n log(d/d0) + S(dB) , where the exponent n represents the decay of path loss and depends on the operating frequency, antenna heights and propagation environments. The reference path loss A0 at a distance d0 from the transmitter is typically found through field measurements. The shadowing loss S denotes a zero mean Gaussian random variable (in decibels) with a standard deviation (also in decibels).

The detailed evaluation of cell size and availability is reported for both models in Annex 1; Table 3 and following consideration summarise the results.

2.1.2.1.1 Hata-Okumura extended model

The results in Table 3 have been obtained for a 95% coverage using section A1.1.3 of Annex 1 (Hata-Okumura) detailed evaluation of the cell size is also made.

System Gain (dB)	**R_{max} (km) (CS height hc = 30m)**	
	γ = 16 (TS ht_{avg} = 20m)	**γ = 12 (TS ht_{avg} = 15m)**
114 (System type A)	4.35 km	3.3 km
106 (System type B)	2.7 km	2 km

Table 3 : Cell radius for 95% TSs coverage at 99.999% availability vs. system gain and TS antenna mean height ("medium cities" - Hata-Okumura extended model)

2.1.2.1.2 IEEE 802.16 model

Regarding the IEEE model, it is based on different parameters and for extracting similar coverage % figures more complex approach is necessary. Section A1.2 of Annex 1 describes the method and report examples of link availability. In addition, Appendix A to Annex 1, using Monte Carlo method, derives expected % of area coverage with the required 99.999% availability.

From those examples it might be concluded that terrain category C of IEEE models gives comparable values.

2.1.3 Interference protection factor (IPF)

The potential coexistence of different cells in adjacent frequency blocks is guaranteed when there is sufficient isolation between interfering transmitters of one cell and victim receivers of the other cell.

This required isolation, generally referred as Interference protection factor (IPF), might be obtained as aggregation (sum) of various contributions summarised as follows:

- Intrinsic Net Filter Discrimination (NFD) obtained mixing TX interferer spectrum and victim receiver selectivity of the equipment considered at their minimum foreseen frequency separation.
- NFD improvement with increasing frequency offset between interferer and victim (Guard Band between assignments)
- Antenna discriminations (both TX and RX) deriving from RPE at offset angles.
- Polarisation discrimination
- Minimum distance between interferer and victim
- Shading attenuation due to buildings or vegetation on the interfering path (on statistical bases offered in urban obstructed path propagation models).

The first two factors related to the NFD are generally "system dependent" and their evaluation requires knowledge of both interferer and victim equipment characteristics. Unfortunately the present ETSI ENs have not been designed for a "technology independent" licensing environment and do not offer mixed NFD values among the wide range of standardised technology.

As a consequence a "technology neutral" approach is hereby used in the form of the above IPF, out of which a specific example is the EIRP density Block-edge mask (BEM) concept, described in Section 2.1.4.

The BEM concept, strictly related to the NFD concept, actually summarised all the equipment/antenna related IPF contributions and might be best fit in environment where equipment characteristics are not known beforehand.

This does not imply that the BEM is always the best method, when system characteristics are known and fixed co-ordination rules might be uniquely set a more detailed approach might be more appropriate.

Also polarisation decoupling is a factor that might not be prejudged (unless different polarisations are imposed in licensing two adjacent blocks operators, limiting their free usage of the block) and in the following evaluation is not taken into account.

The relationship between NFD and BEM is equipment/antenna dependent only and is described as:

$$P_{out\text{-}density}\ (dBW/MHz) + G_{TX} - NFD = X_3\ (dBW/MHz) \qquad (9)$$

where X_3 represents the BEM out-of block requirement (see paragraph 2.1.4.1).

For convenience, in the following sections, where specific numerical examples are made on the base of representative system characteristics defined in Table 1 the parameter X_3 only is used with the understanding that NFD is easily derived from equation 9.

2.1.3.1 Channel arrangements

Prior to evaluating IPF (or BEM) requirements, possible channel arrangement should be analysed, as offered by CEPT/ERC Recommendations 14-03 (3.4-3.6 GHz) and 12-08 (3.6-3.8 GHz).

Both recommend assignments based on "number of slots" 0.25 MHz wide; apparently only symmetric assignments are foreseen and no specific mention is made of internal (go-return) guard band except for the fact that in 3.41-3.6 GHz the "odd" 10 MHz automatically create a ~ 10 MHz guard band. However such guard band disappears for the 3.5-3.6 MHz (50 MHz duplex) and for all 3.6 - 3.8 GHz.

That means that unless specific number of slots are reserved in both go and return sub-bands (wasting at least half of them), adjacent TX/RX interference is expected also for FDD systems.

Moreover, the recommendations mention that:
"where a duplex frequency allocation is required, the spacing between the lower edges of each paired sub-band shall be 100 MHz"

and also:
"P-MP equipment may be used having a duplex spacing other than exactly 50(100) MHz. However, such equipment must conform to the limits of the block allocation as defined above."

These sentences and the fact that no recommendation on sub-band for CS and TS operation is made, clearly show the intention to admit (on a non discriminatory way) TDD and FDD, symmetric and asymmetric systems.

It has been recently demonstrated by CEPT studies for 40 GHz band the best compromise method for allowing flexibility and efficient use of the spectrum with the recommended symmetrical assignment, the deployment of asymmetrical systems being made with mixed uplink/downlink sub-bands within the symmetrical assignment.

The above considerations and the small duplex spacing, lead to the conclusion that, unless the band should be assigned for predefined technology (e.g. FDD only) and spectrum waste is envisaged for creating go-return guard band, a mixed TX/RX in nearly adjacent assignments should be in any case considered.

2.1.3.2 CS-to-CS interference

A "same area, adjacent frequency blocks" scenario will be assumed (Figure 3). CS-to-CS interference is particularly dangerous, since it can cause unavailability of a whole sector[7]. Therefore a worst case analysis will be presented for it. Both CSs are supposed to face each other in line of sight (worst case situation). The fading events (mainly due to clear air multipath) are considered as completely uncorrelated. Rain attenuation is negligible at this frequency band.

It is further assumed that the allowed degradation of the victim receiver threshold due to interference is

$\Delta_{Threshold}$ = 1 dB, hence the allowed interference spectral density is:

$$I_S = N_0 - 6 = -144 + NF - 6 \text{ (dBW/MHz)}.$$

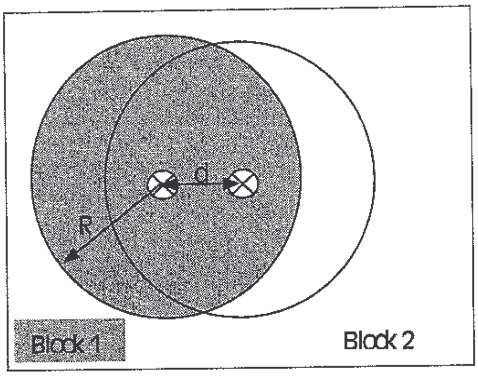

Figure 3: CS-to-CS interference scenario

As in the 40 GHz case, it may be assumed that the victim receiver has selectivity that matches the IPF or the block edge mask. Hence the main carriers of the adjacent block EIRP are always reduced below the interfering out-of-block noise floor so that their residual contribution is negligible. The allowed interfering IPF (or EIRP) is calculated for free-space propagation only, since:

- The distance between CSs is in practice short enough to exclude spherical diffraction.
- Both antennas are in relatively high locations (30m in the example) even in the urban environment. In this case the mean path loss predicted by the modified Okumura or IEEE models (see Annex 1) is near or lower than the free-space attenuation.

$$X_3 - 92.4 - 20\log(RF) - 20\log(d) + G_{RX} = -144 + NF - 6$$

where: $X_3 = P_{out\text{-}density} + G_{TX} - NFD$ represent the CS BEM out-of block requirement dBW/MHz (see paragraph 2.1.4.1), RF is the frequency in GHz, "d" the CS distance in km,

with the assumed system reference values shown in Table 1, a plot of the required X_3 value vs. "d" is shown in Figure 4, giving obviously the same result for both A and B systems, having the same CS antenna gains (16 dBi).

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[7] In principle, it happens for the part of the time when the two CS are in opposite Tx /Rx modes. This will be 100% of the time in the case of two FDD systems, at least for the innermost assigned blocks where the mitigation of predefined up-link/down-link duplex blocks becomes ineffective. When at least one system operates in TDD mode it will be less than 100%. The actual interference intervals will vary because the two CS T/R periods will not be synchronised. In any case the contribution to availability of unsynchronised T/R period tends to be negligible when the multipath activity is large and propagation events last far longer than T/R periods. Therefore this aspect of T/R period impact will not be taken into account.

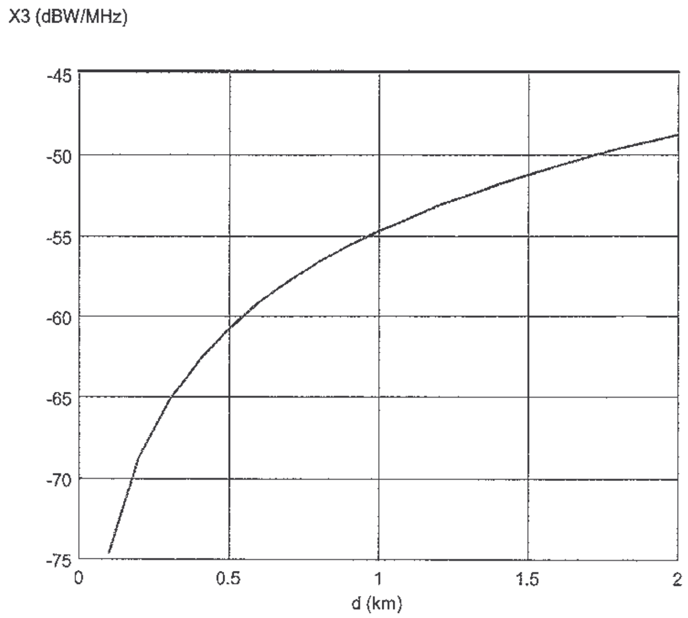

Figure 4: Required CS-to-CS spacing for un co-ordinated deployment

Just as an example if one would adopt an out-of-block emission limit compatible with the spurious emission level stated by CEPT Rec 74-01 (Spurious Emissions), i.e. -50 dBm/MHz at the antenna connector, one would get for X_3

X_3 = - 50 - 30 + G_{antCS} = - 50 - 30 +16 = - 64 dBW/MHz

This would allow a minimum uncoordinated distance of about 350m, which seems quite reasonable in a rural environment, given the typical cell radius values shown in Table 2.

On the other hand a value of:
$X_3 = -73$ dBW/MHz evaluated in next 2.1.3.3 paragraph as the value required for having ISOP $\leq$ 1% for system types B also in urban scenario, would lead to a minimum uncoordinated distance of ~ 100m.

It should be noted that for urban scenarios, the above LoS evaluation is an absolute worst-case. The additional shading attenuation probability is not a negligible factor and using some propagation models helps prove this (e.g. the IEEE 802.16 adopted one depicted in Annex 1.2 and in IEEE document available at http://grouper.ieee.org/groups/802/16/...).

2.1.3.3 CS-to-TS interference

The ISOP approach will be used, due to the random nature of this kind of interference. Also in this case complete uncorrelation will be assumed between fading events affecting the "wanted" and the interference path.

There will be an area in the victim sector where the receiver threshold degradation will exceed the assumed 1 dB limit. Its size and shape depends on the distance between CS's and the additional protection from the terminal antenna RPE. Referring to
Figure 5, we will label V the victim TS, W the "wanted" CS and I the interfering CS.

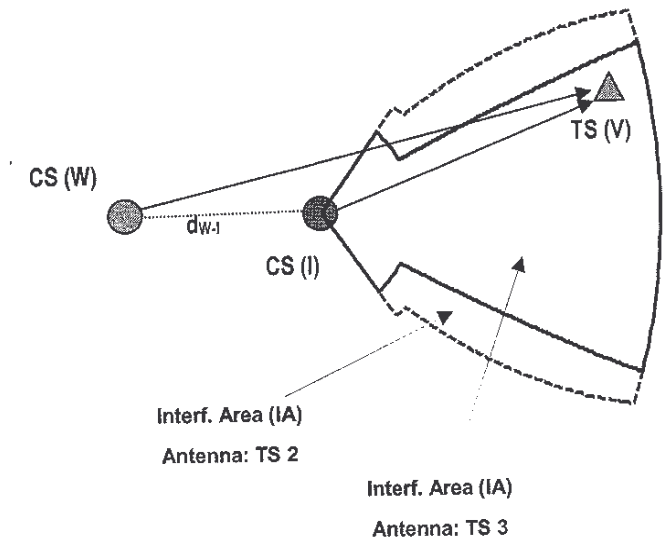

Figure 5: CS to TS interfering scenario

The area where the threshold degradation exceeds the 1 dB objective will be defined by:

$$X_3 - FSPL_{(I-V)} + G_{antTS(V)} - A_{\Phi TS(I-W)} \geq -144 + NF - 6$$

This formula is commonly used for rural scenario considering the un-correlation of deep fading events in the different paths. The same formula is still appropriate also in urban scenario. The Okumura model confirmed that the **"minimum"** attenuation (which is the one that gives the maximum interference we are looking for), at this relatively short distance, is likely to be still dominated by the free space value.

$A_{\Phi TS(I-W)}$ is the additional attenuation given by the TS victim antenna RPE at an angle equal to the difference in azimuth between the victim-to-wanted-CS and the victim-to-interferer-CS path (assuming that the victim antenna is aligned at boresight with the wanted CS).

Using the TS 2 and TS 3 antenna classes (represented by typical ITU-R F.1336 antenna RPE derived with G=16 and 20 dB, still maintaining fixed boresight gain of 16 dB), the "forbidden" interference area IA can be derived and are represented in Figure 6.

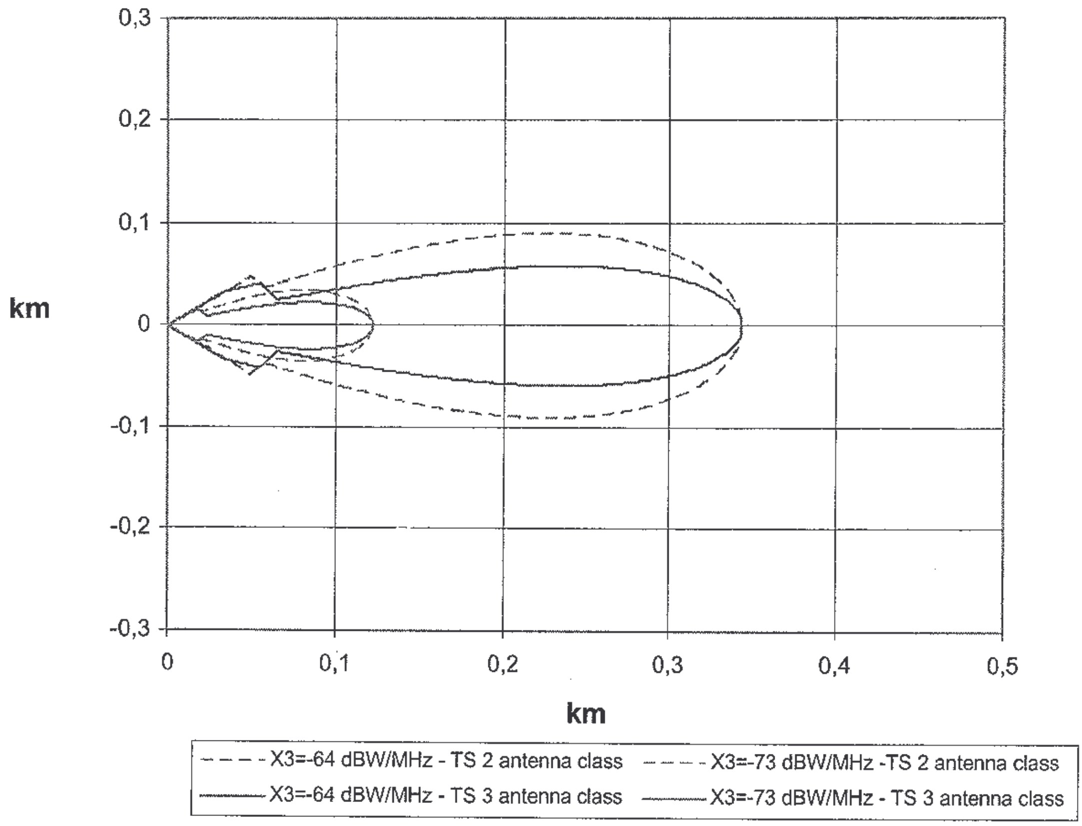

Figure 6: Interference Areas (IA) for victim TS as function of out-of-block EIRP density X3 and ITU-R TS antenna RPE

Figure 6 is representative of the worst case AI experienced when the two W and I CSs are boresight aligned and at their minimum distance (derived in section 2.1.3.2 CS to CS scenario).

ISOP is calculated following the approach in ECC Report 99, as ISOP = $(1-(1-P_1)^{N_t})*P_2*P_3$
where:

- P1 is the probability that one TS falls within the interference area where the margin degradation exceed a predefined value (here assumed 1 dB) evaluated as $P_1 = IA/A_{sector}$.
- N_t is the total number of terminals deployed in a sector.
- P_2 is the probability that the attenuation from wanted TX to victim RX and from interfering TX to victim RX are uncorrelated. In a propagation environment dominated by multipath we assume P_2=1. This is valid for "rural" scenario where the cell size is limited only by LoS propagation following Rayleigh statistics and described in ITU-R Recommendation P.530. For urban near-NLoS scenario this is not generally true; however, due to its shortness, one of the two paths (the interference one) is still here considered LoS for actually affecting the victim TS region. In addition the assumption P_2 = 1 is conservative.
- P_3 is the probability that operators use adjacent frequency blocks and equal coverage on the same area. It depends on the number of available blocks, the number of operators, the relative area coverage and the number of sectors per cell. Assuming 2 or 3 blocks (one per operator) and 4 sectors per cell, P3=1/6 for 2 operators, P3=~1/2 for 3 operators.

Assuming N_t = 64 or N_t = 32 (considered representative of relatively wide-band systems adopted in this frequency bands). An average P_3 = 1/4, a few values of ISOP have been calculated as examples in Table 4a) and Table 4b) with G_{CS}=16dBi, G_{TS} = 16 dBi and TS2 and TS3 antenna typical RPE (using typical ITU-R F.1336 RPE derived with gain of 16 and 20 dBi, respectively).

Scenario	X_3 (dBW/MHz)	TS Antenna	d_{U-I} min (m)	A_{Sector} (km^2)	IA (km^2)	P1	ISOP % N_T=64	ISOP % N_T=32
Rural	-64	TS2	350	274.65	0.0445	0.0162	0.258	0.129
Rural	-64	TS3	350	274.65	0.02924	0.01065	0.1698	0.085
Rural	-73	TS2	100	274.65	0.006	0.0022	0.0352	0.0176
Rural	-73	TS3	100	274.65	0.00397	0.00145	0.0231	0.0156
Urban	-64	TS2	350	14.52	0.0445	0.306	4.455	2.337
Urban	-64	TS3	350	14.52	0.02924	0.2013	3.0254	1.5615
Urban	-73	TS2	100	14.52	0.00605	0.0417	0.658	0.331
Urban	-73	TS3	100	14.52	0.00397	0.0273	0.4337	0.2178

Table 4a): ISOP % as function of out-of block EIRP density in some rural and urban scenarios –System type A (4 states)–

Scenario	X_3 (dBW/MHz)	TS Antenna	d_{U-I} min [m]	A_{Sector} (km^2)	IA (km^2)	P1	ISOP % N_T=64	ISOP % N_T=32
Rural	-64	TS2	350	141.03	0.0445	0.0315	0.499	0.251
Rural	-64	TS3	350	141.03	0.02924	0.02073	0.3296	0.1653
Rural	-73	TS2	100	141.03	0.00605	0.00429	0.0686	0.0343
Rural	-73	TS3	100	141.03	0.00397	0.00282	0.045	0.0225
Urban	-64	TS2	350	5.73	0.0445	0.7765	9.82	5.52
Urban	-64	TS3	350	5.73	0.02924	0.5107	6.985	3.778
Urban	-73	TS2	100	5.73	0.00605	0.1057	1.636	0.832
Urban	-73	TS3	100	5.73	0.00397	0.06935	1.0857	0.5489

Table 4b): ISOP % as function of out-of block EIRP density in some rural and urban scenarios –System type B (16 states)–

The above data are obtained for the worst case of W and I CS placement (boresight aligned and in closest position); however the ISOP drops rapidly as the distance increases. Figure 7 shows two examples taken from those in Table 4.

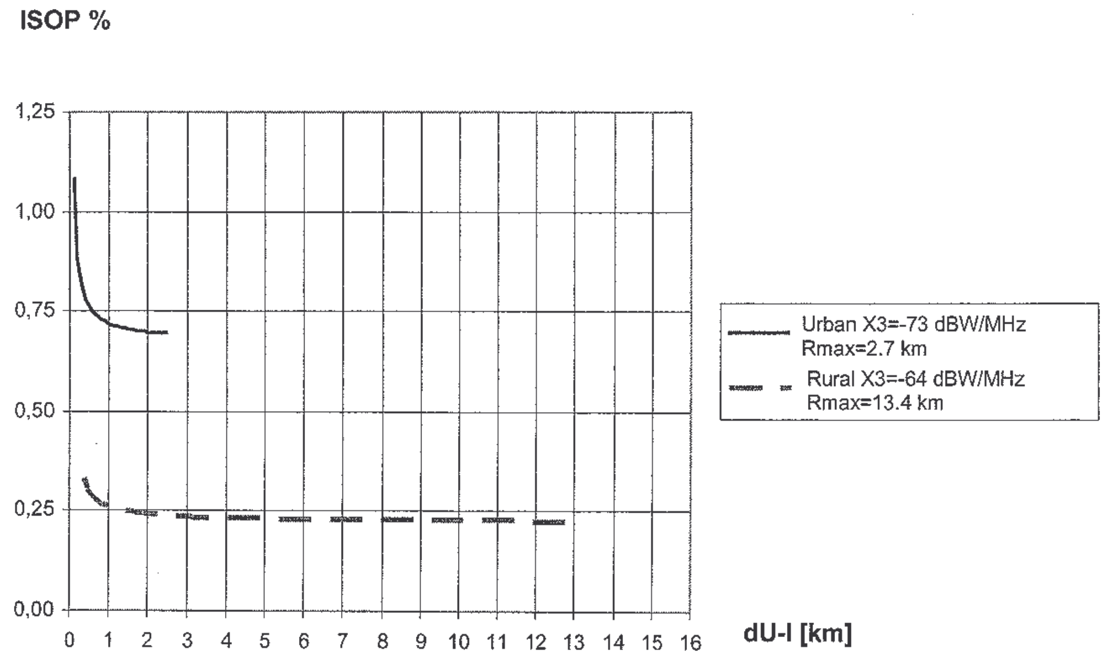

Figure 7: ISOP as function of W and I CS distance

From the above it appears that:

- The use of Class 3 TS antenna reduce the ISOP by ~25% to 35% in comparison to Class 2 one.
- In rural scenario an ISOP < 1% is obtained with the less demanding NFD (or X_3) limit. Therefore the more critical parameter might still be the CS to CS interference.
- In urban scenarios ISOP close to 1% are obtained only with the more demanding NFD (or X_3) limit. However it should be noted that, as mentioned above, this ISOP evaluation has been conservatively done with P_2=1 and worst case W and I CS positioning. In addition it does not take into consideration any excess attenuation (derived from statistical models in Annex 1) eventually experienced in the interference path. These factors would concur in reducing the actual urban ISOP results in Table 4a) and Table 4b).

2.1.3.4 TS to CS interference

This evaluation would lead to setting the required NFD (or the X_3 value of the block-edge mask) for TS.

However, the evaluation might be based only on a statistical IPF, common to the evaluation made in the section devoted to the IPF and guard-band methodology (see Annex 2) and its details are there reported.

From the detailed evaluation made in Annex 2, the required NFD or "out-of-block" EIRP density for suitably low (<1%) probability of TS interfering a victim CS, may be summarised, for the worst cases presented, in Table 5 depending on the assumed TS antenna ITU-R RPE:

TS antennas class	Required "inter-block" TS NFD (referenced to wanted EIRP density + 8 dBW/MHz in the more severe urban scenario)	Required TS "X_3" value (out-of-block EIRP density)
TS 2	~45 dB	– 37 dBW/MHz
TS 3	~43 dB	– 35 dBW/MHz

Table 5: NFD or out-of-block EIRP density requirement for ~ 1% of TS to CS interference probability in urban scenarios

2.1.4 *Block-edge Mask coexistence methodology*

When it is considered appropriate a complete "technology independent/uncoordinated use of the bands, the following BEM methodology is easily derived from the above general evaluation.

2.1.4.1 *Initial considerations*

The proposed block-edge mask shape is shown in Figure 8 (e.g. with similarity to the agreed mask for the 40 GHz band).

With respect to 40 GHz case, there is no decaying portion of EIRP density near the edge. This is due to the far narrower blocks envisaged that, for efficient use in these lower bands, might require tight roll-off and filtering for going as close as possible to the edge (see an example in Annex 3).

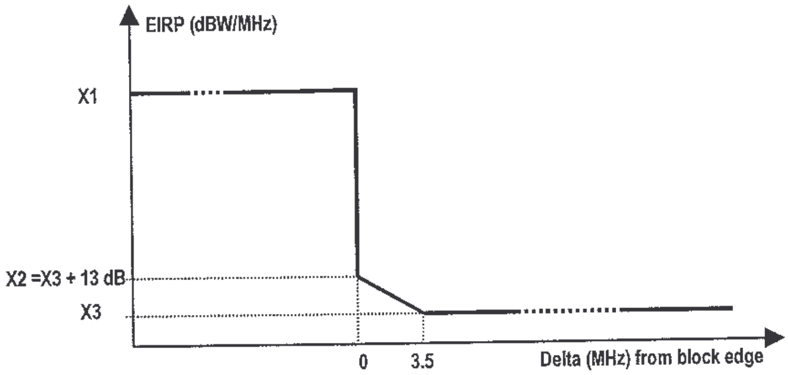

Figure 8: Block-edge mask reference values

It may be possible to tentatively set the reference points, as in Figure 8, considering that systems in the 3.5 GHz will be typically narrower than those used in the 40 GHz band.

The drop-down attenuation near the edge has been maintained to the same amount as for the 40 GHz case in order to ease TX filtering. While the size (3.5 MHz) has been chosen taking into account the typically smaller systems bandwidths. These values are not explored in the simulations carried in this report, but come from practical considerations similar to those made in the 40 GHz MWS ECC Recommendation 01-04 (i.e. this 3.5 MHz will act as "soft" guard band, discouraging its use by narrow-band systems for the expected higher interference).

X_3 value for CSs is function of the acceptable CS-to-CS and CS to TS minimum co-ordination distance. X_3 value for TSs should be derived from statistical interference protection factor (IPF) and NFD in TS to CS interference scenarios.

2.1.4.2 *Conclusions and tentative BEM parameters*

From the above considerations some tentative values for a BEM could be summarised in Table 6 as preliminary proposed reference points for future evaluation.

Station type	EIRP (dBW/MHz) (Note 3)		
	X1 (Note 3)	X2	X3
CS	13	X3 + 13	–64 or –73 (NOTE 1)
TS	23	X3 + 13	–35 or – 37 (NOTE 2)
NOTE 1: the – 64 dBW/MHz will result in a CS to CS minimum distance, for 1 dB maximum degradation of thresholds, of ~350 m, while the – 73 dBW/MHz allows closer distance down to ~ 100 m. NOTE 2: the –35 dBW/MHz should be used for TS using ETSI EN 302 085 class 3 or higher antennas: the –37 dBW/MHz figure should be used for TS using class 2 antennas			

Table 6: preliminary block-mask shape

The in-band EIRP upper limit could be preliminary set from the proposed reference systems data (see Table 1) which are already at or near to the maximum power. But there is some allowance for "higher gain" and/or "smart antennas" deployment (e.g. 5 dB more on CS and 15 dB more for TS, the latter with e.g. a 2 m parabolic antenna in order to cope with special cases).

2.1.4.3 Typical ETSI mask positioning and improvements on practical equipment

Using a block-edge mask regulatory concept implies that operators should meet the requirements having freedom on three elements only:

1. The EIRP level
2. The minimum frequency separation from edge of outermost channels
3. The transmit spectrum mask attenuation enhancement.

The first parameter is intended for maximising coverage, while the other two are strictly related to the actual equipment implementation. Manufacturers might improve the transmitter spectrum mask (and then the possibility of going closer to the block edge) by actually offering guaranteed masks that, at least for the CSs, are tighter than the minimum ETSI requirement.

Managing these three elements, equipment manufacturer and an operator can define systems parameters that better fit the network requirements addressed (e.g. for rural or for urban applications).

Annex 3 shows examples of filtered output masks based on currently available filter technology. Those examples also illustrate the matching of concept of absolute EIRP density mask (BEM) defined in this report and of relative power density mask currently reported in ETSI ENs.

3 "ADJACENT AREA - SAME FREQUENCY BLOCK" INTERFERENCE SCENARIO

3.1 Power Flux Density Limits for adjacent FWS service areas

This document focuses on initial inter-operator co-ordination guidelines that would support assignments to FWA operators in adjacent sub-bands and adjacent geographic areas. These guidelines consist of service boundary PFD limits to assist in co-existence between neighbouring service areas and guard bands to assist with co-existence between adjacent frequency blocks in the same area. The PFD limits are linked with a co-ordination distance, which is the distance from the service area boundary within which transmitter stations should be co-ordinated with adjacent area operators.

The methodology used in this report follows the same approach as for the 40 GHz band, which was base for the relevant Annex 4 of draft ERC Recommendation (01)04.

The specific propagation behaviour in 3.5 GHz band was taken into account; in particular the spherical diffraction attenuation has been introduced as function of the antenna height. Due to the relatively large radius of first Fresnel zone (≈ 50 m) and the typical horizontal pointing of FWA antennas, the spherical diffraction attenuation will play significant role in defining the respective area and the PFD level for triggering co-ordination.

The findings of this section may be as follows:
FWA Central Stations (CS) transmitters should be co-ordinated when the **PFD** generated at the network's service area boundary exceeds the value of PFD [dBW/MHz/m^2] shown in Figure 11

The co-ordination distance and PFD at the boundary strongly depend on the antenna (interfering TX and victim RX) heights.

The values derived from Figure 11 can be used to determine co-ordination distances. For typical values of EIRP expected in the 3.5 GHz band, co-ordination distances are evaluated as ≈ 60 to 80 km for P-MP CS (see Figure 10).

Terminal Stations' (TS) EIRP being similar to that of CS there is no practical difference apart from the typically lower height of their antenna.

Evaluated EIRP = 20 dBW/MHz and antenna heights 20 to 50 m for CS and 10 to 40 for TS.

The range of distance and relevant PFD may be reduced or fixed in case administrations may wish to limit upper-bounds for both EIRP and antenna heights above the ground or to define down-tilt angles in case that height is exceeded.

This section reviews the methodology behind these figures and proposes the principle of boundary PFD limits as an appropriate means of controlling the interference environment between operators assigned same frequency block(s) in neighbouring geographical areas.

The proposed methodology might be also suitable for FSS co-ordination.

3.1.1 Assumptions

In order to cater for the variety of technologies possible for FWA no assumptions were made regarding duplex method or multiple access method. To generate the broadest of guidelines the assumption was merely that an interfering transmitter is deployed in one service area and a victim receiver is operating on the same frequency, but located in an adjacent service area.

In Table 7, equipment characteristics are reported for interference analysis and for a consequent tentative technology independent regulatory framework. Those values are not regarded as "typical" for most current system available on the market, but cater for due allowance for some special cases and possible further technology developments.

Nominal channel bandwidth:	7 MHz[8]
Central station EIRP:	20 dBW/MHz[9]
Central station antenna gain:	18 dBi[10]
Central station antenna radiation pattern (90°):	EN 302 085 class C2
Central station antenna height	20 to 50 m [11]
Terminal station $EIRP_{TX}$:	20 dBW / MHz [12]
Terminal station antenna gain	18 dBi
Terminal station antenna 3dB beam width	~ ±10°
Terminal station antenna radiation pattern:	EN 302 085 class TS2
Terminal station antenna height	10 to 40 m [13]
Typical Central Station and Terminal station receiver threshold (10^{-6} BER)	-84 dBm (4QAM) -76 dBm (16QAM)
Nominal ATPC regulated up-link receiver level	6 dB above 10^{-6} BER threshold
Receiver noise figure	8 dB [14]
Interference limit (kTBF – 10 dB) [15]	-146 dBW / MHz

Table 7: Summary of system characteristics assumed for defining the proposed regulatory framework

In addition the following propagation characteristics have been assumed:

- Line of sight path unless otherwise stated.
- No atmospheric attenuation at 3.5 GHz.
- Spherical diffraction attenuation (1st Fresnel zone partially obstructed due to limited antenna height) calculated following ITU-R Rec. P.562.
- ATPC effect at 3.5 GHz should also be taken into account; however, it is assumed that ATPC, in these lower bands, will be operated by multipath and not by rain, therefore correlation between interfering and victim paths attenuation is negligible.

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[8] This channel spacing is considered the most representative for being used in the calculation. It is considered that the larger channel systems would determine the coexistence rules. Nevertheless lover spacing channels (e.g. from 1.5 MHz up), also widely popular, should more easily fit in that possible framework.

[9] This value includes allowance for feeder losses for full indoor applications. The assumed EIRP is intended to make room for the highest values allowed by present technology, used in particular applications (e.g. very large coverage in remote areas or when non LoS area should be covered at best), nevertheless network considerations would generally lead to lower EIRP. In this case it is also intended that the latter systems would more easily meet any regulatory limit.

[10] Even if antenna gain might be slightly lower in typical applications, antenna technology is in fast evolution; therefore 18 dB has been used for taking into account a not infrequent worst case, while 16 dB has been assumed as typical value in previous section of this report dealing with "same area – adjacent block".

[11] Antenna height would impact the cell coverage but also the pfd at area boundaries. It is current practice for limiting the latter, when high antenna location is used, to down-tilt the antenna itself for remaining in the boundary pfd limits set by the Administration.

[12] This is the worst case, assuming symmetrical up-link/down-link capacity.

[13] In principle there should be no limitation to TS antenna height, it being dependent on the customer location. However, the same consideration made for CS antenna regarding the higher value still applies. For the lower limit, we should consider that second generation FWA systems might employ techniques which enable them to operate without a clear LoS path. The desire for low cost, simple (self) installs has resulted in system performance being improved to allow the TS to be deployed within buildings. Hence, TS heights may be less than 7 meters, and are rarely higher than 2 meters above the subscribers' building height.

[14] Typical front ends noise figure in this band are lower (e.g. ~5 dB). The 8 dB value included allowance for feeder losses and possible narrow-band filters for enhanced selectivity required by dense environment as assumed in this report.

[15] For the "adjacent area- same frequency block" scenario a more stringent requirement is used (i.e. frequency reuse by another operator should be more protected than when operators use adjacent blocks of frequency).

3.1.2 *Methodology*

The PFD threshold has been determined assuming a single interferer and unobstructed LOS, directly aligned path between interferer and victim essentially a "minimum coupling loss" approach. The PFD limit is then used to derive an appropriate maximum co-ordination distance.

The threshold can then be tested using Monte Carlo statistical analysis to check its validity in a typical multiple interferer environment.

3.1.3 *Central Station to Central Station*

3.1.3.1 *Worst case single interferer scenario: 3.5 GHz calculations*

Assuming a 18 dBi victim antenna gain, the minimum separation between the two CSs (R_{min}) vs. the interfering station $EIRP_{int}$, can be derived from the link budget equation, i.e.,

$$P_{RX} = EIRP_{int} - FSPL - A_{sph} + G_{RX}$$

where P_{RX} is the interference power at the receiver input

FSPL is the free space path loss $=20 \log(4\pi R_{min}/\lambda)$

A_{sph} is the spherical diffraction attenuation depending on the heights (***ha*** and ***hb***) of the two CS antennas relative to the ground. This has been calculated following ITU-R Rec. P.562 and approximated as:

$$A_{sph} = 0 \text{ dB } D < D_0 \text{ (km)}$$

$$A_{sph} = 1.3\ (D-D_0) \text{ db } D \geq D_0 \text{ (km)}$$

D_0 is the maximum distance where the total calculated attenuation equals the free space attenuation

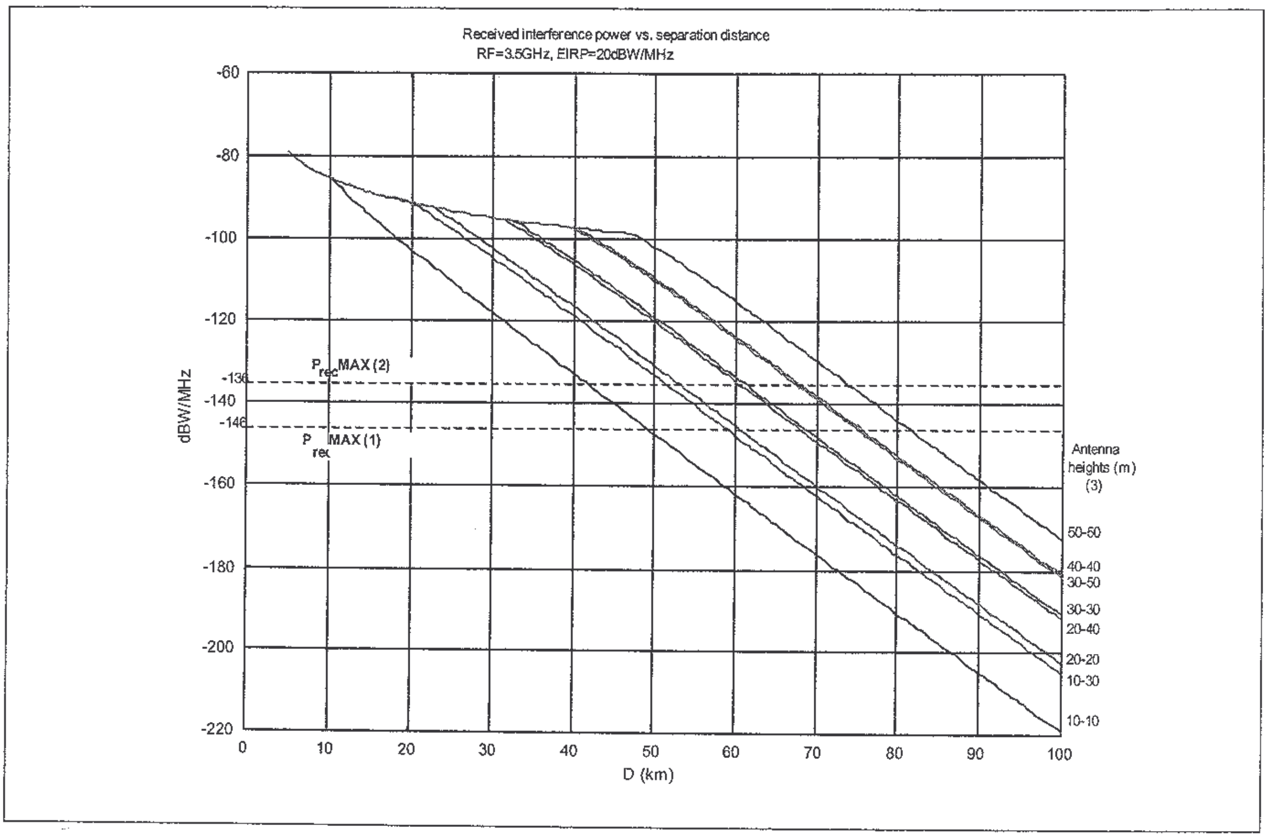
G_{RX} is the receiver antenna gain in the direction of the interferer

$$P_{RX}\ \text{Max (dBW/MHz)} = -146 = EIRP_{int} - 92.5 - 20\log(3.5) - 20\log(D) - A_{sph} + 18$$

Figure 9 shows the received interference power as a function of the separation distance from the interfering transmitter for $EIRP_{int}$= 20dBW/MHz and some different cases of antenna heights (ranging from 20m to 50 m). The curves for different EIRP values can be obtained by simple shift of the same amount.

In Figure 9 flat terrain has been assumed and it shows that in case of different interferer/interfered antenna height, the mean value of the two can be taken into account (e.g. ha=20m and hb=40m correspond to the case ha=hb=30m).

Flat terrain is assumed to be close to the worst case; it is not likely that operator boundaries lie along a relatively narrow valley and, even in that case, antennas would be "ground-grazing" aligned.



(1) $P_{REC}MAX$ proposed for CSs and TSs at nominal operating EIRP (6 dB above threshold)
(2) $P_{REC}MAX$ proposed for TSs (with ATPC enabled) at maximum EIRP
(3) Each curve is valid also for any mixed antenna heights with the same sum value (e.g. 30-30 is valid also for 20-40, 20-30 is valid for 25-25 and so on)

Figure 9: Received interference power vs. separation distance for the CS to CS interference scenario (3.5 GHz, line of sight)

In Figure 9 two limits are shown. The first (-146 dBW/MHz) is valid for little or no degradation of the victim CS receiver.

The second (-136 dBW/MHz) is proposed for TSs at the maximum EIRP (during the small percentage of time when ATPC is required to operate to counteract multipath attenuation) as discussed later.

The minimum separation, required to meet the –146 dBW / MHz interference criterion defined above, between directly aligned CSs under clear LOS air conditions is shown in Figure 10 as a function of EIRP, with the antennas height as parameter.

Within practical antenna heights range (20 to 50 m) the minimum separation distance ranges from 58 to 80 km.

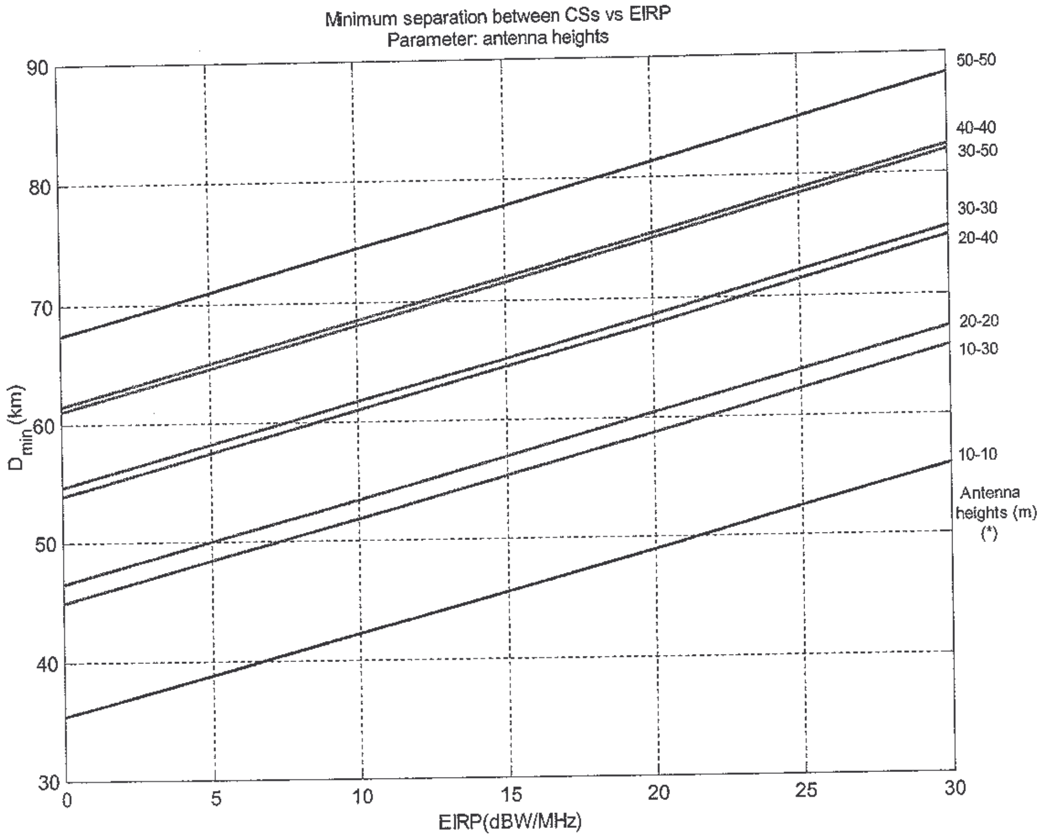


Figure 10: Minimum separation between CSs vs. EIRP for the CS to CS interference scenario (3.5 GHz, line of sight)

If the required separation distance is apportioned equally between the two regions, this will require each operator to ensure any CS *directly aligned* with an adjacent operator's service area boundary is located at least ($D_{min}/2$) km away from the adjacent service area boundary.

The interference power produced by a CS $D_{min}/2$ km away is calculated again as:

$$P_{rec}(D_{min}/2) = EIRP_{tx} - FSPL(D_{min}/2) - A_{sph}(D_{min}/2) + G_{rec}$$

The PFD at this distance can be determined using the formula:

$$PFD = P_{rec} - A_e,$$

where:

$A_e = G_{rec} + 10\log(\lambda^2/4\pi)$ is the receiving antenna effective aperture

$A_e = -14.3$ dB m^2 evaluated at 3.5 GHz with G_{rec}=18 dB

The PFD at $D_{min}/2$ is shown in Figure 11 as a function of $EIRP_{tx}$ for different antenna heights.

Therefore the PFD at the service area boundary should not exceed the values derived from the above relationships, and summarised in Figure 11.

Data in Figure 11 are obtained with $P_{rec}(D_{min}/2)$ evaluated assuming the potential receive antenna height at $D_{min}/2$ to be the same than that at D_{min} (not taking into account any earth surface curving).

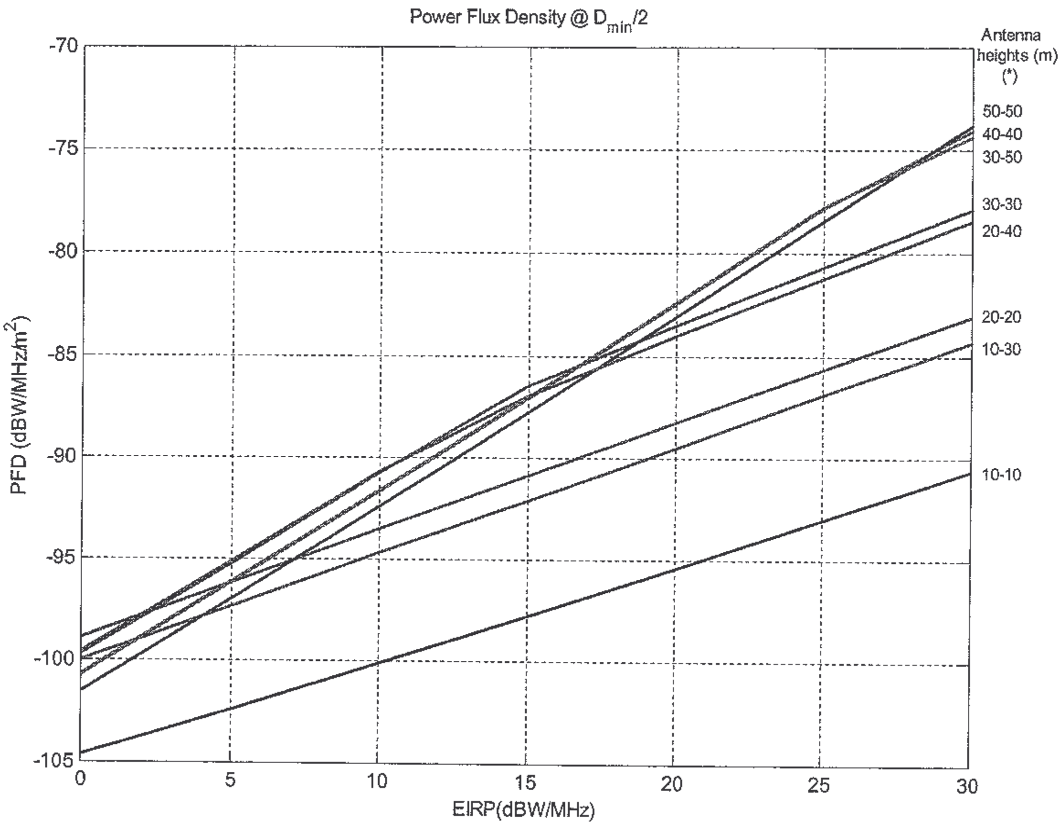


Figure 11: PFD (Φ) at $D_{min}/2$ (half the minimum distance derived from Figure 10 between CSs vs. $EIRP_{tx}$

3.1.3.2 Conclusions and possible self-regulation method for CSs co-ordination distance

Unlike what commonly happens in HDFS frequency bands, where line of sight applications give enough clearance from 1st Fresnel zone for not considering spherical diffraction attenuation, the above discussion has shown that, in the 3.5 GHz band, the co-ordination distance, besides $EIRP_{tx}$,, depends on antenna heights of both interfering and victim CS.

In such a way an operator, according to its own actual deployed maximum $EIRP_{tx}$ and antenna height, and assuming victim receiver antenna height at the maximum foreseen (e.g. 50 m), should:

- # evaluate the minimum co-ordination distance (D_{min} from Figure 10)
- # verify that the PFD at $D_{min}/2$ (service boundary) does not exceed the limits given in Figure 11.

This does not mean that CSs cannot be located closer than $D_{min}/2$ to the boundary. However, the PFD at the boundary should be no greater than that produced via an unobstructed path by a directly aligned transmitter radiating the same EIRP. With an antenna height at a distance $D_{min}/2$ from the adjacent service area boundary, in order to allow a similar transmitter (with the same EIRP and with the tallest antenna mast) at the same $D_{min}/2$ from service boundary.

In this case administrations may wish to limit CSs transmitters in both $EIRP_{tx}$ and maximum antenna height (automatically limiting the maximum co-ordination distance) or to define down-tilt angles in cases when height is exceeded.

At closer distances to the boundary, additional protection in the form of reduced EIRP in the direction of the boundary or shielding from terrain or other obstacles will be required. The extent of additional protection required would be subject of further studies.

3.1.4 Terminal Station to Central Station

3.1.4.1 ATPC impact

The TS is assumed to have ATPC. Under normal conditions each TS is assumed to have its EIRP level set to deliver a signal to the CS 6 dB above the receiver threshold.

Fadings from clear-air multipath on interfering and victim paths are assumed to be uncorrelated. Actually, slight correlation may be expected for directly aligned line of sight interference scenario but a very rough estimate of the percentage of time, where both the useful and the interference path might be contemporarily faded, gives negligible values (based on ITU-R P.530-8 paragraph 2.3.6).

3.1.4.2 Worst case single interferer scenario, 3.5 GHz calculations

For the worst-case interference scenario, it is assumed that the interfering TS is directed towards a CS located at the network service area boundary, pointing into its own service area. The worst-case interference arises when the TS is at the maximum distance from its CS.

This maximum cell size can be determined by considering the downlink power budget, assuming a CS EIRP of 20 dBW / MHz.

This evaluation, assuming multipath environment in rural (flat terrain) scenario, may be found in the previous section "Same area – Adjacent Block scenario" of this report and is summarised, with the fade margin (FM) in Table 8 as function of required availability.

Rural Scenario				
System Type	Availability			
	99.99%		99.999%	
	R_{max} (km)	FM_0 (dB)	R_{max} (km)	FM_0 (dB)
A	18.7 km	17.3	12.4 km	20.9
B	13.4 km	12.2	8.9 km	15.7

Table 8: Typical cell size in rural scenarios

Therefore, the worst-case interference scenario occurs when the interfering TS is at a distance $D_{int} = D_{min}/2 + R_{max}$ from the directly aligned victim CS, where D_{min} is derived from Figure 10 and R_{max} can be taken from Table 8.

With the assumption made of fading uncorrelation, two requirements need to be considered:

a) Interfering TS operating at the "normal" EIRP set by ATPC (unfaded percentage of time ~99.X %)
$EIRP_{ATPC} = EIRP_{max} - FM_0 + FM_{ATPC}$
FM_0 is the fade margin corresponding to maximum transmitted power (from Table 8). In this case (most of the time) the received interference power, into the victim CS, should not exceed the required limit (kTBF - 10dB) for not impairing the victim performance and availability.

b) Interfering TS operating at maximum EIRP (faded percentage of time ~ (100-99.X) %)
Due to uncorrelation, the victim CS would receive normal level, depending on the availability objective and the ATPC range, from the useful link (for a percentage of time usually less than 1%) In this case a higher interference level can be tolerated without impairments.
Assuming that also victim system will work at 6 dB above threshold, we may tolerate up to 3 dB of noise floor degradation (i.e. up to kTBF= -136 dBW/MHz).
Assuming the TS delivering the assumed maximum EIRP of 20 dBW / MHz, the received signal level at the victim CS at this distance is derived from Figure 9, for the rural scenario.

3.1.4.3 Examples:

<u>Example 1</u>

Type B interfering system, height of interfering TS $h_t = 10$ m, height of victim CS $h_c = 30$ m, availability 99.99%.

$R_{max} = 13.4$ km $FM_0 = 12.2$ dB $D_{min} = 68$ km (for CS to CS interference assuming hc = 30 m on both sides)

$$D_{int} = 13.4 + 68/2 = 47.4 \text{ km}$$

$$EIRP_{ATPC} = 20 - 12.2 + 6 = 13.8 \text{ dBW/MHz}$$

From Figure 9 (at D_{int} and scaled to the actual EIRP level) it is possible to derive:
For case a) an interfering power I =~ -132 – (20 - $EIRP_{ATPC}$) = - 138.2 dBW/MHz
For case b) an interfering power I =~ -132 dBW/MHz.

Both these levels are higher than requirement.

In case a) in order to receive an interfering power of -146 dBW/MHz, the CS of the interfering system should be placed at a distance Dx from the border, so that:
D(a) + R_{max} + D_{min}/2 =~ 54 km (from Figure 10, at EIRP = 13.8 dBW/MHz)
D(a) = 54 – 13.4 - 34 = **~ 6.6 km**

for case b), in order to receive an interfering power of -136 dBW/MHz (=kTBF), the CS of the interfering system should be placed at a distance Dy from the border, so that:
D(b) + R_{max} + D_{min}/2 =~ 52 km (from Figure 9 with P_{rec} Max set to –136 dBW/MHz)
D(b) = 52 – 13.4 - 34 = **~ 4.6 km**

Therefore the minimum distance where a CS (supporting far system type B TSs with height lower than 10 m and victim CS height lower than 30 m) could be placed is 6.6 km.

Example 2
Type B interfering system, height of interfering TS h_t = 20 m, height of victim CS h_c = 40 m, availability 99.99%.

R_{max} = 13.4 km FM$_0$ = 12.2 dB D_{min} = 75 km (for CS to CS interference assuming hc = 40 m on both sides)

D_{int} = 13.4 + 75/2 = 50.9 km

$EIRP_{ATPC}$= 20 – 12.2 + 6 = 13.8 dBW/MHz

From Figure 9 (at D_{int} and scaled to the actual EIRP level) we would derive:
For case a) an interfering power I =~ -121 – (20 - $EIRP_{ATPC}$) = - 127.2 dBW/MHz
For case b) an interfering power I =~ -121 dBW/MHz.

Also in this example, both these levels are higher than requirement.

In case a) in order to receive an interfering power of -146 dBW/MHz, the CS of the interfering system should be placed at a distance Dx from the border, so that:
D(a) + R_{max} + D_{min}/2 =~ 64 km (from Figure 10, at EIRP = 13.8 dBW/MHz)
D(a) = 64 – 13.4 - 37.5 = **~ 14.8 km**

for case b), in order to receive an interfering power of -136 dBW/MHz (=kTBF), the CS of the interfering system should be placed at a distance Dy from the border, so that:
D(b) + R_{max} + D_{min}/2 =~ 62 km (from Figure 9 with P_{rec} Max set to –136 dBW/MHz)
D(b) = 62 – 13.4 - 37.5 = **~ 11.1 km.**

Therefore the minimum distance where a CS (supporting system type B TSs with height lower than 20 m and victim CS height lower than 40 m) could be placed is 14.8 km.

Example 3
Type A interfering system, height of interfering TS h_t = 20 m, height of victim CS h_c = 40 m, availability 99.99%.

R_{max} = 18.7 km FM$_0$ = 17.3 dB D_{min} = 75 km (for CS to CS interference assuming hc = 40 m on both sides)

D_{int} = 18.7 + 37.5 = 56.2 km

$EIRP_{ATPC}$= 20 – 17.3 + 6 = 8.7 dBW/MHz.

From Figure 9 (at D_{int} and scaled to the actual EIRP level) derive:
For case a) an interfering power I =~ -129 – (20 - $EIRP_{ATPC}$) = - 140.3 dBW/MHz
For case b) an interfering power I =~ -129 dBW/MHz

Also in this example, both these levels are higher than requirement.

In case a) in order to receive an interfering power of -146 dBW/MHz, the CS of the interfering system should be placed at a distance Dx from the border, so that:

$D(a) + R_{max} + D_{min}/2 = \sim 61$ km (from Figure 10, at EIRP = 8.7 dBW/MHz)

$D(a) = 61 - 18.7 - 37.5 = \sim 4.8$ km.

For case b), in order to receive an interfering power of -136 dBW/MHz (=kTBF), the CS of the interfering system should be placed at a distance Dy from the border, so that:

$D(b) + R_{max} + D_{min}/2 = \sim 62$ km (from Figure 9 with P_{rec} Max set to –136 dBW/MHz)

$D(b) = 62 - 18.7 - 37.5 = \sim 5.8$ km.

Therefore the minimum distance where a CS (supporting system type A TSs with height lower than 20 m and victim CS height lower than 40 m) could be placed is 5.8 km.

3.1.4.4 TS to CS Conclusions

From the above examples, a CS, even if pointing away from the border, could not be indifferently placed nearer than the co-ordination distance evaluated in Figure 9 and Figure 10. The terminals PFD will become determinant and engineering of the cell (reduced EIRP and sector beams pointing) should be used to ensure that also TSs PFD (in the direction of the boundary) does not exceed the values derived from Figure 11.

Figure 12 shows an example of such methodology based on previous examples 2 and 3.

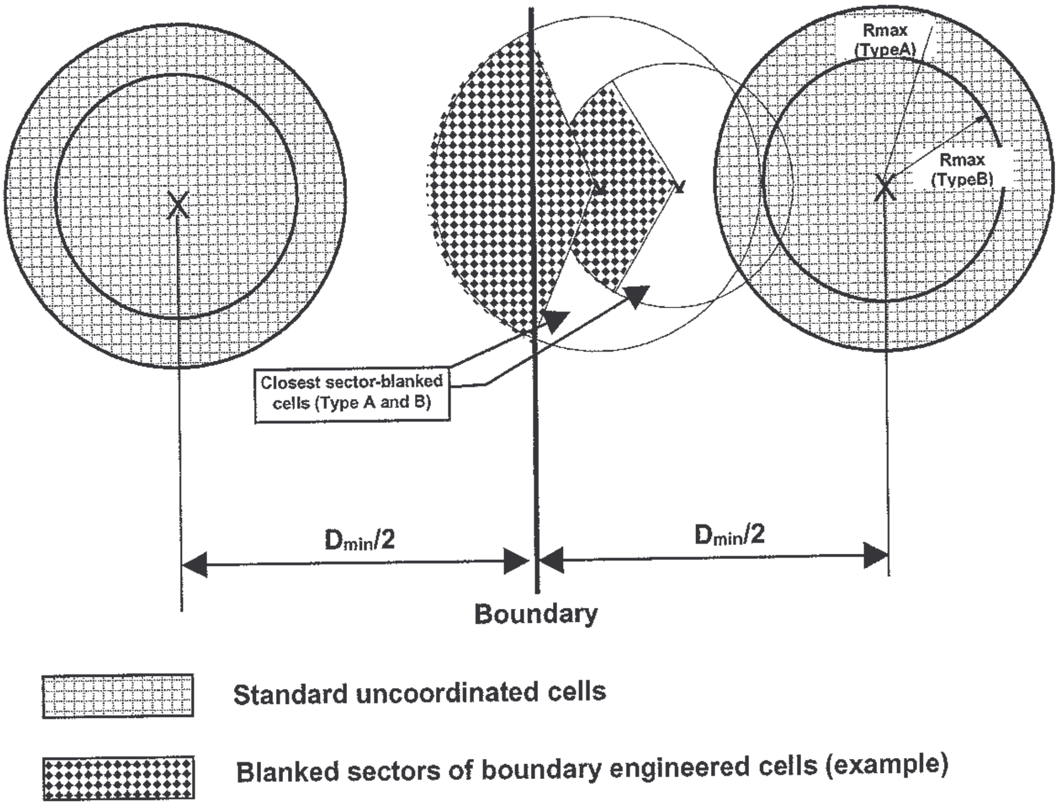


Figure 12: Example of cell sector engineering at service boundary (assuming $h_c = 40$ m on both service areas; for $D_{min}/2$ see Figure 10)

3.1.5 Terminal Station to Terminal Station

This kind of interference, unlike the cases where a CS is involved, would only impair the operation of one terminal; therefore a worst case approach is considered as too stringent. Due to the random nature of this kind of interference, a statistical Monte Carlo approach seems more adequate. A possible scenario could be two CSs located at both sides of the boundary, each pointing into its own service area. Each TS will have its EIRP level set to deliver a signal to the CS 6 dB above the receiver threshold, except one (different in each trial) which would have maximum EIRP, to simulate the occurrence of a fading event.

However this effect, at least for PMP architectures with directive TS antennas, is not generally considered a limiting factor for coexistence (when compared to the other interference cases). This evaluation may require further work in case of mixed PMP and MESH architectures.

3.2 Conclusions on adjacent areas boundary co-ordination

It is therefore recommended that co-ordination between operators using same frequency block(s) in the 3.5 GHz band in adjacent geographic areas should take place for any transmitter (CS and TS assumed to supply very similar EIRP) that produces a PFD derived from Figure 11 or greater at the service area boundary. The distance from the service area boundary that will be subject to co-ordination, as a function of transmitter EIRP, is indicated in Figure 12.

The proposed PFD guidelines can be tested in Monte Carlo simulations to assess their validity in multiple interferer scenarios.

4 CONCLUSIONS OF THE REPORT

This Report has considered a number of facts as initial considerations for deriving the coexistence study:

1. Presently ECC Recommendations 14-03 and 12-08 for the bands 3.6 GHz and 3.8 GHz do not give harmonised and detailed suggestion to administration for implementing FWA (such as those produced for 26, 28 and 40 GHz). Those ECC Recommendations offer only channel arrangements.
2. The band is limited and wasted guard-bands might drastically reduce the number of licensed operators, limiting the potential competition for new services.
3. Legacy systems (P-P and already licensed FWA) are present in these bands. "Block assignment" methods of different sizes (for different applications) are generally used for licensing FWA.
4. Sharing issues with FSS, radiolocation (in adjacent band), ENG/OB exist and should be taken into account.
5. At least for CSs, ETSI ENs in these bands are not presently designed for a technology neutral deployment (this is done only in the 40 GHz MWS EN 301 997) therefore do not contain system controlling parameters, in terms of EIRP, which would be useful for the desired "technology neutral" and "uncoordinated" deployment
6. The suggested guard-bands/mitigation(s) would depend on system bandwidth/characteristics. Presently, in this band, it is not possible to identify a "typical" system bandwidth on which base the definition of a guard-band. Symmetric/asymmetric, narrow/wide/broad band services[16], TDD/FDD, P-MP/Mesh architectures are already available on the market, each one with its own benefits and drawbacks, fitting to specific segments of the whole FWA market. It should be noted that e-Europe initiatives call for faster Internet applications (i.e. requiring relatively wide-band FWA) to be available on the whole European territory.
7. Typical block size ~ 7 to 14 MHz (e.g. from a block of channels based on 3.5 MHz raster) or ~10 to 15 MHz (e.g. when a basic 0.5 MHz raster is used) is considered practical for new wide/broad band services demand. Nevertheless the conclusions should be valid for wider block sizes (e.g. up to ~ 28/30 MHz) depending on the band availability in each country.
8. Also for "conventional" symmetric FDD the central-gap between go and return sub-bands do not exist in ECC Recommendations 14-03 and 12-08; therefore situation with TX/RX happening on adjacent channels exist (unless specifically addressed by single administrations in licensing rules).
9. It is also shown that, for PMP TSs, the antenna RPE plays a fundamental role in the coexistence; the more directive is the antenna of TSs, the less demanding might be their NFD (or the EIRP density BEM) required (offering a flexible trade-off to the market).

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16 Narrow band services are considered here as < 64 kbit/s, wide-band from 64 to 1.5 Mbit/s and broadband above 1.5 Mbit/s

10. MP-MP (MESH) architectures have not been considered in this Report. In particular it is recognised that, for MESH architectures, a number of assumptions (e.g. on the omni-directional/directional antenna use) need to be defined in order to devise the typical intra-operator, mixed MP-MP/PMP interference scenarios for which simulations would habe to be carried.

Based on the above inputs, this Report recommended Interference Protection Factor/ isolation values ensuring acceptable coexistence levels between systems.

It has been shown that the required IPF levels can be achieved, depending on situations, by a combination of basic equipment NFD and appropriate additional isolation factor (e.g. suitable guard bands and/or mitigation(s) techniques).

In the case of a block assignment and where a guard band approach is not retained, these IPF levels can be ensured with additional EIRP BEM. This is deemed convenient for "technology independent" deployment and eventually feasible from a cost-effective equipment point-of-view. Especially when considering that the additional EIRP constraint (with respect to ETSI EN) might burden only CS design.

In addition, basic rules has been set for the co-ordination distance and PFD boundary levels between operators re-using the same block in adjacent geographical areas. In this field, the importance of limiting CS antenna height (or down-tilt angle) as possible licensing parameter is highlighted in order of having sensible co-ordination distances (i.e. limited by spherical diffraction attenuation).

ANNEX 1: URBAN AREA PROPAGATION MODELS

A1.1 The Okumura-Hata model used in this Report

A1.1.1 Tentative extrapolation of the Okumura-Hata propagation model for A_{50} up to 3.5 GHz

Important remark on terrain classification:
The original Okumura experimental data are said by the authors to refer to an "urban area", with a further subdivision into "large city" and "medium city" for what concerns the terminal antenna height gain G_t.

Okumura also gives diagrams of correction factors for "suburban" and "open" areas.

It should be noted that this classification was based on the characteristics of the Tokyo area.

It is considered that the "medium city" model is better suited to describe the typical European suburban areas. Moreover, the correction factor for "open areas" is said to give rather optimistic results (see [2] and [3]).

For the above reasons, the Report was limited to the "urban" models (large and medium cities) and numerical examples to "medium cities" only.

Further extrapolations can be of course done in the same way for other environments.

The empirical Hata propagation model, based on field measurements reported by Okumura [1], is a well-established one, widely used at UHF bands.

An extension of the model toward higher frequencies is found in COST-231 report, however this model, although probably useable up to 3 GHz, addresses typical mobile scenarios, with very small peripheral antenna heights.

For a point-to-multipoint 3.5 GHz scenario a slightly different approach has been sought, starting from curves derived from Okumura's measurements, as published in [1].

According to Okumura, the median path attenuation is given by:

$$A_{50}=A_{fs} + A_{bm} - G_c - G_t$$

where:

A_{fs} :is the free space attenuation, (FSPL in this document

A_{bm} :is the "basic median path loss" (Figure 13) for which Okumura provides extensive experimental data up to 3 GHz only, obtained with a base station antenna height h_c = 200m and a peripheral station height h_t = 3m,

G_c is the "central (base) station height gain factor" (Figure 15) for different h_c values,
and
G_t is the "terminal (peripheral) station height gain factor" (Figure 14) for different h_t values.

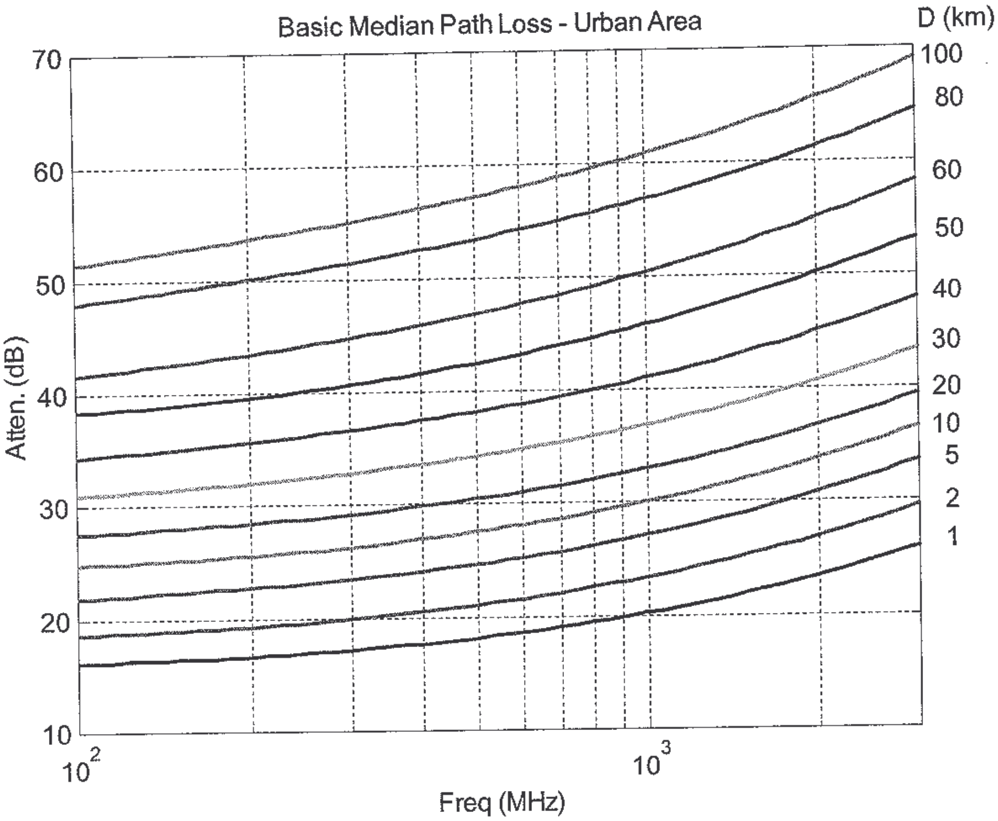

Figure 13: Okumura experimental data for A_{bm} vs. frequency

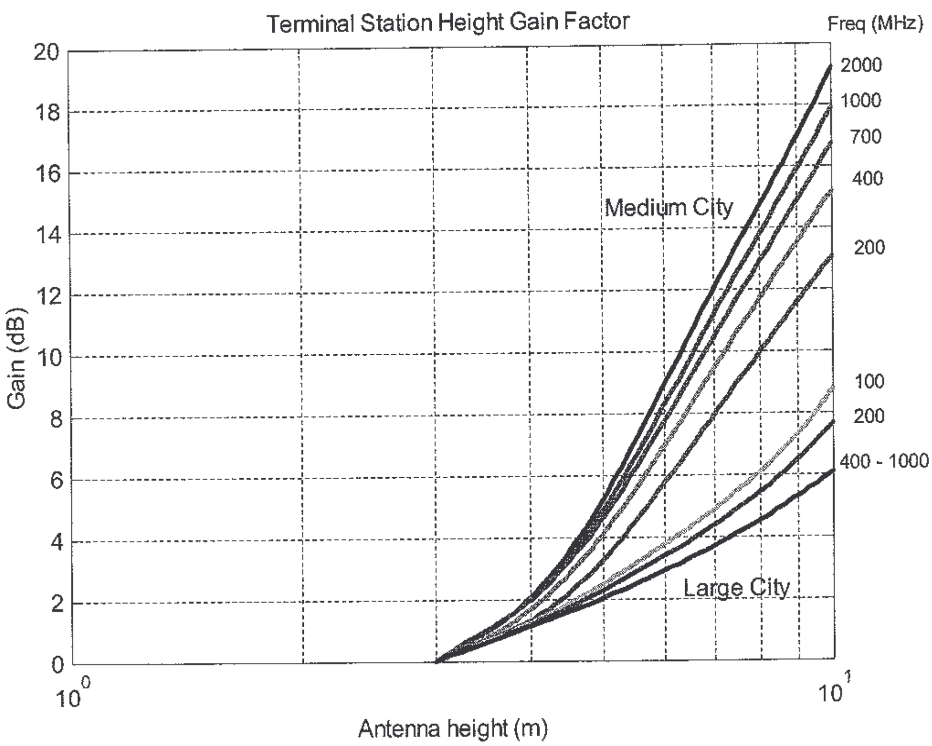

Figure 14: Okumura experimental data for G_t vs. h_t

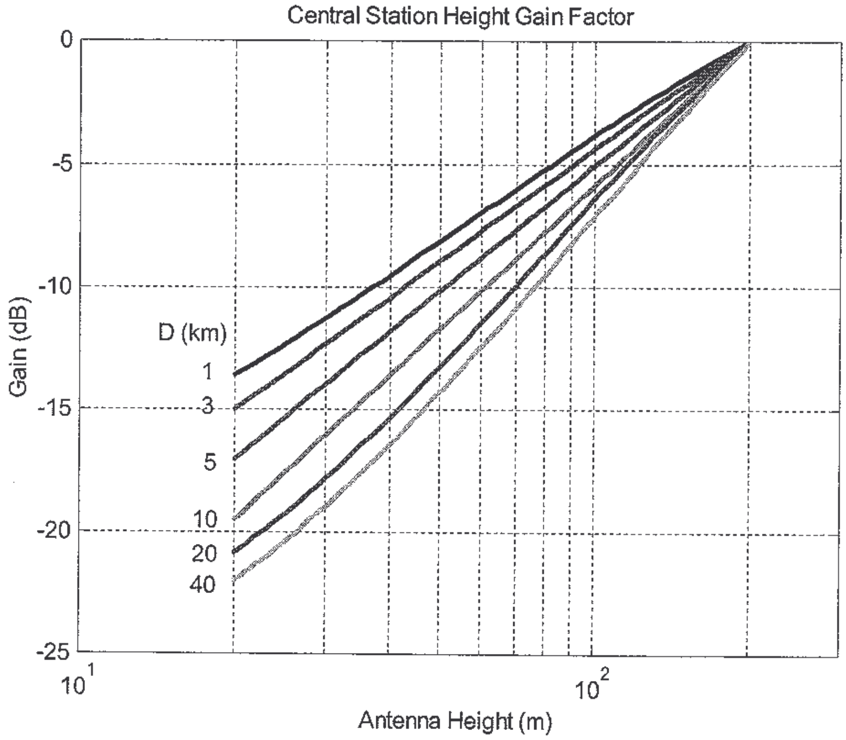

Figure 15: Okumura experimental data for G_c vs. h_c

In this Report's extrapolation exercise, the curves of $A_{bm}(RF,D)$ have been fitted in the least square sense between 700 and 3000 MHz in frequency.

The curves of $G_c(h_c,D)$ have been fitted from 1 to 10 km in distance, for central station antenna heights between 20 and 200 m.

The curves of $G_t(h_t,RF)$ have been fitted from 700 to 2000 MHz in frequency, for terminal station antenna heights between 5 and 10 m.

The calculated RMS error was less than 0.2 dB for each individual fitting.

The resulting extrapolated expressions are given below:

$$A_{fs} = 92.4 + 20\log(D) + 20\log(RF)$$

$$A_{bm} = 20.41 + 9.83\log(D) + 7.894\log(RF) + 9.56\,[\log(RF)]^2$$

$$G_c = \log(h_c/200)\,\{13.958 + 5.8\,[\log(D)]^2\}$$

$$G_t = [42.57 + 13.7\log(RF)]\,[\log(h_t) - 0.585] \quad \text{(for medium city environment)}$$

$$G_t = 0.795\,h_t - 1.862 \quad \text{(for large city environment)}$$

where RF is in GHz, D in km, h_c and h_t in m.

For comparison with Hata's original formula, the explicit formula for the median attenuation A_{50} resulting from the above extrapolation is given as (this time with RF in MHz):

$$A_{50} = 147.376 + 29.83\log(D) - 13.958\log(h_c) - 29.466\log(RF) + 9.56\,[\log(RF)]^2 + \\ +[13.34 - 5.8\log(h_c)]\,[\log(D)]^2 - [1.47 + 13.7\log(RF)]\,[\log(h_t) - 0.585)] \qquad (10)$$

to be compared with the original Hata formula:

$$A_{50Hata} = 69.55 + [44.9 - 6.55\log(h_c)]\log(D) - 13.82\log(h_c) + 26.16\log(RF) + \\ - [1.1\log(RF) - 0.7]\,h_t + [1.56\log(RF) - 0.8] \qquad (11)$$

In both cases the terms in *italic* refer to the terminal antenna height gain for a "medium city" environment.

A1.1.2 Confidence check on the proposed extrapolation

The value of A_{50} in (12) has been computed for 39083 different sets of the parameters of relevance (D, RF, h_c, h_t) with the proposed formulas in the original ranges for which the Okumura approach was considered valid:

RF	1000 to 2000 MHz	h_c	20 to 100 m
D	1 to 10 km	h_t	5 to 10 m

All the differences from the values of the Okumura curves derived from (13) were calculated.

The resulting RMS error was 0.3164 dB (Figure 16), which was judged a fairly acceptable figure for the model extrapolation effectiveness.

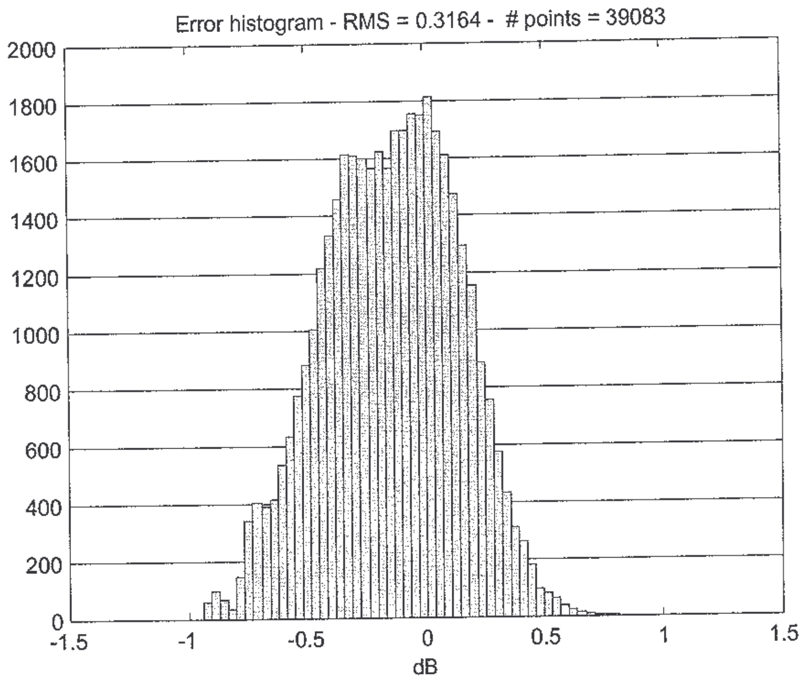

Figure 16 : Confidence check on the proposed methodology (39083 cases)

A1.1.3 Practical application to the proposed scenario

In this Report A_{50} is evaluated from the extrapolation of the Okumura empirical model described in previous sections.

Regarding σ, a discussion can be found in paragraph 9.5 of [3]. The formula presented there may be accepted.

Clear-air multipath cannot in principle be disregarded, although very little is known about its occurrence in urban areas. The usual model (ITU-R Recommendation 530) will be used for lack of a better one.

In this case, the link budget may be written as:

$$SG + G_{TX} + G_{RX} = A_{50} + A_{sh} + FM \qquad (12)$$

where:

- SG, G_{TX} and G_{RX} are the same as in formula 1 for the rural case.
- FM=10 log(P_0) -10 log(un_{year}) +36 log(D) (similarly to formula 6 for the rural case).
- A_{50} is the mean path loss, and is a function of distance, CS and TS antenna heights and frequency.
- A_{sh} is the "shadowing loss", random component with normal p.d.f. about A_{50} and standard deviation σ.

According to the method described in section A1.1, A_{50} is given (for medium city environment) by:

$$A_{50} = 147.376 + 29.83 \log(D) - 13.958 \log(h_c) - 29.466 \log(f) + 9.56 [\log(f)]^2 + $$
$$+ [13.34 - 5.8 \log(h_c)] [\log(D)]^2 - [1.47 + 13.7 \log(f)] [\log(h_t) - 0.585)] \qquad (13)$$

where D is the distance in km, h_c and h_t the CS and TS antenna heights in meters and f the frequency in GHz.

The standard deviation "σ" of A_{sh} is given by:

$$\sigma = 0.65\,[\log(f)]^2 - 1.3\,\log(f) + A \qquad (14)$$

with f in MHz, A=5.2 dB (urban) or 6.6 dB (suburban) as given in [1].

Due to the random nature of A_{sh} , the maximum radius R may be found by evaluating the probability that (A_{50} + A_{sh}) exceeds (SG + G_{TX} + G_{RX} - FM) . This is a function of D, whose integral over the area of a circle with radius R gives the average uncovered area in the cell.

The following diagram shows the results of calculations with the assumed equipment parameters and antenna heights h_c=30m and h_t=10, 20, 30 m

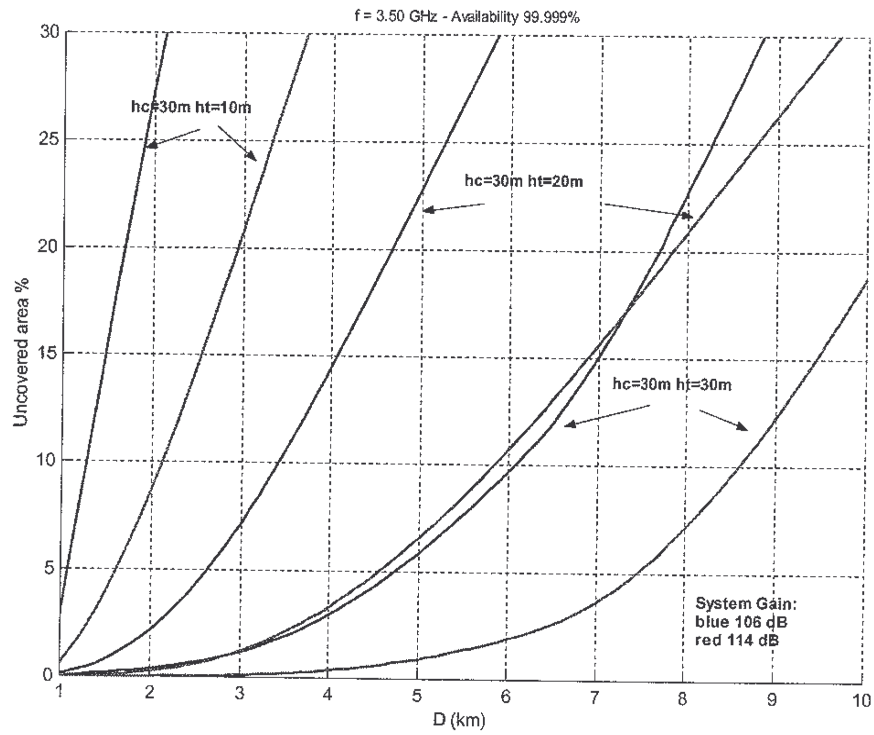

Figure 17: Example of Cell radius (D) versus area coverage in urban scenario

From Figure 17 it may be seen that again the antenna heights play a fundamental role, Rmax for a system Type A would range from 1.6 to 7.5 km and system type B from 1.1 to 4.5 km, according to the TS antenna height.

It should be noted that this diagram applies to an urban scenario, where buildings are assumed to be spread in height from minimum to a maximum for the uncovered percentage area.

In addition, the Okumura model assumes that terminals (mobile) are spread randomly on the territory without any attempt for looking for "line-of-sight" connection; in Fixed applications countermeasures (masts or roof positioning) are generally sought.

Therefore the following considerations, on the covered percentage of TSs, are valid in a context of real "consumer" terminals (i.e. bought and installed by the user, wherever he likes). This would be considered a very worst case for typical FWA systems.

It has to be further considered that in an actual scenario the heights of the buildings will show a random distribution. ITU-R Recommendation P.1410 suggests a Rayleigh p.d.f., with parameter γ

The actual cell radius can be roughly estimated as follows, from the above data:

- divide the range of building heights into 3 segments: below 15m, 15 to 25m, above 25m
- evaluate the relative weight of each segment (dependent on the parameter γ)
- calculate the radius R_{max} as the weighted sum of the values from Figure 17, at the wanted coverage objective.

Results in Table 9 have been obtained for 95% coverage:

System Gain (dB)	**R_{max} (km)**	
	$\gamma = 16$ ($h_{avg} = 20m$)	**$\gamma = 12$ ($h_{avg} = 15m$)**
114 (System type A)	4.35 km	3.3 km
106 (System type B)	2.7 km	2 km

Table 9 : Cell radius for 95% TSs coverage at 99.999% availability Vs system gain and TS antenna mean height (Okumura-Hata model)

A1.2 The IEEE 802.16 model

A1.2.1 Channel Model Considerations and Constraints

In the IEEE 802.16 models, coverage and availability highly depend on the channel models used and on the selected terrain category. This is mainly characterized by the mean excess loss and additional factors (e.g.: log-normal shadowing and Rice fading factor) contributing to further refinement[17].

For excess path loss, the three categories of terrain type identified are:

Category A: **hilly with moderate to heavy tree densities.**
Category B: **intermediate path loss conditions.**
Category C: **mostly flat with light tree densities.**

For these three categories, empirical equations have been developed for median excess path loss referenced to a LOS distance of 100 m. The equations identify the excess path loss exponent and include correction terms for TS and CS antenna heights. A log-normal shadowing factor s is also identified with s ranging from 8.2 to 10.6 dB.

In conjunction with the three terrain categories, reference [4] identifies six channel models, these being denoted as SUI-1 through SUI-6.

Also identified for the channel models is a characterisation of Rician fading. Rician fading results from motion of the reflective facets (diffuse reflections). Rician fading differs from Rayleigh in that a primary signal component is present. Rician fading is characterised by Rice parameter K, this being the ratio of the primary signal power to that of the diffuse power. Figure 18 illustrates excess percentage E vs. K in dB. Note that K = 0 dB is approximately within 1 dB of Rayleigh.

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[17] *The path loss can be seen as the summation of basic free space loss (FSL) and the excess loss (Lex) due to the local blockage conditions or reduction of antenna gains: PL(dB) = FSL (dB) + Lex (dB).*
The path loss can be modeled as follows: PL(dB) = A0(dB) + 10 n log10 (d/d0) + S(dB), where the exponent n represents the decay of path loss and depends on the operating frequency, antenna heights and propagation environments. The reference path loss A0 at a distance d0 from the transmitter is typically found through field measurements. The shadowing loss S denotes a zero mean Gaussian random variable (in decibels) with a standard deviation (also in decibels).

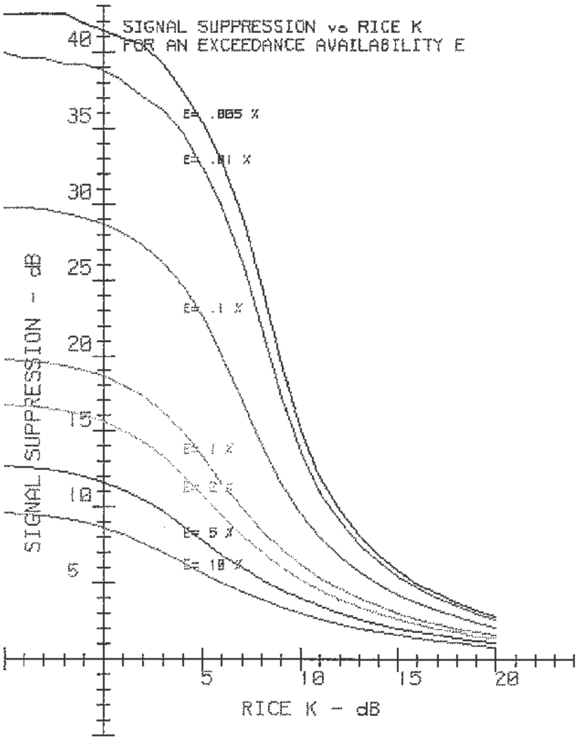


Figure 18 Signal Suppression Excess E vs. Rice K

Figure 19 illustrates the median value of Rice K vs. distance based on the empirical equations described in [4]. The plots are referenced to a TS antenna elevation of 10 m and to TS antenna beam widths of 15 degrees and 35 degrees. These beam widths respectively correspond to those of "representative" and ETSI TS2 antennas. At R_{max} = 2 - 2.7 km, the mean values for Rice K are roughly 8 dB and 11 dB. The difference results from antenna beam width, the ETSI TS2 antenna yielding lower values of K. **These Rice K values correspond very closely to those recommended in [4] for the SUI-1 and SUI-2 channel models that are respectively 12 dB and 9 dB**. The SUI values will subsequently be employed for coexistence simulation analysis.

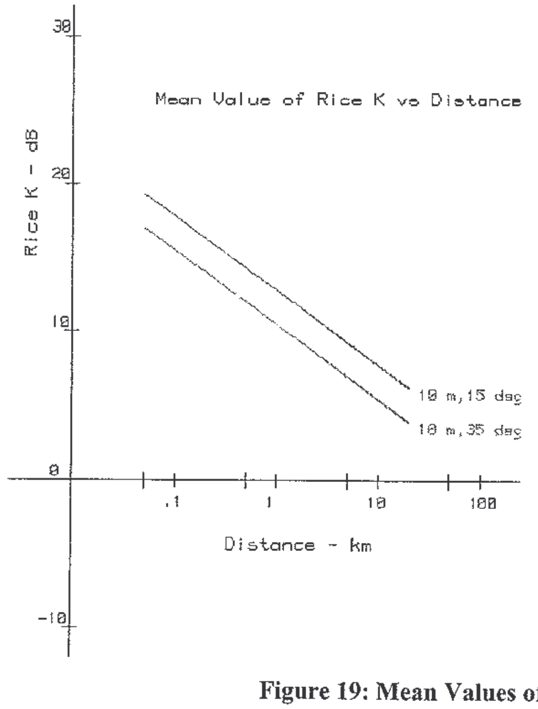


Figure 19: Mean Values of Rice K vs. Distance

The measured data for Rice K reported on in [4] has been described to have a significant variation about the mean value with a log-normal sigma of 8 dB. Figure 20 illustrates a computational estimate for the spread of K when this is taken into account. Rice K values were computed for 50 m distance increments. Note that the distance scale is logarithmic.

Only mean values for K will be employed in the subsequent simulations.

The measured data in [4] reported a transmission distance d variation in K as d^{γ}, where $\gamma = -0.5$. For the simulations, this adjustment is taken into account for each interference and victim link distance.

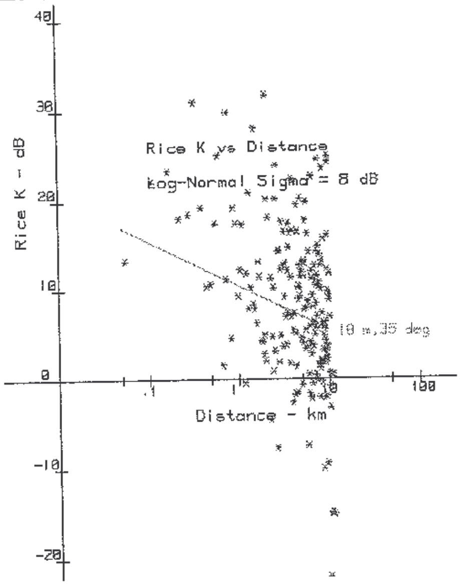


Figure 20: Illustrative Spread of Rice K vs. Distance for a Log-Normal Sigma of 8 dB

For the Monte Carlo simulations an estimate of the up-fade or down-fade adjustment to signal level is required for each interference or victim link. These are developed based on the random deviate acceptance/rejection method described in [5]. Here, we note that the diffuse components of the Rician signal envelope are Rayleigh distributed, but the envelope is modified by the addition of a randomly phased primary signal component. The relative value of the primary signal to that of the diffuse Rayleigh distributed component is set by the specified value for K.

Figure 21 illustrates the probability distribution function (p.d.f.) for Rice K based on this procedure. Cell edge SUI-1 and SUI-2 values for Rice K of 12 dB and 9 dB are illustrated. K =0 dB is illustrated for reference. Again, it may be noted that it is very close to Rayleigh. K = 20 dB is also illustrated for reference. Here, it is apparent that the likelihood of a deep fade is very small.

For the simulations, setting K to 20 dB corresponds very closely to the unfaded case.

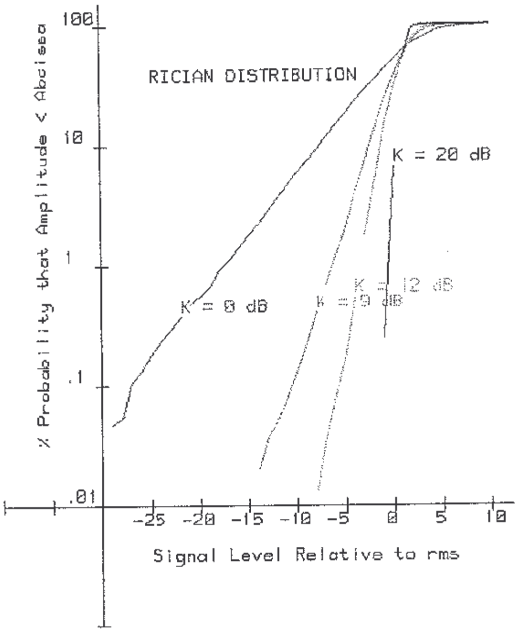


Figure 21: Rice K p.d.f. vs. Signal Level as Developed from Random Deviates

A1.2.2 Urban area availability/coverage at 3.5 GHz

For the three IEEE 802.16 model terrain categories, empirical equations have been developed for median excess path loss referenced to a LOS distance of 100 m. The equations identify the excess path loss exponent and include correction terms for TS and CS antenna heights. A log-normal shadowing factor σ is also identified with σ ranging from 8.2 to 10.6 dB.

Based on the empirical equations, computed median excess loss is shown in Table 10a) through Table 10c) as a function of the cell radius (R_{max}). The estimates are based on respective CS and TS antenna heights of 30 m and 10/15/20 m. Log-normal shadowing is excluded.

Table 11a) through Table 11f) further illustrate some link availability estimates based on link budgets for system types A and B characteristics defined in **Table 1** (developed for TS antenna heights = 10, 15 and 20 m).

Based on a link budget analysis referenced against the assumed transmission parameters, it is concluded that, at least for system type B, acceptable system operation is possible only for terrain category C. For the other two terrain categories, excess median loss is such that cell edge receive signal levels are less than the threshold requirements, even ignoring any fading. Thus, even with perfect multiple-input / multiple-output (MIMO) diversity to combat fading, link availability objectives could not be achieved.

In Appendix 1 to this Annex 1, further simulations, using Monte Carlo technique, derive statistical percentage of Excluded Cell Area coverage with the required availability.

Terrain Category	Excess Path Loss Exponent	Excess Loss (dB) R_{max}= 2 km	Excess Loss (dB) R_{max}= 2.7 km	Excess Loss (dB) R_{max}= 3.3 km	Excess Loss (dB) R_{max}= 4.35 km
A	**4.78**	30.3	33.9	36.4	39.7
B	**4.38**	24.8	27.9	30	32.9
C	**4.12**	15	17.8	19.6	22.2

Table 10a: Path Median Excess Loss (MEL) (CS=30 m; TS=10 m)

Terrain Category	Excess Path Loss Exponent	Excess Loss (dB) R_{max}= 2 km	Excess Loss (dB) R_{max}= 2.7 km	Excess Loss (dB) R_{max}= 3.3 km	Excess Loss (dB) R_{max}= 4.35 km
A	**4.78**	28.4	32	34.5	37.8
B	**4.38**	22.9	26	28	30.9
C	**4.12**	11.5	14.3	16.1	18.6

Table 10b: Path Median Excess Loss (MEL) (CS=30 m; TS=15 m)

Terrain Category	Excess Path Loss Exponent	Excess Loss (dB) R_{max}= 2 km	Excess Loss (dB) R_{max}= 2.7 km	Excess Loss (dB) R_{max}= 3.3 km	Excess Loss (dB) R_{max}= 4.35 km
A	**4.78**	27	30.7	33.1	36.4
B	**4.38**	21.6	24.6	26.7	29.6
C	**4.12**	9.0	11.7	13.6	16.1

Table 10c: Path Median Excess Loss (MEL) (CS=30 m; TS=20 m)

The following Table 11a) through Table 11f) illustrate some link availability estimates based on link budgets for system types A and B characteristics defined in **Table 1** (developed for TS antenna heights = 10, 15 and 20 m).

Terrain Category	Cell Radius (km)	Mean Excess Loss (dB)	Fade Margin (dB)	Link Availability (%)				
				K=5 dB	K=8 dB	K=10 dB	K=12 dB	K=15 dB
A	2.0	30.3	6.3	----------	----------	98.0	99.6	99.995
	2.7	33.9	0.3	----------	----------	----------	----------	----------
B	2.0	24.8	12.3	----------	99.6	99.96	99.998	----------
	2.7	27.9	6.3	----------	----------	98.0	99.6	99.996
C	2.0	15	21.6	99.6	99.96	99.999	----------	----------
	2.7	17.8	16.4	99.0	99.9	99.994	----------	----------

Table 11a: Link Availability for a Type A System with MEL and Rician Fading
TS Antenna Elevation = 10 m

Terrain Category	Cell Radius (km)	Mean Excess Loss (dB)	Fade Margin (dB)	Link Availability (%)				
				K=5 dB	K=8 dB	K=10 dB	K=12 dB	K=15 dB
A	2.0	28.4	8.2	----------	----------	99.4	99.94	99.9998
	2.7	32	2.4	----------	----------	----------	----------	99.997
B	2.0	22.9	13.9	98.2	99.6	99.98	99.999	99.9998
	2.7	26	8.4	----------	----------	99.4	99.96	99.999
C	2.0	11.5	25.2	99.88	99.99	99.999	99.9998	----------
	2.7	14.3	19.8	99.6	99.96	99.998	99.9998	----------

Table 11b: Link Availability for a Type A System with MEL and Rician Fading
TS Antenna Elevation = 15 m

Terrain Category	Cell Radius (km)	Mean Excess Loss (dB)	Fade Margin (dB)	Link Availability (%)				
				K=5 dB	K=8 dB	K=10 dB	K=12 dB	K=15 dB
A	2.0	27	9.8	----------	98.8	99.82	99.99	99.9998
	2.7	30.7	3.5	----------	----------	----------	----------	99.2
B	2.0	21.6	15.3	98.8	99.86	99.99	99.9998	----------
	2.7	24.6	9.6	----------	98.8	99.8	99.98	99.9998
C	2.0	9	27.6	99.92	99.994	99.9998	----------	----------
	2.7	11.7	22.4	99.6	99.98	99.999	99.9998	----------

Table 11c: Link Availability for a Type A System with MEL and Rician Fading
TS Antenna Elevation = 20 m

Terrain Category	Cell Radius (km)	Mean Excess Loss (dB)	Fade Margin (dB)	Link Availability (%)				
				K=5 dB	K=8 dB	K=10 dB	K=12 dB	K=15 dB
A	2.0	30.3	-1.7	----------	----------	----------	----------	----------
	2.7	33.9	-7.7	----------	----------	----------	----------	----------
B	2.0	24.8	3.9	----------	----------	----------	----------	99.6
	2.7	27.9	-1.7	----------	----------	----------	----------	----------
C	2.0	15	13.6	98.0	99.6	99.96	99.999	99.9998
	2.7	17.8	8.4	----------	----------	99.4	99.96	99.9993

Table 11d: Link Availability for a Type B System with MEL and Rician Fading
TS Antenna Elevation = 10 m

Terrain Category	Cell Radius (km)	Mean Excess Loss (dB)	Fade Margin (dB)	Link Availability (%)				
				K=5 dB	K=8 dB	K=10 dB	K=12 dB	K=15 dB
A	2.0	28.4	0.2	----------	----------	----------	----------	----------
	2.7	32	-5.6	----------	----------	----------	----------	----------
B	2.0	22.9	5.6	----------	----------	----------	99.2	99.986
	2.7	26	-0.2	----------	----------	----------	----------	----------
C	2.0	11.5	17	99.2	99.92	99.994	99.9998	----------
	2.7	14.3	11.8	----------	99.4	99.94	99.998	99.9998

Table 11e: Link Availability for a Type B System with MEL and Rician Fading
TS Antenna Elevation = 15 m

Terrain Category	Cell Radius (km)	Mean Excess Loss (dB)	Fade Margin (dB)	Link Availability (%)				
				K=5 dB	K=8 dB	K=10 dB	K=12 dB	K=15 dB
A	2.0	27	1.8	----------	----------	----------	----------	----------
	2.7	30.7	-4.5	----------	----------	----------	----------	----------
B	2.0	21.6	7.3	----------	----------	99.0	99.88	99.999
	2.7	24.6	1.6	----------	----------	----------	----------	----------
C	2.0	9	19.6	99.4	99.96	99.998	99.9998	----------
	2.7	11.7	14.4	98.4	99.82	99.986	99.9989	99.9997

Table 11f: Link Availability for a Type B System with MEL and Rician Fading
TS Antenna Elevation = 20 m

APPENDIX A TO ANNEX 1: COVERAGE AREA AVAILABILITY FOR THE IEEE 802.16 SUI CHANNEL MODELS USING MONTE CARLO SIMULATION TECHNIQUES

A.a) Simulation Model

The simulation model is illustrated on Figure 22. The cell is subdivided into segments whose angular width is θ. Within each segment, angular arcs are positioned at R_j multiples of 0.1 R_{max} where R_{max} is the radius of the cell. There are thus 10 arcs within each segment. Hence, there are 10 bounded sub-area limits within each segment. The area limits of each may be readily computed.

TS are assumed to be centrally positioned within each sub-area. For each TS, the transmission distance is computed. The impairments relative to LOS are then added. These include Mean Excess Loss (MEL), the random variations to MEL due to log-normal shadowing and the impact of Rician fading.

For a given simulation, MEL and Rician K are set to the values specified for the SUI channel models. A standard deviation of $\sigma = 9$ dB is set for log-normal shadowing. This is a mid-range value of the range set for the SUI models. A random deviate procedure is employed to create shadow loss and Rician K signal variations. For MEL estimates, the CS antenna elevation was set to 30 m and the TS antenna elevation and gain set to the indicated values.

Setting $\theta = 1$ degree results in 3600 estimates of signal level. When the signal level of an estimate is found to be less than the specified performance threshold, the sub-area associated with the estimate is accumulated in an "excluded area" running total. At the completion of a simulation, the ratio of the running total to the cell area defines the % of the cell that cannot meet coverage requirements for 99.999% availability.

The TS antenna RPEs are those derived from ITU-R F.1336 (see Figure 1), while antenna gain is kept fixed at 16 dBi as for general system assumptions in **Table 1**.

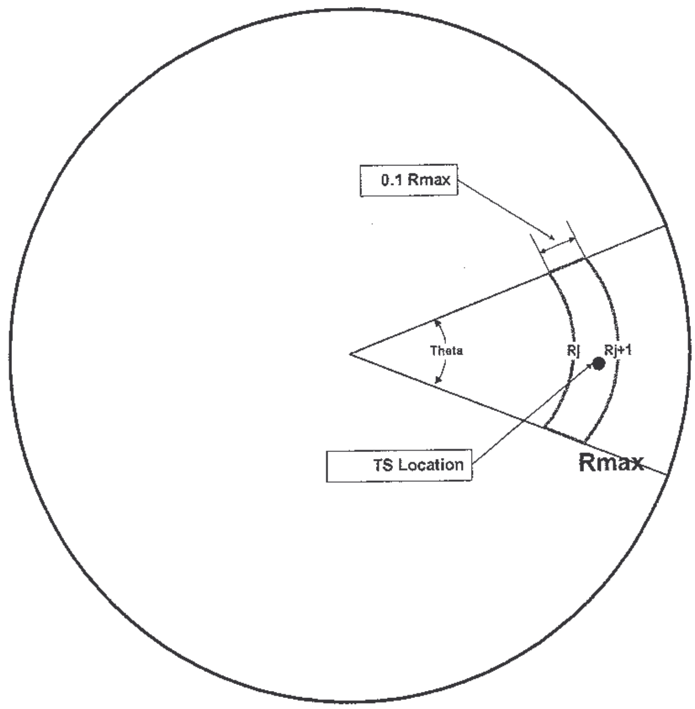


Figure 22: Simulation Model

A.b) Mean Excess Loss (MEL) only

When only MEL was considered, there were no exposures found that exceeded the performance threshold of Type A Systems. Table 12 and Table 13 illustrate the simulation results for covered areas of Type B systems. Log-normal shadowing and Rician fading are excluded.

SUI Terrain Category	Excluded Area (%)		
	TS antenna class TS 2 *(ITU-R RPE G=+16 dBi)*	TS2/TS3 intermediate RPE *(ITU-R RPE G= +18 dBi)*	TS antenna class TS 3 *(ITU-R RPE with G= +20 dBi)*
A	18.8	0	0
B	0	0	0
C	0	0	0

Table 12: Type B System MEL Excluded Area for R_{max}= 2.0 km, TS Antenna Elevation = 10 m

TS Antenna Elevation (m)	SUI Terrain Category	Excluded Area (%)		
		TS antenna class TS 2 *(ITU-R RPE G=16 dBi)*	TS2/TS3 intermediate *(ITU-R RPE G= +18 dBi)*	TS antenna class TS 3 *(ITU-R RPE with G=20 dBi)*
10	A	51	37.3	35.5
	B	19	0	0
	C	0	0	0
15	A	39.6	36	19
	B	0	0	0
	C	0	0	0
20	A	36	19	0
	B	0	0	0
	C	0	0	0

Table 13: Type B System MEL Excluded Area for R_{max} = 2.7 km

A.c) Mean Excess Loss and Log-Normal Shadowing

Table 14 through Table 17 show the results of the simulations when both MEL and log-normal shadowing are considered. As previously noted, the standard deviation for the log-normal fading was set to σ = 9 dB.

With the inclusion of log-normal shadowing, it is apparent that even a Type A system will begin to experience coverage problems. This is constrained to Terrain Category A and R_{max} = 2.7 km.

Due to reduced threshold, coverage issues for Type B systems are significantly increased. Referenced to Table 16 and Table 17, both 2.0 km and 2.7 km cell radius designs exceed coverage objectives in Terrain Categories A and B.

TS Antenna Elevation (m)	SUI Terrain Category	Excluded Area (%)		
		TS antenna class TS 2 *(ITU-R RPE G=16 dBi)*	TS2/TS3 intermediate *(ITU-R RPE G= +18 dBi)*	TS antenna class TS 3 *(ITU-R RPE with G=20 dBi)*
10	A	8.9	5.7	2.8
	B	2.8	1.9	1.2
	C	0.2	0	0
15	A	5.9	3.9	1.5
	B	1.9	1.1	0.45
	C	0	0	0
20	A	4.1	2.6	1.5
	B	1.6	0.6	0
	C	0	0	0

Table 14: Type A System Excluded Area Due to MEL and Log-Normal Shadowing (R_{max} = 2.0 km)

TS Antenna Elevation (m)	SUI Terrain Category	Excluded Area (%)		
		TS antenna class TS 2 *(ITU-R RPE G=16 dBi)*	**TS2/TS3 intermediate** *(ITU-R RPE G= +18 dBi)*	**TS antenna class TS 3** *(ITU-R RPE with G=20 dBi)*
10	**A**	22.0	16.8	13.4
	B	8.7	6.3	4.3
	C	0.7	0.5	0
15	**A**	17.2	11.85	9.4
	B	6.9	4.0	3.5
	C	0	0.36	0
20	**A**	12.8	8.1	6.2
	B	5.5	2.9	2.3
	C	0	0	0

Table 15: Type A System Excluded Area Due to MEL and Log-Normal Shadowing (R_{max} = 2.7 km)

TS Antenna Elevation – m	SUI Terrain Category	Excluded Area (%)		
		TS antenna class TS 2 *(ITU-R RPE G=16 dBi)*	**TS2/TS3 intermediate** *(ITU-R RPE G= +18 dBi)*	**TS antenna class TS 3** *(ITU-R RPE with G=20 dBi)*
10	**A**	26.8	20.1	16.8
	B	12.8	9.7	6.2
	C	1.9	1.4	1.0
15	**A**	20.3	16.0	11.9
	B	9.0	6.9	4.2
	C	0.8	0.46	0
20	**A**	17.3	13.1	9.3
	B	7.6	5.0	4.2
	C	0.5	0	0

Table 16: Type B System Excluded Area Due to MEL and Log-Normal Shadowing (R_{max} = 2.0 km)

TS Antenna Elevation (m)	SUI Terrain Category	Excluded Area (%)		
		TS antenna class TS 2 *(ITU-R RPE G=16 dBi)*	**TS2/TS3 intermediate RPE** *(ITU-R RPE G= +18 dBi)*	**TS antenna class TS 3** *(ITU-R RPE with G=20 dBi)*
10	**A**	44.6	39.9	33.4
	B	29	23.0	19.0
	C	5.9	4.0	3.2
15	**A**	39.2	33.6	26.4
	B	21.7	17.5	13.3
	C	3.1	1.8	1.2
20	**A**	35.4	29.2	23.3
	B	18.8	13.0	9.4
	C	1.8	0.6	0.6

Table 17: Type B System Excluded Area Due to MEL and Log-Normal Shadowing (R_{max} = 2.7 km)

A.d) Mean Excess, Log-Normal Shadowing and Rician Fading

Generally speaking, it is not appropriate to inter-relate space and time availability. However, in the NLOS transmission environment, Rician fading is constantly present. In the event that there is no motion associated with the reflective facets, it simply means that we are in a fixed up or down fade, subject to the vector addition of all of the signal components.
In order to examine the significance of Rician fading, its impact was examined for each of the SUI channel models by running 10 simulations for each channel model. The range of variation in the excluded area was noted and these are presented in Table 18 and Table 19 for R_{max} = 2 km. Table 20 and Table 21 examine the same scenarios for R_{max} = 2.7 km.

SUI Channel Model	Terrain Category	Rice K (dB)	Excluded Area Spread (%)
SUI-1	C	12	0.0 - 0.15
SUI-2	C	8	0.0 - 0.1
SUI-3	B	5	1.7 - 2.8
SUI-4	B	0	3.1 -4.2
SUI-5/6	A	0	6.9 - 8.5

Table 18: Impact of Rician Fading on Type A Systems (R_{max} = 2 km)

SUI Channel Model	Terrain Category	Rice K (dB)	Excluded Area Spread (%)
SUI-1	C	12	0.32 - 0.78
SUI-2	C	8	0.39 - 0.79
SUI-3	B	5	8.5 -9.8
SUI-4	B	0	11.0 - 12.4
SUI-5/6	A	0	20.6 - 22.9

Table 19: Impact of Rician Fading on Type B Systems (R_{max} = 2 km)

SUI Channel Model	Terrain Category	Rice K – (dB)	Excluded Area Spread (%)
SUI-1	C	12	0.04 - 0.36
SUI-2	C	8	0.16 - 0.46
SUI-3	B	5	5.4 - 6.7
SUI-4	B	0	7.2 - 9.2
SUI-5/6	A	0	16.6 - 20.1

Table 20: Impact of Rician Fading on Type A Systems (R_{max} = 2.7 km)

SUI Channel Model	Terrain Category	Rice K - dB	Excluded Area Spread (%)
SUI-1	C	12	1.9 - 2.8
SUI-2	C	8	2.0 - 3.2
SUI-3	B	5	20 -22.1
SUI-4	B	0	22.8 -25.2
SUI-5/6	A	0	38.0 -40.9

Table 21: Impact of Rician Fading on Type B Systems (R_{max} = 2.7 km)

A.e) Sensitivity Analysis for Mean Excess Loss and Log-Normal Shadowing

For the SUI Channel models, the measured data [6] identified a standard deviation for log-normal shadowing between 8.2 dB and 10.6 dB. In the preceding, a mid-range value of 9 dB was employed. Standard deviations of 5.2 dB and 6.6 dB have been considered in the current SE19 report. Table 22 identifies the simulation results when these standard deviation values are employed. Rician fading is excluded. The simulation results apply only to a Type B system and R_{max} = 2.7 km. They can be compared against the appropriate columns of Table 16 and Table 17

SUI Terrain Cat.	Excluded Area (%)			
	R_{max} = 2.0 km		R_{max} = 2.7 km	
	σ = 5.2 dB	σ = 6.6 dB	σ = 5.2 dB	σ = 6.6 dB
A	8.76	11.9	29.2	30.75
B	0.71	2.8	9.5	12.0
C	0	0.5	0.1	0.46

Table 22: Excluded Area vs. Log-Normal σ for Type B systems and R_{max} = 2.7 km

A.f) Simulation Caveat

Sections A.d) and A.e) do not cover all of the combinations as Sections A.b) and A.c): they are just "mid-range" values illustrative sensitivity analysis examples, with TS antenna height = 15 m and TS antenna gain = +18 dBi).

A close examination of the Tables might imply that there are some inconsistencies in the Table entries. However, this is not the case. For example, examine Table 13 and Table 17 for Terrain Type A and R_{max} =2.7 km. It may be noted that the Excluded Area is less when the MEL plus log-normal shadowing loss is considered compared to that just resulting from MEL. However, this is a quite possible result of simulation. The shadowing loss exhibits a random +/- variation about the mean value that can enhance the signal level of some links. The same may be said about Rician fading for which both up and down fades can occur.

ANNEX 2: TS TO CS INTERFERENCE EVALUATION

A2.1 Rural scenario

A2.1.1 System Model and Simulation Methodology

In subsequent sections, estimates of interference susceptibility are based on Monte Carlo simulations that identify the spatial probability of a victim link experiencing an excessive level of interference. Graphically, the simulation results are presented as an interference grade of service (GOS) probability shown as a Cumulative Distribution Function (CDF) vs. C/I.

The TS to CS system model is illustrated on Figure 23. It is computationally convenient to consider the overlaid sector/cell as being the victim. This is parametrised at some separation distance S between the two CS sites. Within the victim sector, all TS locations are assumed to employ distance proportional ATPC. Thus, all received signal levels from victim TS links are assumed to arrive at the victim CS at the same level of signal strength. Thus, it is only necessary to set a victim TS to CS signal level based on that of a single cell-edge victim link located at distance R_{max}.

Even for the rural environment, the link margin is modest; thus no cell edge ATPC is assumed. It is important to note that there is no valid technical reason to apply cell edge ATPC except for interference exposures associated with TS to TS couplings. These are considered to be quite rare. Maximising cell edge signal level reduces the sensitivity of CS to CS couplings (not examined in this report).

The number of randomly located interference TS locations within a sector is set to N_t. = 64. There is no statistical measurement data available to identify how these TS locations should be located. Two extreme possibilities can be considered. The first assumption might be to assume that the TS locations are randomly distance-proportionally located referenced to the maximum cell radius R_{max}. The second assumption is to assume that the TS locations are randomly area-proportionally located. In this latter case, approximately 50 % of TS locations would be expected to be located at greater than $0.75R_{max}$. Only the area proportional assumption will be subsequently examined.

To account for the assumption that there is no operator co-ordination, the relative boresight alignment of the two CS antennas is considered to be unknown. A simulation run is configured to spin the relative sector alignment in 5 degree increments. A complete simulation run thus consists of $360/5*N_t$ interference estimates (N_t = 64, resulting in 4608 interference estimates).

In the rural environment, only LOS transmission is considered. Thus, the only fading mechanism considered to be applicable is that of atmospheric Rayleigh multipath. Generally speaking, it is not statistically appropriate to mix spatial link availability with time varying availability. However, we will examine this situation, with the caveat that it only applies during the time intervals when Rayleigh fading occurs.

Due to the distance differentials associated with the victim and interference paths, uncorrelated Rayleigh fading is ensured. To account for Rayleigh fading, it is necessary to generate random Rayleigh deviates that are created from the uniform random deviates available with computational machine programs. The procedure is based on the Acceptance-Rejection method as detailed in [3] and is summarised in Appendix A to Annex 2.

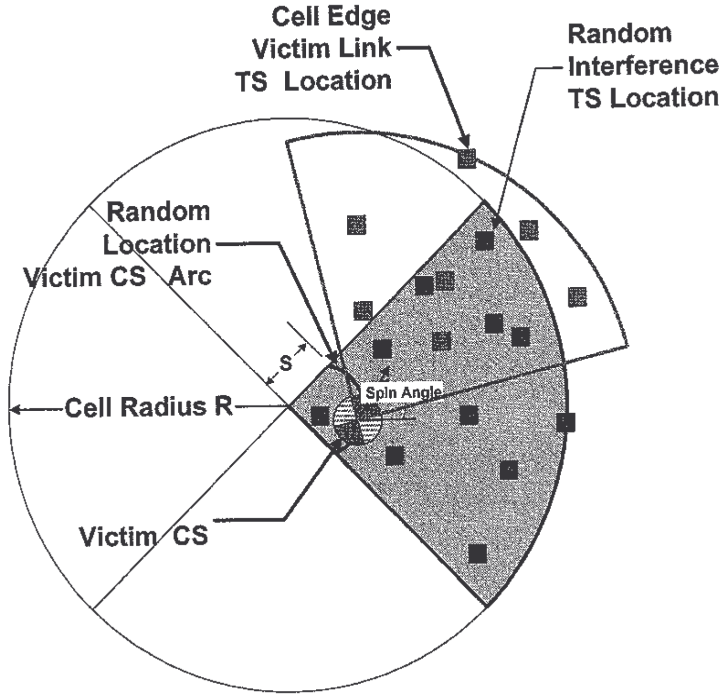


Figure 23: Simulation Model

The inclusion of Rayleigh fading adds considerable complexity to the simulation model. It is best described by reference to Figure 24. It is no longer valid to assign the victim TS to be at distance R_{max}. Only one victim TS is active during a given TDMA time block. As the magnitude of Rayleigh fading is distance related, we should now place the victim TS at some random distance R_v from it's serving CS. To establish link loss, we must now do the following:

- Compute FSL based on the distance R_v.
- Adjust the FSL signal level PT_v so that it is reduced to be ATPC distance proportional, i.e., by $20\log(R_v/R_{max})$.
- Determine the Rayleigh fading adjustment as discussed above. Modify the value of PT_v accordingly.
- Adjust the victim TX signal level via ATPC so that it adjusts to the FSL margin level set at R_{max}. If the Rayleigh fade impairment exceeds this adjustment, then set the victim TX power to be at its maximum level.

This sets the TX power level of the victim link transmitter. However, we now have to examine the TX power of the interference link. Given that we have a local meteorological environment that induces Rayleigh fading on the victim link, it is quite valid to assume that the same conditions apply to the interference link. But we now have two transmission paths to consider. Referenced to Figure 24, the first of these is the link between the interference TS and it's serving CS. For any one of the N_t interference TS's, located at some random distance R0, the uncorrelated Rayleigh fading signal level adjustment is described as above. This fixes the TX power level PT_i of any single interference link.

However, the interference coupling path is a different uncorrelated Rayleigh path at a distance R_i. Employing the same methodology as previously described, a new Rayleigh fading adjustment is determined for this path. Given that both the uncorrelated Rayleigh faded victim signal level (C) and the interference signal (I) can now be computed, the C/I of each interference estimate can be determined.

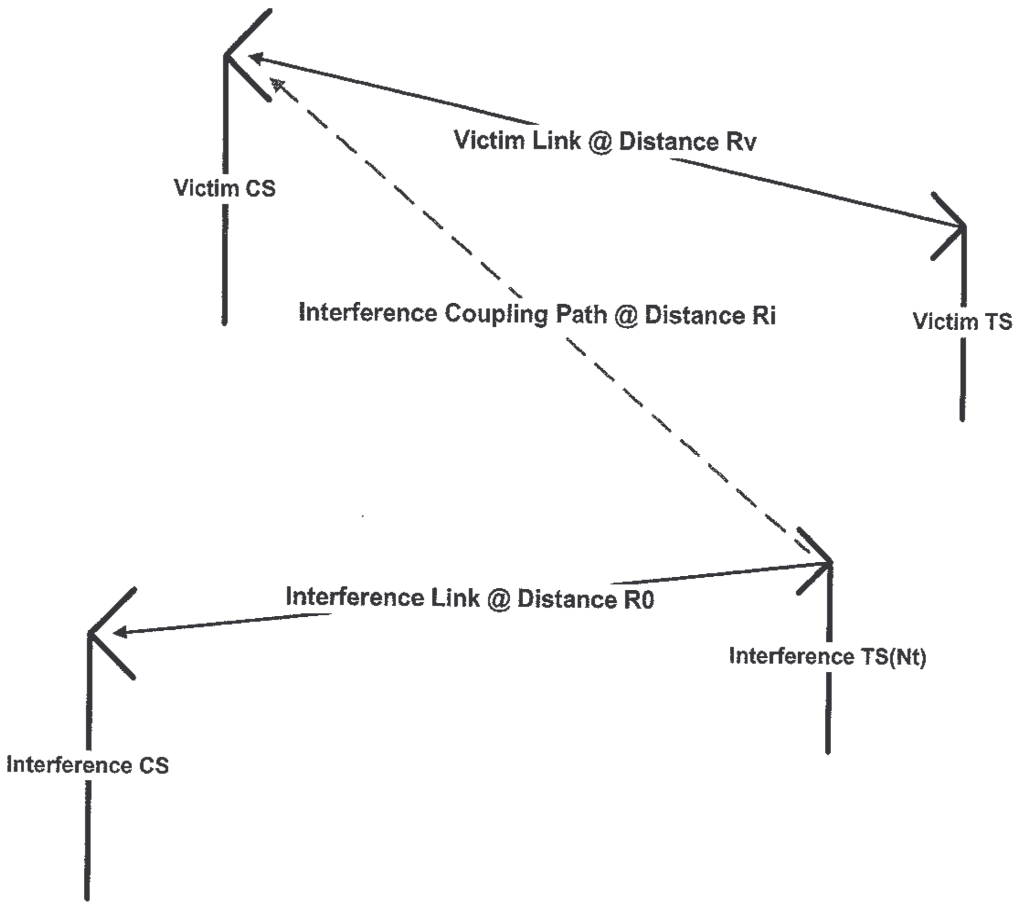


Figure 24: Rayleigh Faded Interference Model

A2.1.2 Unfaded Simulation Results

For a cell size of Rmax = 8.9 km, Figure 25 trough Figure 28 illustrate the Monte Carlo simulation results (unfaded) with antenna classes TS2 to TS3 (i.e. with typical RPE derived from ITU-R F.1336 TS antenna using Gain = 16, 18 and 20 dBi).

In each figure a value of NFD has been selected, identifying the minimum NFD requirement to "hit" the ~ 1% CDF at the C/I critical threshold for the system types reported in Table 1.

Figure 25 applies to S being between 3 to 6 km while Figure 26 applies to a CS separation distance S from 0.1 to 2 km. A comparative examination of Figure 25 and Figure 26 indicates that the poorest CDF results occur when S is large. These differences can be explained as follows:

- When S is small, and both the interference and victim CS antennas are partially aligned, a high percentage of the interference TS links are illuminated by the victim CS antenna. Also, when S is small, FSL is comparable on both links and TS Antenna RPE is modest. With ATPC, both interference and victim link signals would be expected to arrive at the victim CS at comparable levels. Hence, the major difference in signal level is that of NFD and, as shown on Figure 26, there is a resultant sharp "knee" in the C/I in the vicinity of the NFD value.
- As S increases, conflicting geometrical results occur. Some interference TS locations are essentially eliminated as they are behind the victim CS antenna. As well, as interference TS distance from victim CS decreases, angles increase, and the RPE rejection of the interference TS increases, thus further reducing the number of serious interference exposures. Countering this, is relative distance proportional ATPC. It now becomes modest on the interference links, thus setting up an increase in signal level differentials. The C/I "knee" is thus diminished while the percentage of C/I exposures above the knee is reduced. However the level, and percentage of worst case C/I exposures, will increase, as shown on Figure 25.

Hence in the subsequent simulations (Figure 27 and Figure 28), we will only present the S > 3 km case, which controls the NFD requirement.

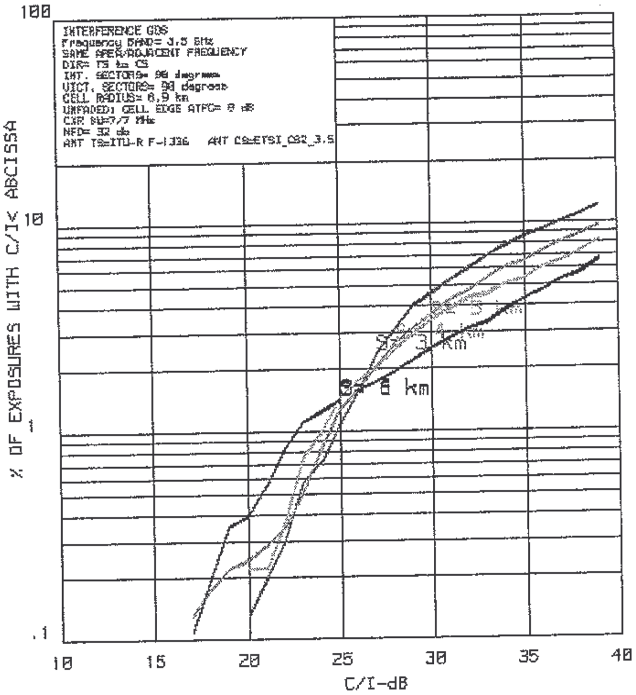


Figure 25 . Unfaded CDF (S > 3 km, NFD = 32 dB)
(TS 2 antenna class *(ITU-R RPE G=16 dBi)*)

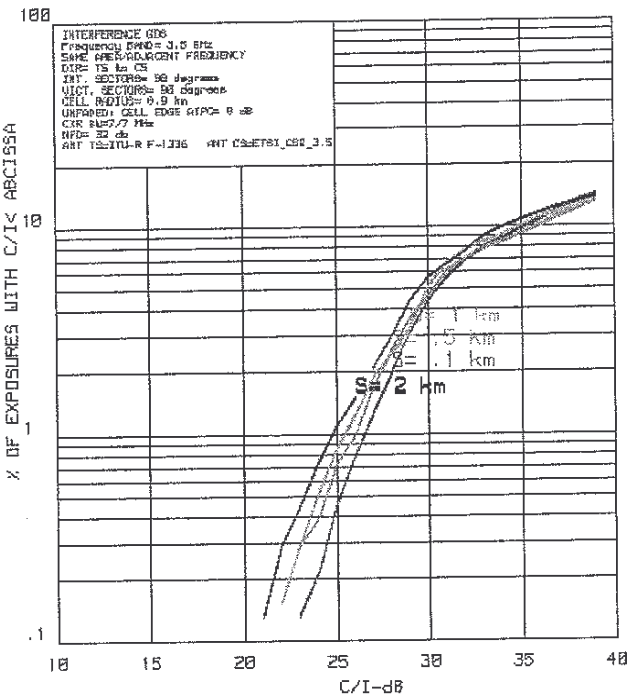


Figure 26: Unfaded CDF S < 2 km, NFD = 32 dB)
(TS 2 antenna class *(ITU-R RPE G=16 dBi)*)

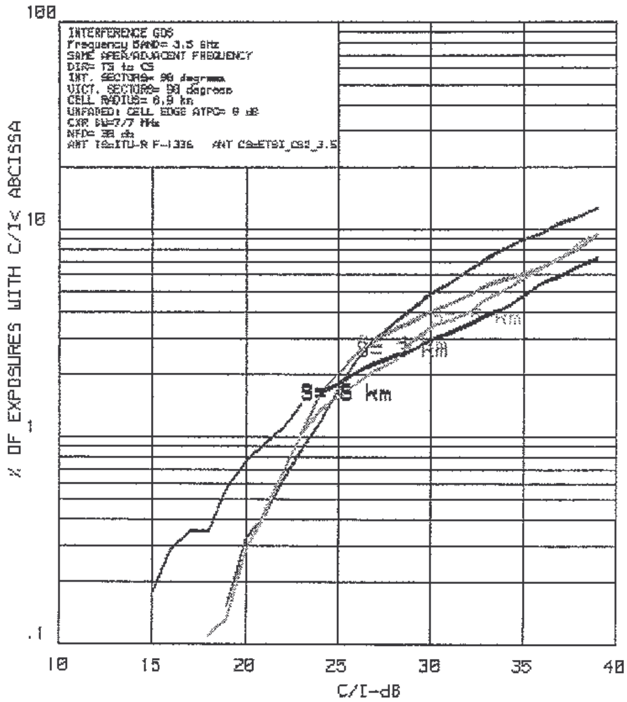


Figure 27: Unfaded CDF (S > 3 km, NFD = 30 dB)
(TS2/TS3 intermediate RPE ***(ITU-R RPE G= +18 dBi)*****)**

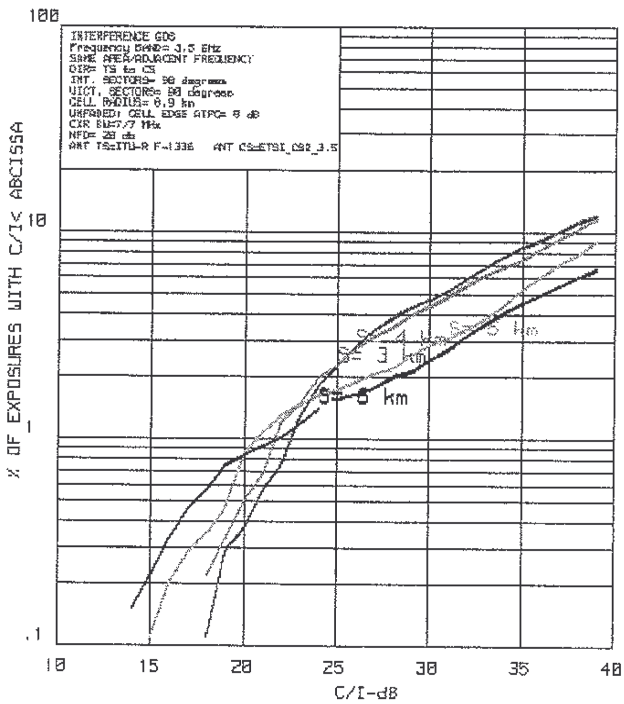


Figure 28: Unfaded CDF (S > 3 km, NFD = 28 dB)
(TS 3 antenna class ***(ITU-R RPE G=20 dBi)*****)**

A2.1.3 Rayleigh Faded Simulation Results

Figure 29through Figure 32 illustrate the results for the case where the Rayleigh fading distance probability coefficient d_{coeff} is set to 3.. As compared to the unfaded case, the CDF impairments resulting from uncorrelated Rayleigh fading are quite modest.

To explain this somewhat surprising result, we first note that the median level p.d.f. crossover for Rayleigh occurs at 63%. But this also means that 37% of the links will be in excess of the median level. For the interference links, these TS transmitters are ATPC adjusted to be lower in power. They thus transmit at a lower power than in the unfaded coexistence scenario.

For the victim links, a statistical examination of the ATPC adjusted signal level was performed. Here, it was found that 24% of the victim links were required to operate at maximum power. For the remainder, the distance proportional ATPC range was sufficient to restore the signal level to its unfaded margin level. However, 50% of these maximum power links were within 3 dB of the unfaded signal margin. Thus, a high percentage of victim links arrive at close to the same signal level as that for the unfaded scenario.

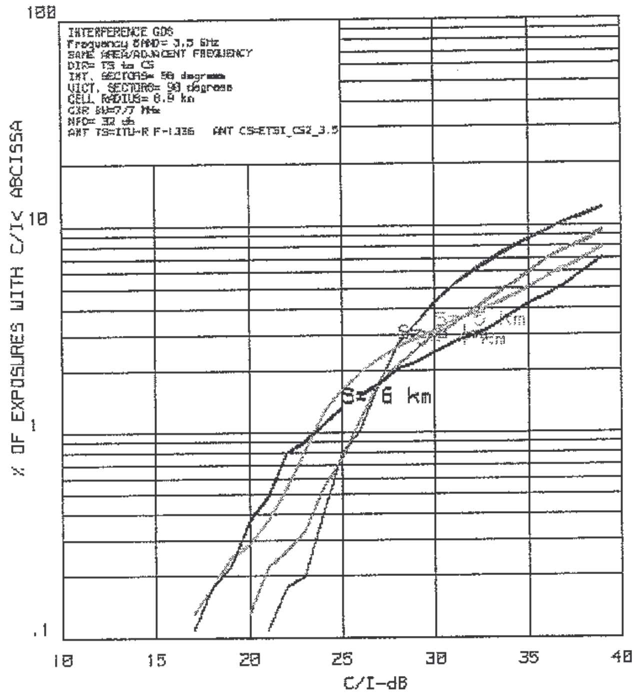


Figure 29: Rayleigh Faded CDF (S > 3 km, NFD = 32 dB)
(TS 2 antenna class *(ITU-R RPE G=16 dBi)*)

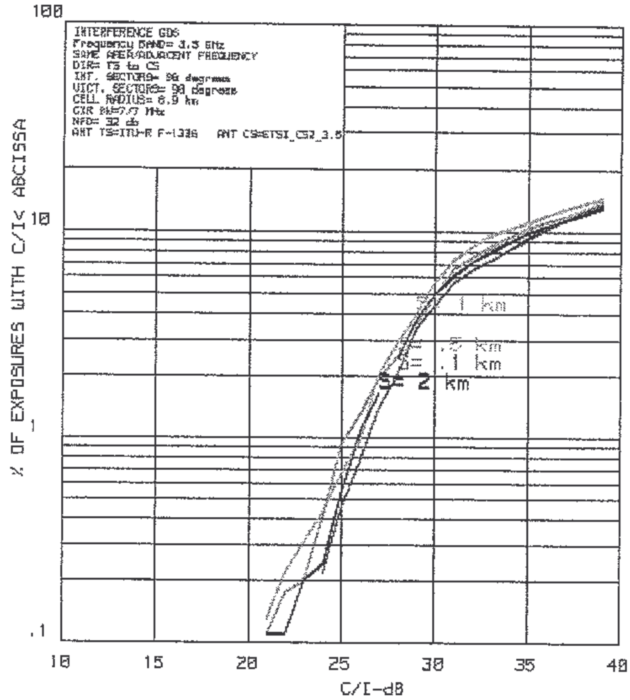


Figure 30: Rayleigh Faded CDF (S < 2 km, NFD = 32 dB)
(TS 2 antenna class *(ITU-R RPE G=16 dBi)*)

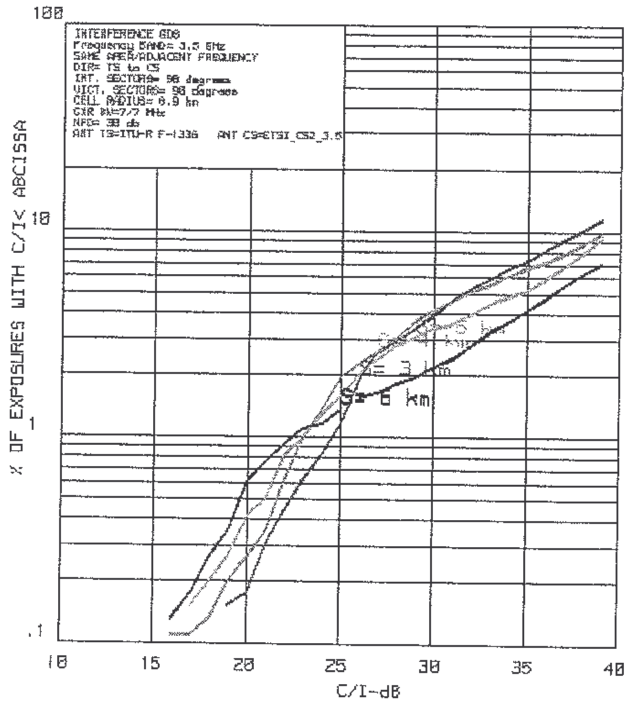


Figure 31: Rayleigh Faded CDF (S > 3 km, NFD = 30 dB)
(TS2/TS3 intermediate RPE *(ITU-R RPE G= +18 dBi)*)

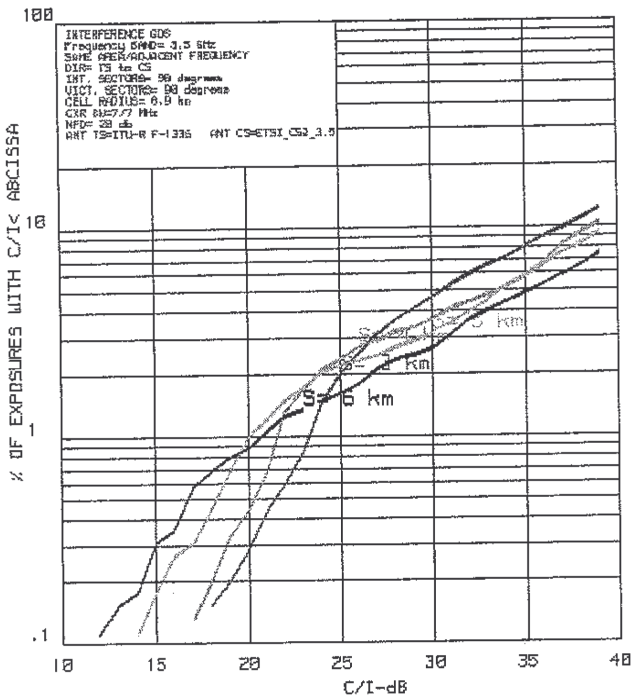


Figure 32: Rayleigh Faded CDF (S > 3 km, NFD = 28 dB)
(TS 3 antenna class *(ITU-R RPE G=20 dBi)*)

A2.1.4 Conclusions

It is concluded that the NFD values summarised in the following Table 23 are acceptable values for the TS emissions associated with TS to CS interference couplings in the rural scenario.

TS antenna class	**TS antenna class TS 2** *(ITU-R RPE G=16 dBi)*	**TS2/TS3 intermediate RPE** *(ITU-R RPE G= +18 dBi)*	**TS antenna class TS 3** *(ITU-R RPE with G=20 dBi)*
Minimum NFD required for Type B System (dB)	32	30	28

Table 23: Minimum NFD required for Type B Systems Rural scenario

A2.2 Urban Scenario

A2.2.1 Simulation Methodology

The simulation model is comparable to that described in section A2.1 and Figure 24 for the rural scenario. Again, there are three transmission paths to consider. These are the victim link at distance R_v, the interference link at distance R_0 and the interference-coupling path at distance R_i. For each interference computation it is necessary to set the TX power of the TS for the first two links. The procedure is as follows:

- Compute FSL based on the distance R_x equal to R_v or R_0.
- Adjust the FSL signal level so that it is reduced to be distance proportional, i.e., $20\log(R_x/R_{max})$.
- Compute the mean excess path loss based on the distance R_x.
- Compute the mean value of Rician K based on distance R_x and relative to the SUI value for K, as specified for the cell edge at R_{max}.
- Determine the Rician fading adjustment by the random deviate method.
- Adjust the RX signal level to account for both mean excess loss and Rician fading.
- Readjust the TX signal levels via ATPC so that some signal margin above the threshold level is restored. This would typically be somewhere between 6 dB and 15 dB. As subsequently discussed, the simulations found some degree of C/I performance sensitivity referenced to the margin value selected.
- Set the TS - TX Power level accordingly. If the ATPC range is insufficient to achieve the specified margin, then set the TX power to P_{max}.

The TX power of both the interference and victim links is now set. The signal level of the interference-coupling path at distance R_i is now determined based on the procedure for computation of excess loss and Rician fading described. The C/I for each interference estimate can now be determined.

A2.2.2 Simulation Results

A2.2.2.1 Unfaded

Figure 33 through Figure 44 in this section illustrate the CDF vs. C/I results for:

- Rice factor K = 30 dB. For this K value, the probability of a deep fade is extremely low. Hence, this is essentially the case without fading.
- R_{max} = 2.7 km. and R_{max} = 2.0 km
- Different TS antenna heights (15 and 20 m)
- Different TS antenna classes TS2 to TS3 (i.e. with typical RPE derived from ITU-R F.1336 TS antenna using Gain = 16, 18 and 20 dBi, still with fixed 16 dBi boresight gain).

Each time, in the presented simulations the NFD used correspond to the minimum required to "hit" the ~ 1% of cases with C/I over the critical C/I threshold for the system type as reported in **Table 1**.

Performance degrades noticeably as CS separation distance S increases. This is a result of the excess loss differential and can be explained as follows:

- When S is small, a large number of interference and victim links are at a comparable distance from their serving CS sites. Consequently, excess loss is comparable on both interference and victim links.
- When S is large, there are fewer interference links that can illuminate the victim CS. But for those that do so, the interference distance is small; thus setting up an excess loss differential that strongly favours the interference link.

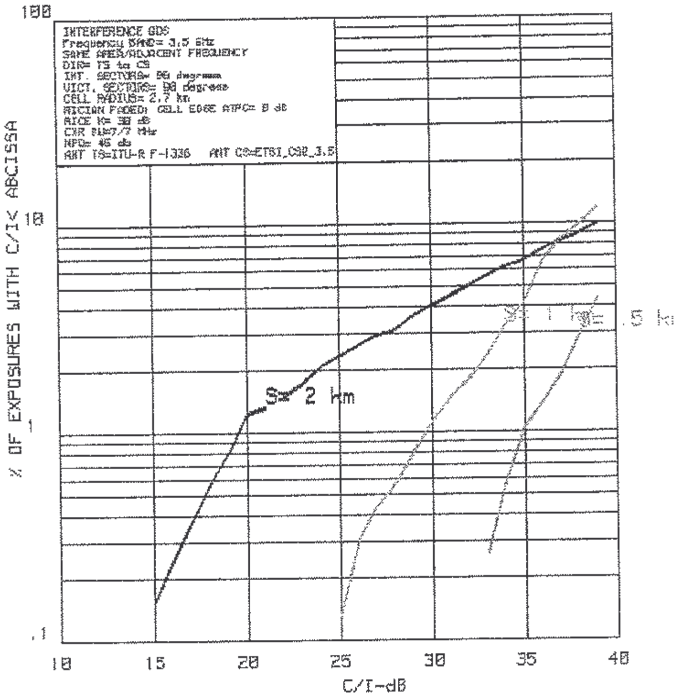


Figure 33: Mean Excess Loss-based CDF R_{max} = 2.7 km, TS Ant Elev = 15 m, NFD = 45 (TS 2 antenna class *(ITU-R RPE G=16 dBi)*)

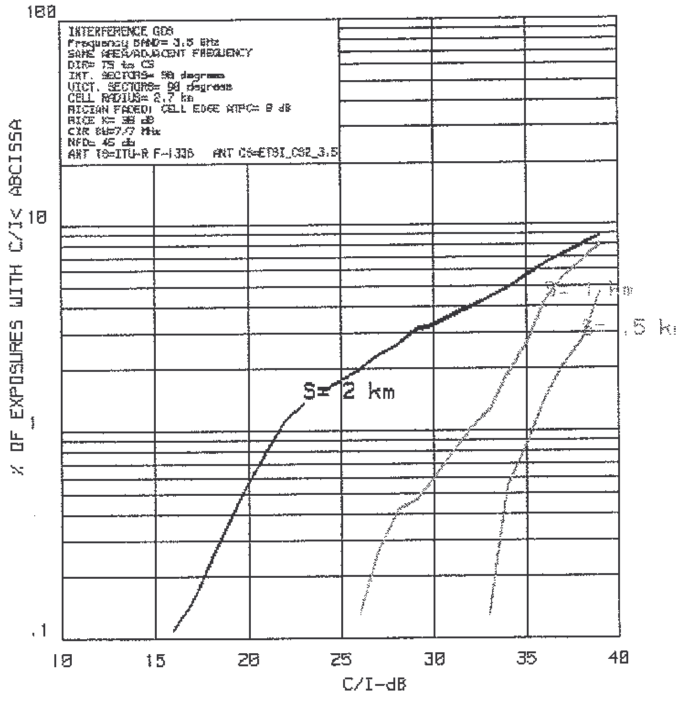


Figure 34: Mean Excess Loss-based CDF R_{max} = 2.7 km, TS Ant Elev = 15 m, NFD = 45 dB (TS2/TS3 intermediate RPE *(ITU-R RPE G= +18 dBi)*)

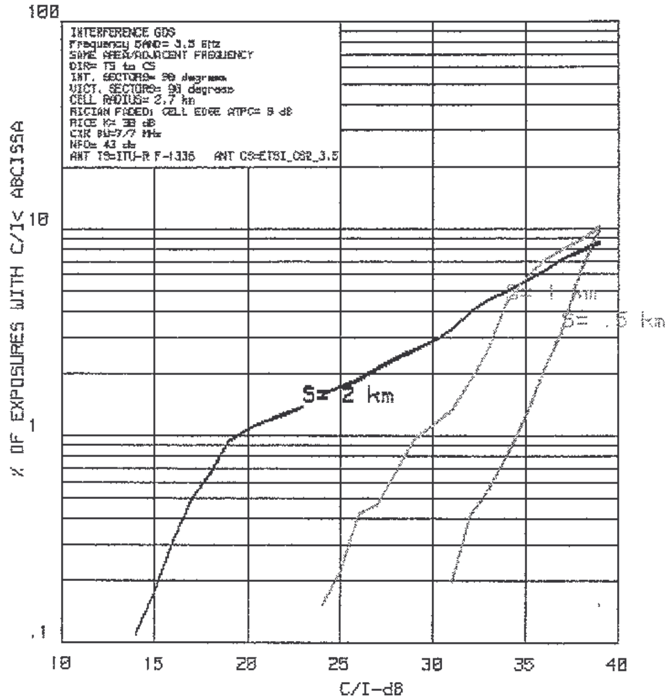


Figure 35: Mean Excess Loss-based CDF R_{max} = 2.7 km, TS Ant Elev = 15 m, NFD = 43 dB (TS 3 antenna class *(ITU-R RPE G=20 dBi)*)

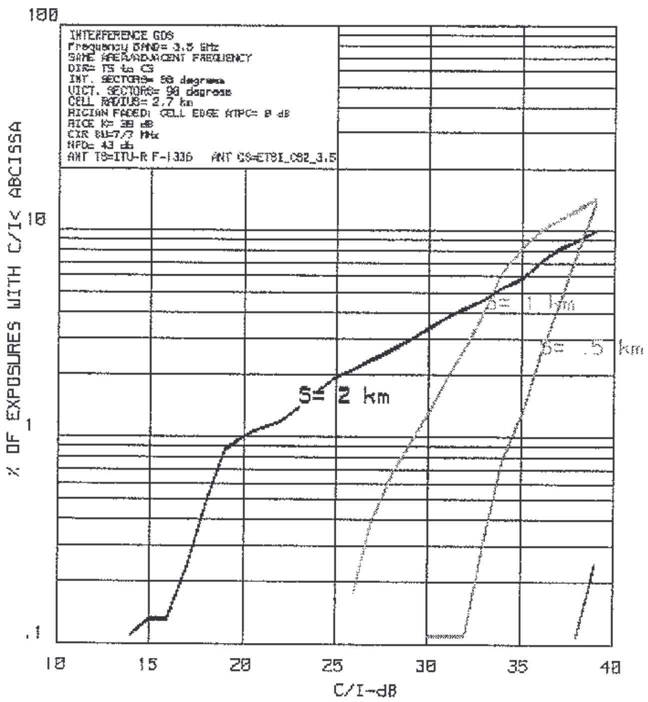


Figure 36: Mean Excess Loss based CDF R_{max} = 2.7 km, TS Ant Elev = 20 m, NFD = 43 dB (TS 2 antenna class *(ITU-R RPE G=16 dBi)*)

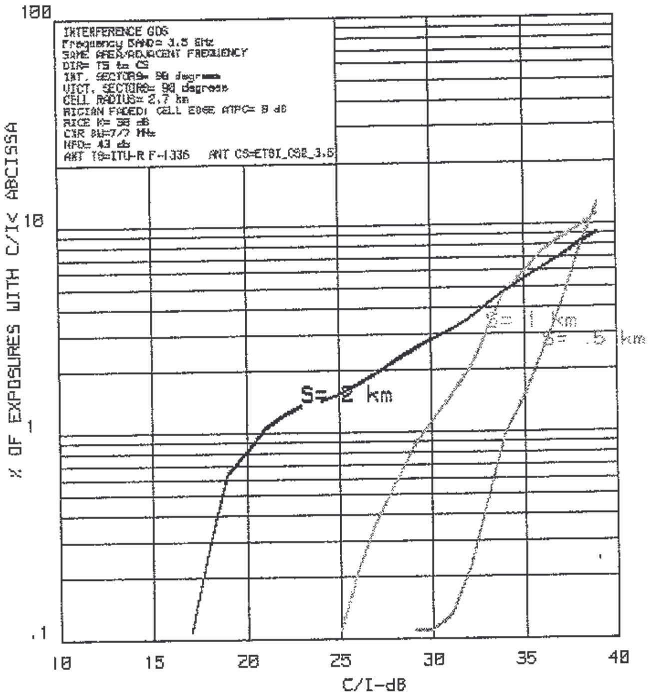


Figure 37: Mean Excess Loss based CDF R_{max} = 2.7 km, TS Ant Elev = 20 m, NFD = 43 dB (TS2/TS3 intermediate RPE ***(ITU-R RPE G= +18 dBi)*****)**

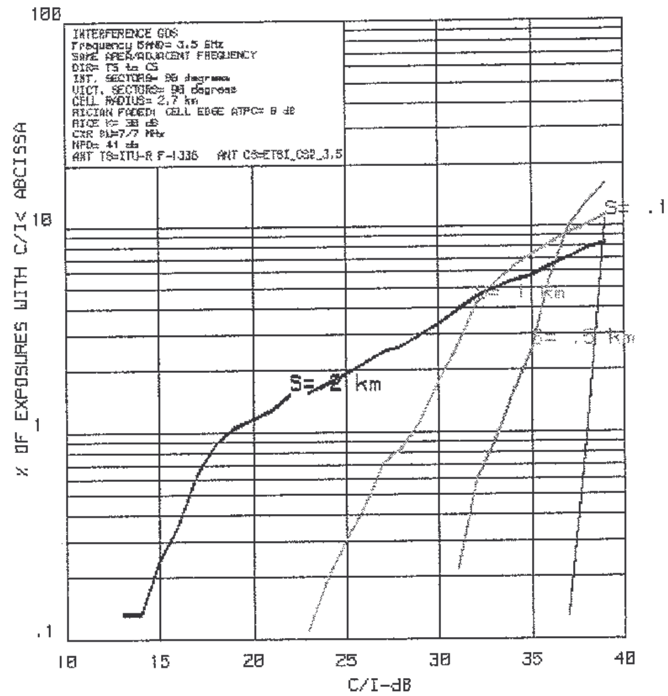


Figure 38: Mean Excess Loss based CDF R_{max} = 2.7 km, TS Ant Elev = 20 m, NFD = 41 dB (TS 3 antenna class ***(ITU-R RPE G=20 dBi)*****)**

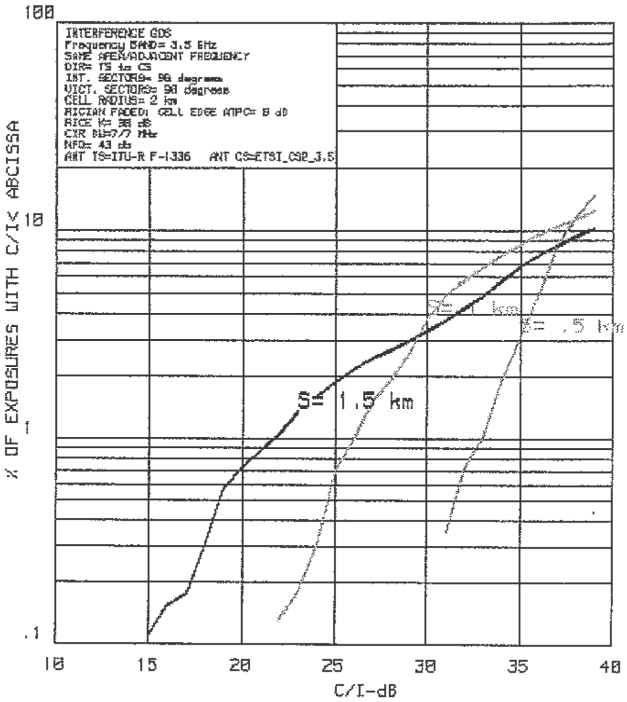


Figure 39: Mean Excess Loss based CDF R_{max} = 2.0 km, TS Ant Elev = 15 m, NFD = 43 dB (TS 2 antenna class *(ITU-R RPE G=16 dBi)*)

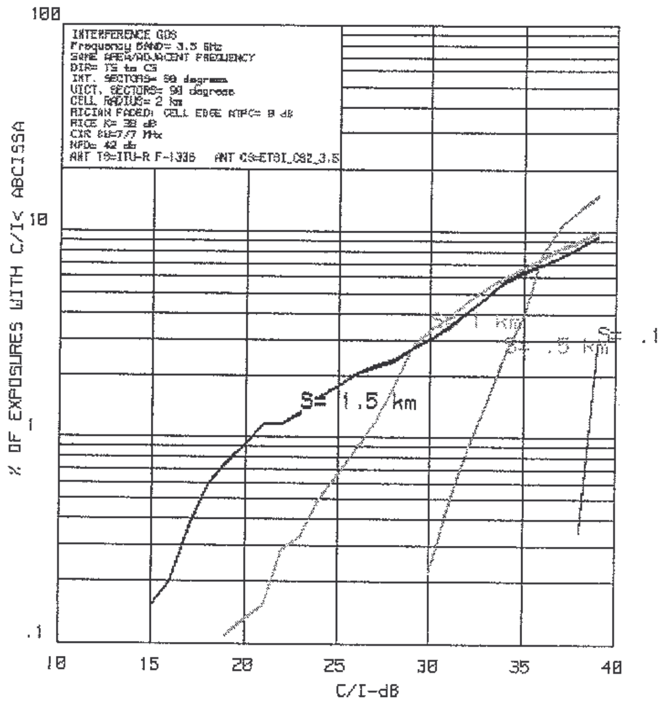


Figure 40: Mean Excess Loss based CDF R_{max} = 2.0 km, TS Ant Elev = 15 m, NFD = 42 dB (TS2/TS3 intermediate RPE *(ITU-R RPE G= +18 dBi)*)

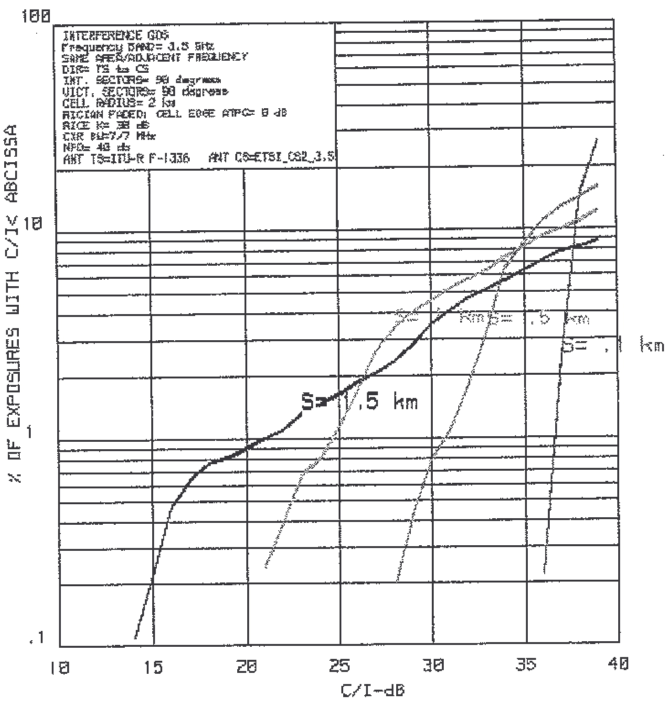


Figure 41: Mean Excess Loss based CDF R_{max} = 2.0 km, TS Ant Elev = 15 m, NFD = 40 dB (TS 3 antenna class *(ITU-R RPE G=20 dBi)*)

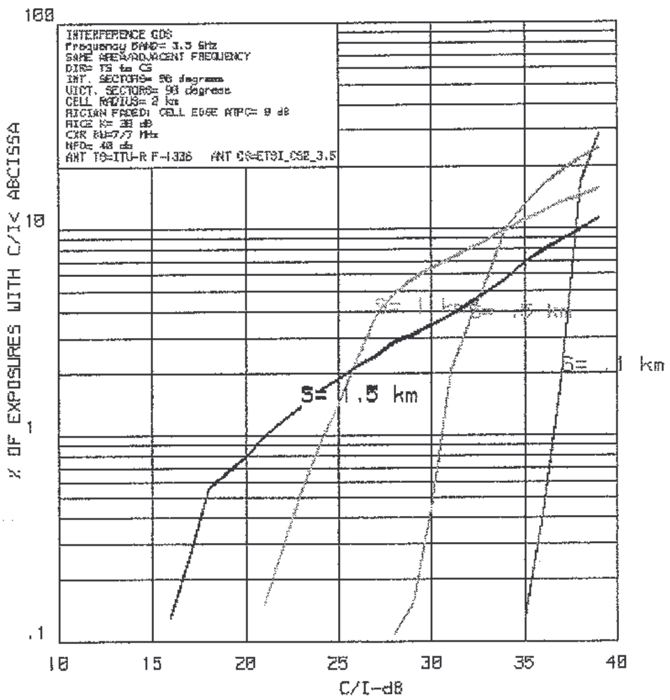


Figure 42: Mean Excess Loss based CDF R_{max} = 2.0 km, TS Ant Elev = 20 m, NFD = 40 dB (TS 2 antenna class *(ITU-R RPE G=16 dBi)*)

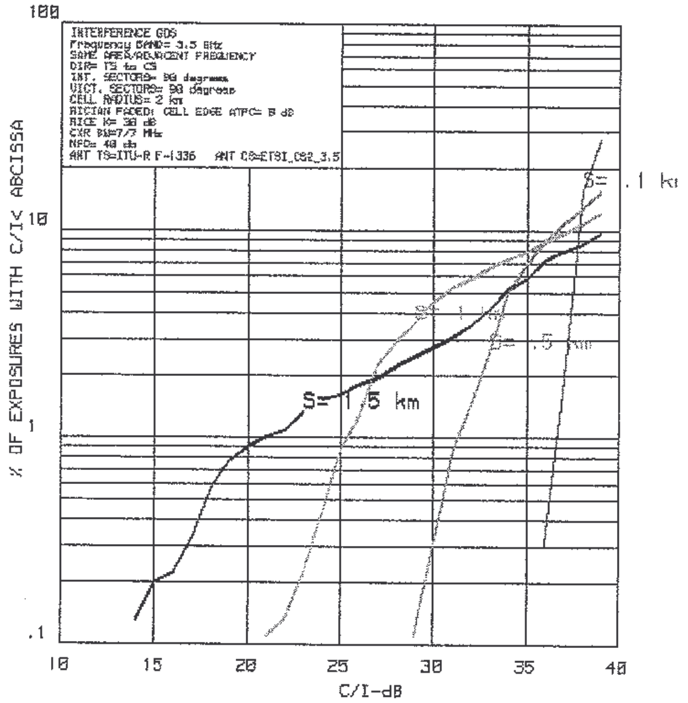


Figure 43: Mean Excess Loss based CDF R_{max} = 2.0 km, TS Ant Elev = 20 m, NFD = 40 dB (TS2/TS3 intermediate RPE ***(ITU-R RPE G= +18 dBi)*****)**

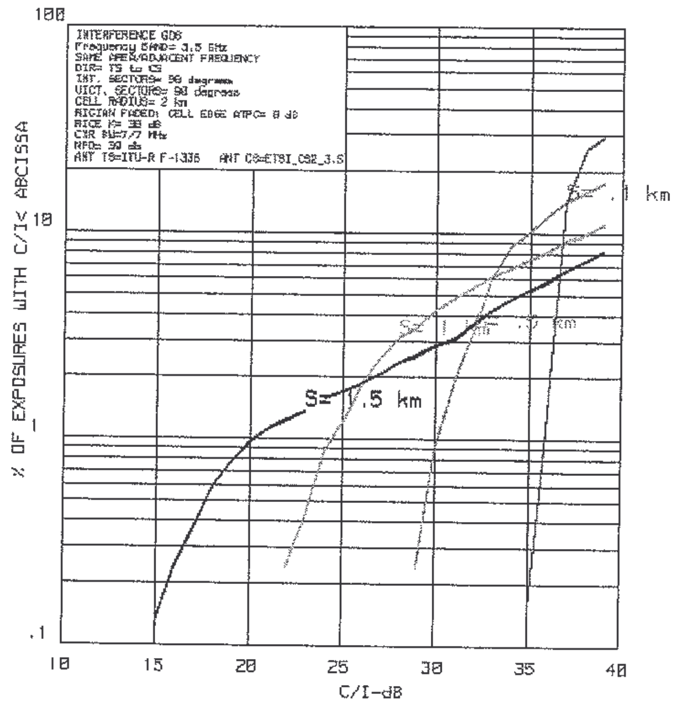


Figure 44: Mean Excess Loss based CDF R_{max} = 2.0 km, TS Ant Elev = 20 m, NFD = 39 dB (TS 3 antenna class ***(ITU-R RPE G=20 dBi)*****)**

The following Table 24 summarizes, for the most critical system type B, the main findings, in terms of minimum required NFD value, for the various configurations in the urban scenario:

	TS Antenna Height (m) ⇩	TS Antenna class		
		TS antenna class TS 2 *(ITU-R RPE G=16 dBi)*	TS2/TS3 intermediate RPE *(ITU-R RPE G= +18 dBi)*	TS antenna class TS 3 *(ITU-R RPE with G=20 dBi)*
		Minimum NFD value required (dB) ⇩		
System Type B (Cell size 2.7 km)	**15**	45	45	43
	20	43	43	41
System Type B (Cell size 2.0 km)	**15**	43	42	40
	20	40	40	39

Table 24: Minimum NFD required for Type B Systems Urban scenario

In case of 4-QAM system (system type A), there is an 8 dB increase in system gain. Thus, the critical receiver levels drop to 14.2 dB and 20.2 dB and the CDFs values improve.

A2.2.2.2 Rician Faded

If we run simulations for the SUI-1 channel model with cell edge Rice K = 12 dB, with cell radius R_{max} = 2.7 km, except for differences in detail, there will be very little difference between the previous unfaded results and the Rician faded case. This result is expected, Rician fading is modest for K = 12 dB. As well, the uncorrelated fading relationship results in an "averaging out" of fading differentials between the interference and victim paths. Coexistence performance criteria are thus dominated by the excess loss differential associated with near-NLoS transmission.

For simulation for a cell radius of R_{max} = 2 km, a SUI-2 channel is assumed with a mean value of Rice K equal to 9 dB at cell edge. Note that the maximum value for S has to be reduced to 1.5 km, reflecting the smaller value of R_{max}.

In spite of the reduced value of K, the results will be little changed from those of the previous SUI-1 case. Due to the smaller cell size, excess path loss at cell edge is reduced, resulting in a larger fade margin. As the excess loss differential was previously concluded to control CDF vs. C/I performance, this loss differential reduction is sufficient to offset the increased probability of deep fades.

A2.2.3 Conclusions

From the preceding analysis and simulations, the following may be concluted:

1. The system gain set for the asumed transmission model constrains near-NLoS operation to be within the SUI-1 and SUI-2 transmission environment. To operate in more severe near-NLoS environments, additional system gain is required. While means exist to provide some increase in system gain, they are outside the scope of this Report.
2. With the use of ITU-R F.1336 TS antenna RPE, representative of reasonably designed ETSI antennas, a NFD between 40 dB and 45 dB looks adequate for acceptable percentages of interference impairment, depending both on antenna gain and TS antenna heights.

APPENDIX A TO ANNEX 2: ACCEPTANCE-REJECTION METHOD

i. Generate three uniform random deviates U1, U2, U3. U3 is a spare deviate to be subsequently described.
ii. Let F_{max} be the maximum value of a normalized Rayleigh distribution.
iii. Compute a probability point $P_r(3U2)$ based on the Rayleigh probability equation and within a finite truncated range for U2. Setting the range for U2 to be within (0, 3) allows Rayleigh fades to span the range from $-\infty$ to +10 dB.
iv. Examine the ratio $u = P_r(3U2)/ F_{max}$. If the ratio u is less than U1, then accept U2 as the random deviate. If not, then reject the triplet and start again.
v. Once accepted as a valid Rayleigh deviate, the adjustment to the FSL signal level is 20log(U2).

Random deviate U3 was not required in the preceding. However, once U1 and U2 are accepted, the associated U3 value is employed to identify the probability of Rayleigh fading at some transmission distance R_x. For Rayleigh fading, the probability of it's occurrence is known to vary as the 3rd power of the distance [4], [5]. The simulation assumptions are as follows:

a) Under Rayleigh fading conditions, set the probability of a Rayleigh fade at maximum distance R_{max} to be $\rho(R_{max}) = 1$. For some lesser distance, say R_x, set the probability to be $\rho(R_x) = (R_x / R_{max})^{d_{coeff}}$, where $d_{coeff} = 3$.
b) Compare the value of $\rho(R_x)$ with that of U3. If U3 > $\rho(R_x)$, then conclude that there is no Rayleigh fading on the link. If U3 < $\rho(R_x)$, then set the Rayleigh fading adjustment to be that given by step v. above.

ANNEX 3: EXAMPLES FOR MANAGING A BLOCK-EDGE MASK

In the following graphs the proposed block-edge mask is provided against the FDMA type A equipment for 7 MHz channels.

As an example, simple Tchebyschef channel filters with 3 to 6 cavities have been applied to the spectrum mask (assumed un-filtered in ETSI EN). The result in terms of the maximum EIRP allowed by the mask is shown in Figure 45. Without extra filtering system it could be placed only at 10.5 MHz from the edge and transmit -20 dBW/MHz (i.e. ~+18 dBm EIRP only). With the simplest 3 cavity extra filtering at the same distance from edge, the EIRP might increase up to + 2 dBW/MHz and with only 4 cavity the full proposed + 14 dBW/MHz could be reached.

As a second example, in Figure 46 systems at maximum proposed EIRP are allowed to be placed nearer to block-edge as far as the filter complexity increases (e.g. from 10.5 to 5.5 MHz).

RF filters up to 6 cavities are considered common technology in these frequency bands; cheap and relatively low loss could be achieved within small dimension (important for TS applications).

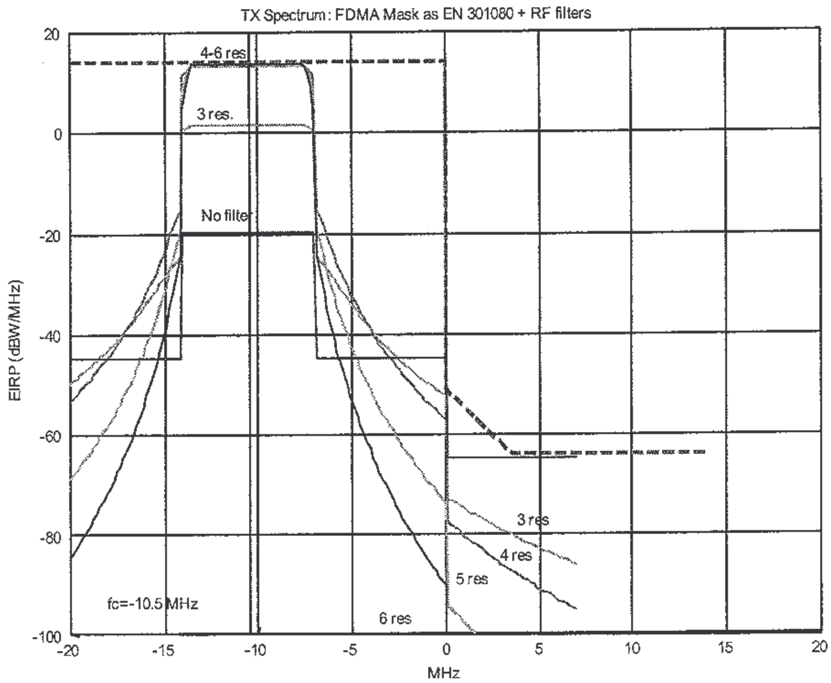


Figure 45: Example of increasing EIRP with RF filtering at same edge distance

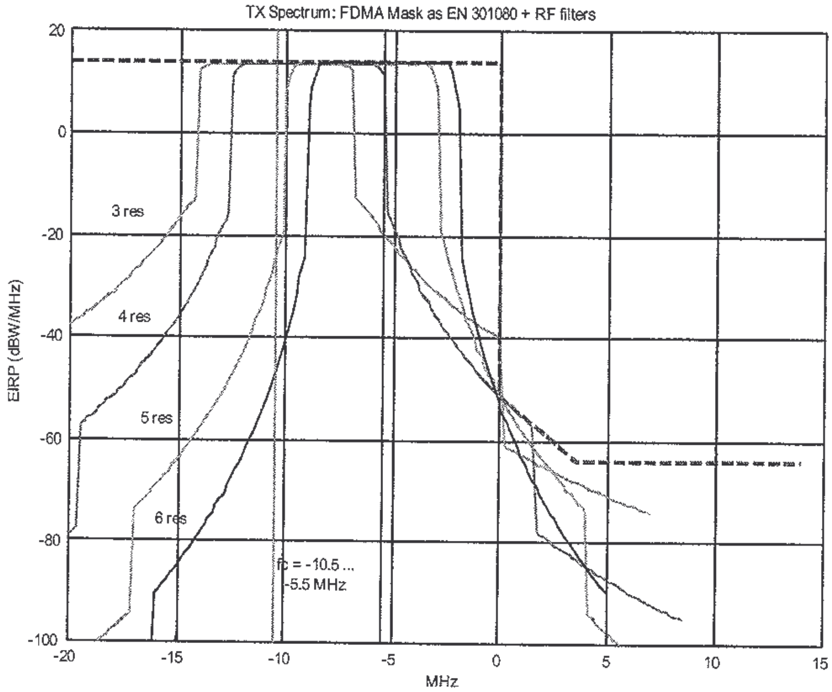


Figure 46: Example of decreasing edge distance with RF filtering at same max EIRP

REFERENCES:

[1] Y. Okumura, E. Ohmori, T. Kawano, K. Fukuda "Field Strength and its Variability in VHF and UHF land-Mobile Radio Service" (in "Communication Channels: Characterization and Behaviour", Editor B. Goldberg, IEEE Press 1976).

[2] J.D. Parsons "The Mobile Radio Propagation Channel" Pentech Press, London.

[3] S. R. Saunders "Antennas and Propagation for Wireless Communication Systems" J. Wiley & Sons.

[4] IEEE 802.16.3c-01/29r4, Channel Models for Fixed Wireless Applications, 2001-07-17.

[5] SE19(02)107 Rural Area TS to CS Coexistence Requirements at 3.5 GHz.

[6] ETSI EN 302 085 v1.1.2,(2001-02) Fixed Radio Systems; Point-to-Multipoint Antennas; Antennas for point-to-multipoint fixed radio systems in the 3 GHz to 11 GHz band.

[7] Coexistence Same Area Simulations at 3.5 GHz (Inbound), C802.16.2a-02/08,02/03/16.

Anlage 1/Anhang D

Schutz von Peilempfangsanlagen

Zum Schutz der nachstehend angeführten stationären Peilempfangsanlagen der Fernmeldebehörden darf an den angegebenen Standorten der durch die Sendeanlagen verursachte Spitzenwert der Feldstärke, gemessen mit der jeweiligen systemspezifische Bandbreite, den Wert von 105 dBµV/m nicht überschreiten.

Wien

16E20 08	48N15 45	1190	WIEN, Krapfenwaldgasse 17
16E22 39	48N14 24	1200	WIEN, Höchstädtplatz 3
16E15 43	48N13 04	1140	WIEN, Ulmenstraße 160
16E23 09	48N12 35	1030	WIEN, Hintere Zollamtstraße 2b
Niederösterreich			
16E28 43	48N19 40	2201	GERASDORF, Peilstelle Seyring (EZ 146/2)
14E48 24	48N00 12	3332	ROTTE, Nöchling Nr. 5
Oberösterreich			
14E16 02	48N17 52	4020	LINZ, Freinbergstraße 22
14E01 31	48N14 54	4611	SCHARTEN, Hochscharten 3
Salzburg			
13E02 44	47N49 14	5020	SALZBURG, Mittelstraße 17
13E02 20	47N48 05	5020	SALZBURG, Mönchsberg 35
13E26 02	47N46 35	5360	ST.GILGEN, Schafberg/Berghotel
Tirol			
11E26 23	47N15 56	6020	INNSBRUCK, Valiergasse 60
11E22 51	47N18 43	6020	INNSBRUCK, Hafelekar/Berghütte
11E33 19	47N15 12	6060	HALL, Tulferberg, Tulfes 59
Vorarlberg			
09E43 05	47N29 32	6900	BREGENZ, Holzackergasse 25
09E39 38	47N26 49	6890	LUSTENAU, Hagen-Silo
09E38 36	47N29 06	6972	FUSSACH, Peilstelle
Steiermark			
15E25 49	47N02 07	8055	GRAZ, Triester Straße 280
15E29 14	47N05 01	8010	GRAZ-RIES, Ledermoarweg 19
15E27 13	46N46 52	8442	KITZECK IM SAUSAL, Steinriegel 11
15E54 51	47N31 49	8253	WALDBACH, Hochwechsel-Aspangberg (Wetterkoglerhaus)
Kärnten			
14E18 21	46N37 24	9010	KLAGENFURT, Dr. Herrmann-Gasse 4
14E18 07	46N36 25	9020	KLAGENFURT, Südring 240
13E51 34	46N36 46	9500	VILLACH, Dr. Semmelweißstraße 18
14E29 43	46N38 07	9131	GRAFENSTEIN, Thon 21

(Koordinatenangaben nach WGS84)

Anlage 1/Anhang E

Verzeichnis der Bezirke und Gemeinden der Regionen

Region 1

ABBILDUNG 1: REGION 1

Die folgende Tabelle enthält die der Region 1 zugeordneten Bezirke:

Bezirks ID	Bezirk	Bundesland
101	Eisenstadt (Stadt)	Burgenland
102	Rust (Stadt)	Burgenland
103	Eisenstadt-Umgebung	Burgenland
106	Mattersburg	Burgenland
107	Neusiedl am See	Burgenland
108	Oberpullendorf	Burgenland
301	Krems an der Donau (Stadt)	Niederösterreich

Bezirks ID	Bezirk	Bundesland
302	Sankt Pölten (Stadt)	Niederösterreich
303	Waidhofen an der Ybbs (Stadt)	Niederösterreich
304	Wiener Neustadt (Stadt)	Niederösterreich
306	Baden	Niederösterreich
307	Bruck an der Leitha	Niederösterreich
308	Gänserndorf	Niederösterreich
309	Gmünd	Niederösterreich
310	Hollabrunn	Niederösterreich
311	Horn	Niederösterreich
312	Korneuburg	Niederösterreich
313	Krems (Land)	Niederösterreich
314	Lilienfeld	Niederösterreich
315	Melk	Niederösterreich
316	Mistelbach	Niederösterreich
317	Mödling	Niederösterreich
318	Neunkirchen	Niederösterreich
319	Sankt Pölten (Land)	Niederösterreich
320	Scheibbs	Niederösterreich
321	Tulln	Niederösterreich
322	Waidhofen an der Thaya	Niederösterreich
323	Wiener Neustadt (Land)	Niederösterreich
324	Wien Umgebung	Niederösterreich
325	Zwettl	Niederösterreich
901	Wien Innere Stadt	Wien
902	Wien Leopoldstadt	Wien
903	Wien Landstraße	Wien
904	Wien Wieden	Wien
905	Wien Margareten	Wien
906	Wien Mariahilf	Wien
907	Wien Neubau	Wien
908	Wien Josefstadt	Wien
909	Wien Alsergrund	Wien
910	Wien Favoriten	Wien
911	Wien Simmering	Wien
912	Wien Meidling	Wien
913	Wien Hietzing	Wien

Bezirks ID	Bezirk	Bundesland
914	Wien Penzing	Wien
915	Wien Rudolfsheim-Fünfhaus	Wien
916	Wien Ottakring	Wien
917	Wien Hernals	Wien
918	Wien Währing	Wien
919	Wien Döbling	Wien
920	Wien Brigittenau	Wien
921	Wien Floridsdorf	Wien
922	Wien Donaustadt	Wien
923	Wien Liesing	Wien

TABELLE 1: BEZIRKE VON REGION 1

In der folgenden Tabelle sind jene Gemeinden der Region 1 aufgelistet, welche neben den oben aufgelisteten Bezirken der Region zugeordnet wurden:

Bezirks ID	Bezirk	Gemeinde ID	Gemeinde	Bundesland
305	Amstetten	30501	Allhartsberg	Niederösterreich
305	Amstetten	30502	Amstetten	Niederösterreich
305	Amstetten	30503	Ardagger	Niederösterreich
305	Amstetten	30504	Aschbach-Markt	Niederösterreich
305	Amstetten	30507	Biberbach	Niederösterreich
305	Amstetten	30510	Ertl	Niederösterreich
305	Amstetten	30511	Euratsfeld	Niederösterreich
305	Amstetten	30512	Ferschnitz	Niederösterreich
305	Amstetten	30516	Hollenstein an der Ybbs	Niederösterreich
305	Amstetten	30517	Kematen an der Ybbs	Niederösterreich
305	Amstetten	30520	Neuhofen an der Ybbs	Niederösterreich
305	Amstetten	30521	Neustadtl an der Donau	Niederösterreich
305	Amstetten	30522	Oed-Oehling	Niederösterreich
305	Amstetten	30524	Opponitz	Niederösterreich
305	Amstetten	30532	Seitenstetten	Niederösterreich
305	Amstetten	30533	Sonntagberg	Niederösterreich
305	Amstetten	30526	St.Georgen am Reith	Niederösterreich
305	Amstetten	30527	St.Georgen am Ybbsfeld	Niederösterreich
305	Amstetten	30536	Viehdorf	Niederösterreich
305	Amstetten	30538	Wallsee-Sindelburg	Niederösterreich
305	Amstetten	30541	Winklarn	Niederösterreich

Bezirks ID	Bezirk	Gemeinde ID	Gemeinde	Bundesland
305	Amstetten	30542	Wolfsbach	Niederösterreich
305	Amstetten	30543	Ybbsitz	Niederösterreich
305	Amstetten	30544	Zeillern	Niederösterreich
612	Liezen	61205	Altenmarkt bei St.Gallen	Steiermark
612	Liezen	61210	Gaishorn am See	Steiermark
612	Liezen	61211	Gams bei Hieflau	Steiermark
612	Liezen	61219	Johnsbach	Steiermark
612	Liezen	61221	Landl	Steiermark
612	Liezen	61230	Palfau	Steiermark
612	Liezen	61239	St.Gallen	Steiermark
612	Liezen	61246	Treglwang	Steiermark
612	Liezen	61248	Wießenbach an der Enns	Steiermark
612	Liezen	61250	Weng bei Admont	Steiermark
612	Liezen	61251	Wildalpen	Steiermark
411	Perg	41102	Arbing	Oberösterreich
411	Perg	41108	Bad Kreuzen	Oberösterreich
411	Perg	41103	Baumgartenberg	Oberösterreich
411	Perg	41104	Dimbach	Oberösterreich
411	Perg	41105	Grein	Oberösterreich
411	Perg	41107	Klam	Oberösterreich
411	Perg	41112	Mitterkirchen im Machland	Oberösterreich
411	Perg	41113	Münzbach	Oberösterreich
411	Perg	41115	Pabneukirchen	Oberösterreich
411	Perg	41123	Saxen	Oberösterreich
411	Perg	41119	St.Georgen am Walde	Oberösterreich
411	Perg	41121	St.Nikola an der Donau	Oberösterreich
411	Perg	41122	St.Thomas am Blasenstein	Oberösterreich
411	Perg	41125	Waldhausen im Strudengau	Oberösterreich
415	Steyr-Land	41505	Gaflenz	Oberösterreich
415	Steyr-Land	41519	Weyer Land	Oberösterreich
415	Steyr-Land	41520	Weyer Markt	Oberösterreich

TABELLE 2: ZUGEORDNETE GEMEINDEN VON REGION 1

Region 2

ABBILDUNG 2: REGION 2

Die folgende Tabelle enthält die der Region 2 zugeordneten Bezirke:

Bezirks ID	Bezirk	Bundesland
401	Linz (Stadt)	Oberösterreich
402	Steyr (Stadt)	Oberösterreich
403	Wels (Stadt)	Oberösterreich
404	Braunau am Inn	Oberösterreich
405	Eferding	Oberösterreich
406	Freistadt	Oberösterreich
407	Gmunden	Oberösterreich

Bezirks ID	Bezirk	Bundesland
408	Grieskirchen	Oberösterreich
409	Kirchdorf an der Krems	Oberösterreich
410	Linz-Land	Oberösterreich
412	Ried im Innkreis	Oberösterreich
413	Rohrbach	Oberösterreich
414	Schärding	Oberösterreich
416	Urfahr-Umgebung	Oberösterreich
417	Vöcklabruck	Oberösterreich
418	Wels-Land	Oberösterreich
501	Salzburg (Stadt)	Salzburg
502	Hallein	Salzburg
503	Salzburg-Umgebung	Salzburg
504	Sankt Johann im Pongau	Salzburg

TABELLE 3: BEZIRKE VON REGION 2

In der folgenden Tabelle sind jene Gemeinden der Region 2 aufgelistet, welche neben den oben aufgelisteten Bezirken der Region zugeordnet wurden:

Bezirks ID	Bezirk	Gemeinde ID	Gemeinde	Bundesland
305	Amstetten	30506	Behamberg	Niederösterreich
305	Amstetten	30508	Ennsdorf	Niederösterreich
305	Amstetten	30509	Ernsthofen	Niederösterreich
305	Amstetten	30514	Haag	Niederösterreich
305	Amstetten	30515	Haidershofen	Niederösterreich
305	Amstetten	30529	St.Pantaleon-Erla	Niederösterreich
305	Amstetten	30530	St.Peter in der Au	Niederösterreich
305	Amstetten	30531	St.Valentin	Niederösterreich
305	Amstetten	30534	Strengberg	Niederösterreich
305	Amstetten	30539	Weistrach	Niederösterreich
612	Liezen	61228	Öblarn	Steiermark
612	Liezen	61201	Admont	Steiermark
612	Liezen	61202	Aich	Steiermark
612	Liezen	61203	Aigen im Ennstal	Steiermark
612	Liezen	61204	Altaussee	Steiermark
612	Liezen	61206	Ardning	Steiermark
612	Liezen	61207	Bad Aussee	Steiermark

Bezirks ID	Bezirk	Gemeinde ID	Gemeinde	Bundesland
612	Liezen	61226	Bad Mitterndorf	Steiermark
612	Liezen	61208	Donnersbach	Steiermark
612	Liezen	61209	Donnersbachwald	Steiermark
612	Liezen	61212	Gössenberg	Steiermark
612	Liezen	61213	Gröbming	Steiermark
612	Liezen	61214	Großsölk	Steiermark
612	Liezen	61215	Grundlsee	Steiermark
612	Liezen	61216	Hall	Steiermark
612	Liezen	61217	Haus	Steiermark
612	Liezen	61218	Irdning	Steiermark
612	Liezen	61220	Kleinsölk	Steiermark
612	Liezen	61222	Lassing	Steiermark
612	Liezen	61223	Liezen	Steiermark
612	Liezen	61224	Michaelerberg	Steiermark
612	Liezen	61225	Mitterberg	Steiermark
612	Liezen	61227	Niederöblarn	Steiermark
612	Liezen	61229	Oppenberg	Steiermark
612	Liezen	61233	Pichl-Kainisch	Steiermark
612	Liezen	61232	Pichl-Preunegg	Steiermark
612	Liezen	61235	Pürgg-Trautenfels	Steiermark
612	Liezen	61234	Pruggern	Steiermark
612	Liezen	61236	Ramsau am Dachstein	Steiermark
612	Liezen	61237	Rohrmoos-Untertal	Steiermark
612	Liezen	61238	Rottenmann	Steiermark
612	Liezen	61242	Schladming	Steiermark
612	Liezen	61243	Selzthal	Steiermark
612	Liezen	61240	St.Martin am Grimming	Steiermark
612	Liezen	61241	St.Nikolai im Sölktal	Steiermark
612	Liezen	61244	Stainach	Steiermark
612	Liezen	61245	Tauplitz	Steiermark
612	Liezen	61247	Trieben	Steiermark
612	Liezen	61252	Wörschach	Steiermark
612	Liezen	61249	Wießenbach bei Liezen	Steiermark
411	Perg	41101	Allerheiligen/Mühlkreis	Oberösterreich

Bezirks ID	Bezirk	Gemeinde ID	Gemeinde	Bundesland
411	Perg	41106	Katsdorf	Oberösterreich
411	Perg	41109	Langenstein	Oberösterreich
411	Perg	41110	Luftenberg an der Donau	Oberösterreich
411	Perg	41111	Mauthausen	Oberösterreich
411	Perg	41114	Naarn im Machlande	Oberösterreich
411	Perg	41116	Perg	Oberösterreich
411	Perg	41117	Rechberg	Oberösterreich
411	Perg	41118	Ried in der Riedmark	Oberösterreich
411	Perg	41124	Schwertberg	Oberösterreich
411	Perg	41120	St.Georgen an der Gusen	Oberösterreich
411	Perg	41126	Windhaag bei Perg	Oberösterreich
415	Steyr-Land	41501	Adlwang	Oberösterreich
415	Steyr-Land	41502	Aschach an der Steyr	Oberösterreich
415	Steyr-Land	41503	Bad Hall	Oberösterreich
415	Steyr-Land	41504	Dietach	Oberösterreich
415	Steyr-Land	41506	Garsten	Oberösterreich
415	Steyr-Land	41507	Großraming	Oberösterreich
415	Steyr-Land	41508	Laussa	Oberösterreich
415	Steyr-Land	41509	Losenstein	Oberösterreich
415	Steyr-Land	41510	Maria Neustift	Oberösterreich
415	Steyr-Land	41511	Pfarrkirchen bei Bad Hall	Oberösterreich
415	Steyr-Land	41512	Reichraming	Oberösterreich
415	Steyr-Land	41513	Rohr im Kremstal	Oberösterreich
415	Steyr-Land	41515	Schiedlberg	Oberösterreich
415	Steyr-Land	41516	Sierning	Oberösterreich
415	Steyr-Land	41514	St.Ulrich bei Steyr	Oberösterreich
415	Steyr-Land	41517	Ternberg	Oberösterreich
415	Steyr-Land	41518	Waldneukirchen	Oberösterreich
415	Steyr-Land	41521	Wolfern	Oberösterreich

TABELLE 4: ZUGEORDNETE GEMEINDEN VON REGION 2

Region 3

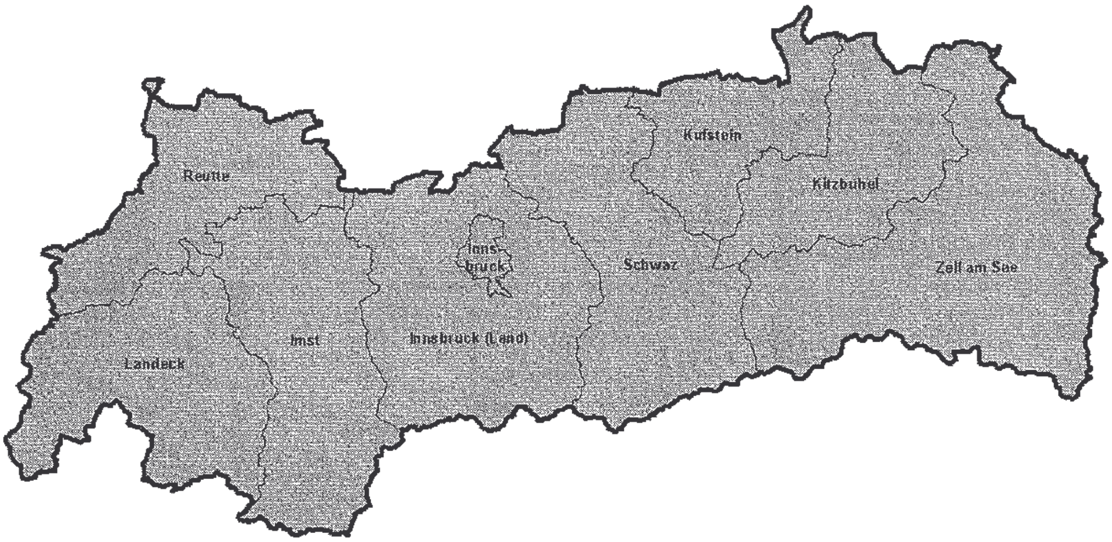


ABBILDUNG 3: REGION 3

Die folgende Tabelle enthält die der Region 3 zugeordneten Bezirke:

Bezirks ID	Bezirk	Bundesland
506	Zell am See	Salzburg
701	Innsbruck (Stadt)	Tirol
702	Imst	Tirol
703	Innsbruck (Land)	Tirol
704	Kitzbühel	Tirol
705	Kufstein	Tirol
706	Landeck	Tirol
708	Reutte	Tirol
709	Schwaz	Tirol

TABELLE 5: BEZIRKE VON REGION 3

Region 4

ABBILDUNG 4: REGION 4

Die folgende Tabelle enthält die der Region 4 zugeordneten Bezirke:

Bezirks ID	Bezirk	Bundesland
801	Bludenz	Vorarlberg
802	Bregenz	Vorarlberg
803	Dornbirn	Vorarlberg
804	Feldkirch	Vorarlberg

TABELLE 6: BEZIRKE VON REGION 4

Region 5

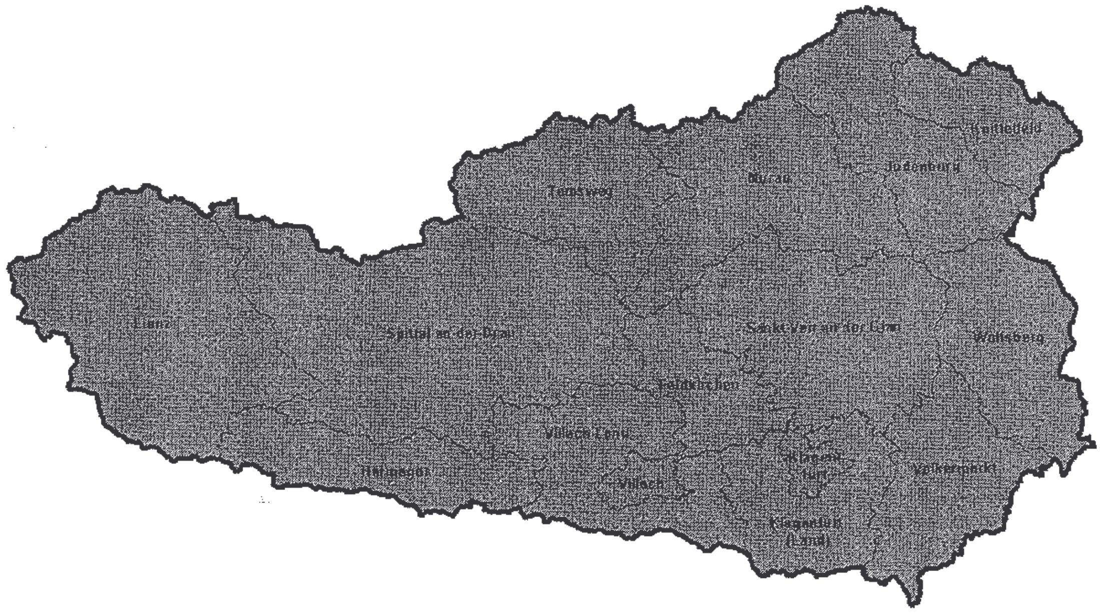


ABBILDUNG 5: REGION 5

Die folgende Tabelle enthält die der Region 5 zugeordneten Bezirke:

Bezirks ID	Bezirk	Bundesland
201	Klagenfurt (Stadt)	Kärnten
202	Villach (Stadt)	Kärnten
203	Hermagor	Kärnten
204	Klagenfurt (Land)	Kärnten
205	Sankt Veit an der Glan	Kärnten
206	Spittal an der Drau	Kärnten
207	Villach Land	Kärnten
208	Völkermarkt	Kärnten
209	Wolfsberg	Kärnten
210	Feldkirchen	Kärnten
505	Tamsweg	Salzburg
608	Judenburg	Steiermark
609	Knittelfeld	Steiermark
614	Murau	Steiermark
707	Lienz	Tirol

TABELLE 7: BEZIRKE VON REGION 5

Region 6

ABBILDUNG 6: REGION 6

Die folgende Tabelle enthält die der Region 6 zugeordneten Bezirke:

Bezirks ID	Bezirk	Bundesland
104	Güssing	Burgenland
105	Jennersdorf	Burgenland
109	Oberwart	Burgenland
601	Graz (Stadt)	Steiermark
602	Bruck an der Mur	Steiermark
603	Deutschlandsberg	Steiermark

Bezirks ID	Bezirk	Bundesland
604	Feldbach	Steiermark
605	Fürstenfeld	Steiermark
606	Graz-Umgebung	Steiermark
607	Hartberg	Steiermark
610	Leibnitz	Steiermark
611	Leoben	Steiermark
613	Mürzzuschlag	Steiermark
615	Radkersburg	Steiermark
616	Voitsberg	Steiermark
617	Weiz	Steiermark

TABELLE 8: BEZIRKE VON REGION 6

Anlage 1/Anhang F

Draft ECC/REC 04/05 (RECOMMENDED GUIDELINES FOR ACCOMMODATION AND ASSIGNMENT OF MULTIPOINT FIXED WIRELESS SYSTEMS IN FREQUENCY BANDS 3.4-3.6 GHZ AND 3.6- 3.8 GHZ)

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

DRAFT

ECC RECOMMENDATION (04)05

RECOMMENDED GUIDELINES FOR ACCOMMODATION AND ASSIGNMENT OF MULTIPOINT FIXED WIRELESS SYSTEMS IN FREQUENCY BANDS 3.4-3.6 GHZ AND 3.6- 3.8 GHZ

INTRODUCTION

Multipoint Fixed Wireless Systems (FWS) are deployed in several bands, with the lowest of identified in CEPT/ERC/REC13-04 preferential bands for Fixed Wireless Access (FWA) being the band 3.4-3.6 GHz.

In that band, CEPT/ERC REC14-03 recommends channel arrangements that, for Point-to-Multipoint (P-MP) systems, are limited to frequency assignment in multiple slots of 0.25 MHz with possible duplex spacing of 50 and 100 MHz.

In addition, CEPT/ERC REC12-08 recommends the optional use of the band 3.6-3.8 GHz, which is therefore used by some administrations as an extension of, or an alternative to the 3.4–3.6 GHz band. The REC 12-08 recommends, for P-MP systems, the same channel arrangement, frequency assignment criteria and duplex spacing as in REC 14-03.

However, none of the above mentioned recommendations gives any further guidance on the assignment rules among different operators, in either co-ordinated or uncoordinated deployment, leaving to administrations to decide on any further limitations (e.g. in term of EIRP limitation, guard-bands, co-ordination distance for frequency re-use, etc.).

Those bands, even if being of limited size, are valuable because they provide for quite wide cell coverage when Line-of-Sight (LoS) rural deployment is considered, as well as connections with partially obstructed paths, which is important in urban/sub-urban deployments where simple and cost-effective access connections are desirable. Therefore the bands around 3.5 GHz are potentially interesting for a quick growth of domestic/small business access connectivity of moderate capacity, typically for ensuring the policy goals of proliferation of broadband Internet (IP) connections (e.g. in accordance with EU Europe action plan).

For such purpose a wide variety of FWA technologies are already available on the market; they span from different system capacities, access methods (e.g. TDMA, FDMA and CDMA), system architectures (P-MP and MP-MP), duplex arrangements (TDD and FDD) and asymmetry (different up-stream/down-stream traffic as typically needed for IP-based access). Each technology offers to operators specific benefits for specific market segments/characteristics; in addition, the continuous extensive evolution of the market and of the related technologies could imply that operators might be willing to change the system deployed with others, which better fit the changing needs; and this switch-over should not impact other operators, irrespective of the newly selected system.

FWA systems, whenever the local conditions and the administrative (license) policies permit, may be used profitably also for provisioning of mobile network infrastructure, in particular for traffic collection from mobile base stations serving rural low density and urban pico-cells.

Consequence of the above considerations is the need for a technology neutral assignment methodology, possibly harmonised among CEPT administrations for reducing the market fragmentation. A specific study to justify this has been carried out in ECC Report 33 and this Recommendation, based on the conclusions of that report, offers an immediate response to such needs.

Multipoint-to-Multipoint (MP-MP), also known as "Mesh", network architectures have not yet been considered in ECC Report 33. In order to include MP-MP Mesh architectures into the same frequency assignment framework, a number of assumptions on "typical" applications in these bands (e.g. on the use of omni-directional/directional antennas) still need to be defined in order to devise a typical set of intra-operator, mixed MP-MP/PMP interference scenarios, then necessary simulations should be carried out to define, as needed, any specific requirements.

BACKGROUND TO RECOMMENDED ARRANGEMENTS

In order to cater for the mix of technologies and services to be delivered it is most appropriate that a block (or blocks) of spectrum should be made available to a potential operator in a manner consistent with the technology and market that the operator may wish to address.

Medium size blocks are anticipated and the size will depend to certain extent on the applications foreseen. Administrations should be aware of the spectrum engineering measures proposed in the annexes of this recommendation and their relationship to the assigned block size. A key principle of the assignment guidelines is that even though a technology specific channelisation scheme is expected to operate within an assigned block, this channelisation is not the basis for the assignment process.

It is a requirement of the block assignment process detailed in this recommendation that systems supporting both symmetric and asymmetric traffic are accommodated as well as systems that employ FDD and TDD techniques.

Actually, different methodologies for the assignment of those blocks might be envisaged; namely, either block-edge regulations or guard bands between assigned blocks might be enforced depending on the required protection between adjacent assignments. However the amount of protection depends on equipment technology and characteristics that, in these bands, are consistently varying from system to system due to the large number of different market needs addressed. On this basis, this recommendation addresses the "block-edge mask" method only (i.e. without any guard band), which is considered the most "spectral efficient" among "technology neutral" methods not requiring specific frequency coordination.

Measures are recommended for dealing with the issue of inter-operator coexistence both between frequency blocks and between neighbouring geographic areas. The basis for these measures is to allow deployment with the minimum co-ordination, although more detailed co-ordination is encouraged as an inter-operator issue.

In order to cope with often conflicting requirements of allowing a wider number of technologies versus the terms for efficient and appropriate block assignments, some compromise had to be made to develop reasonable assignment guidelines, which balances any constraints, as far as possible, on any specific technology.

The recommendation recognises that the current technology for FWA in bands around 3.5 GHz, is in continuous extensive evolution since first ECC recommendations 14-03 and 12-08 were developed. A detailed study on the coexistence of various technologies was needed in order to provide guidance to administrations that wish to adopt an efficient and technology neutral approach to the deployment rules in these bands. ECC Report 33 offers, for some representative cases, detailed study of the coexistence requirements, on which results this Recommendation is based.

It is also noted that ETSI ENs in these bands are not presently designed for a technology neutral deployment (this is done only in the 40 GHz MWS EN 301 997) therefore do not contain system controlling parameters, in terms of EIRP, useful for the desired "technology neutral" and "uncoordinated" deployment. Not having any previous ECC harmonised guidance for such deployment, the ENS are still bound to a cell-by-cell "co-ordinated deployment" concept actually not used in most of the licensing regimes. It is therefore assumed, that this recommendation would eventually generate feedback actions in revising also ETSI ENs accordingly.

Aspects that relate to sharing issues with FSS, radiolocation (in adjacent band) and ENG/OB are not considered in this Recommendation. However they should be taken into account when applying any method of deployment suggested in this document.

The applicability of this Recommendation is based on the following aspects:

- The presented guidelines should be independent from the access methods described in the ETSI ENs (e.g. EN 301 021, EN 301 124, EN 301 744, EN 301 080 and EN 301 253).

- MP-MP (Mesh) architectures have not yet been considered. In order to include Mesh architectures, within the same assignment framework, a number of assumptions on "typical" application in these bands (e.g. on the use of omni-directional/directional antennas) still need to be defined in order to devise a typical set of intra-operator, mixed MP-MP/PMP interference scenarios and any necessary simulations should be carried out in order of define, if needed, specific requirements for that.

- Also channel sizes and modulation schemes were not specifically considered unless for defining "typical" system parameters. It should be noted that highest state modulations (i.e. 64/128 QAM) have not been specifically addressed in the typical system parameters; nevertheless they would not change the general framework of this recommendation. This might be considered during future update.

- Use of either FDD/TDD, symmetric/asymmetric deployments was considered.

- Additionally, system independent, EIRP density limits and/or guard-bands at the edge of deployed region (pfd boundary conditions), as well as at the edge of assigned spectrum (block edge boundary conditions) are considered as licensing conditions for neighbouring operators' co-existence (similarly to the principles in ECC/REC 01-04 for the 40 GHz band).

Presently, the spectrum blocks assigned per operator vary widely from country to country; examples of assigned blocks ranging from ~10 MHz up to ~28MHz (single or duplex) have been reported. The block size and the frequency re-use plan, employed by the operator to achieve a multi-cell and multi-sector deployment, drive the channel bandwidth of the systems presently on the market to be typically no greater than 7 MHz. On the other hand, the requirement for higher data throughputs is driving the need for wider channel widths (e.g. up to ~28 MHz) and therefore correspondingly wider spectrum blocks assignment in the future.

Therefore, system channel bandwidths and block sizes are not fixed, even if typical data for current technologies was used for feasibility analysis of the "block-edge" constraints.

"The European conference of Postal and Telecommunications Administrations,

considering

a) that within CEPT the band 3.4-3.6 GHz has been identified as a preferred frequency band for Fixed Wireless Access (FWA) (ERC/REC13-04, ERC/REC14-03 refer);

b) that the band 3.6-3.8 GHz is also used or might be used in the future in some CEPT countries for multipoint FWS in accordance with provisions of ERC/REC 12-08;

c) that the EU "eEurope" program states that "affordable, high speed Internet access, available over a variety of technology platforms, is crucial to ensuring that everybody has access to the benefits of the Information Society";

d) that harmonisation of the frequency assignment regulation will greatly enhance the penetration of such service through appropriate FWS technologies;

e) that FWA in the bands 3.41–3.6 GHz and 3.6–3.8 GHz is expected to provide wideband and broadband services with enhanced availability for fast Internet connections, including telephony, video, media streaming and data services to both residential and business customers;

f) that Multipoint FWS, subject to national licensing policy, may be profitably employed in these bands for mobile networks infrastructures, linking remote, lower traffic base stations;

g) that it is desirable to achieve a flexible frequency assignment plan that can accommodate both symmetrical and asymmetrical FWA traffic requirements, whilst remaining consistent with good spectrum management principles, including provision for inter-system/services operation and overall spectrum efficiency;

h) that both time division duplex (TDD) systems and frequency division duplex (FDD) systems should be accommodated, provided that appropriate co-existence criteria can be met;

i) that sufficient capacity and flexibility for deployment of multiple systems within a desired service area can be achieved by the aggregation of a variable number of contiguous frequency slots from a homogeneous pattern to form a block assignment;

j) that in order to enhance the efficient use of the assigned block(s) according present and future available technology, operators should be able to freely define and modify suitable channel arrangement(s) within the block(s) according to the selected technology(ies);

k) that it is desirable that the assignment of adjacent blocks to different operators should be made as far as possible without obligation for co-ordination between them; but co-ordination should nevertheless be encouraged in order to maximise the efficient use of the blocks and when special/critical conditions are envisaged;

l) that a flexible frequency assignment plan would enable FWA to co-exist with other FWS systems where appropriate;

m) that the fixed satellite service is also allocated primary status in these bands and in some locations appropriate measures will be needed in the planning and deployment of FWA around earth stations installations to protect the satellite service;

n) that guidance material, on which this recommendation is based, is available in ECC Report 33 to assist administrations with the assignment of frequency blocks to operators for FWA systems;

o) in some countries interference to FWA operations was noted from radars operating below 3.4 GHz, therefore administrations should take this potential problem into account when assigning frequencies to FWA in lower parts of 3.4 GHz band;

p) that the national implementation of measures recommended in this recommendation should take due account of any prior bi- or multi-lateral coordination agreements in the subject band;

q) that in ECC Report 33 only Point-to-multipoint (P-MP) architectures with terminals using directional antennas have been considered; multipoint-to-multipoint (MP-MP or Mesh) architectures and any systems with terminals using sectorial or omnidirectional antennas have not been considered. Applications with indoor terminals are also on the market and more might become available within ETSI and IEEE standardisation process. Therefore further studies might be necessary in order to broaden the applicability of this recommendation.

recommends

1) that administrations, considering new use or re-deployment for Multipoint FWS in bands subject of this recommendation, should consider the guidance in Annexes 1 and 2 in order to create block assignments based upon an aggregation of frequency slots (channels);

2) that interference between the assignments may be avoided through the measures given in Annexes 3 and 4, which also may be used for setting cross-border agreements between the countries;

3) that blocks should be assigned in a manner that might assist future expansion of successful services, ideally without further regulatory requirements on the actual channel arrangements and centre frequencies inside the blocks;

4) that administrations encourage inter-operator co-operation on co-existence issues to maximise utilisation of the assigned blocks."

Note:

Please check the Office web site (http//:www.ero.dk) for the up to date position on the implementation of this and other ECC and ERC recommendations.

ANNEX 1

GUIDANCE FOR THE PREFERRED CONSTRUCTION OF FREQUENCY ASSIGNMENT PLANS

Steps leading to a general case of recommended assignment plan with no pre-judgment on present and future technology

FWA systems may be provided by a number of different access technologies. The following approach, recommended as the General Case, includes steps addressing the situation whereby no decision is taken beforehand by an administration regarding the technology anticipated. It provides the most flexibility and freedom for operators to choose how to make best use of the spectrum:

1. Consider any constraints brought about by the need to share with other services;

2. The blocks should be based on the raster of frequency slots, 0.25 MHz wide, or basic 3.5 MHz frequency channel arrangements provided by CEPT ERC/RECs 14-03 and 12-08;

3. Consider the appropriate block size (B) for assignment. Although it is difficult to determine an absolute value for the optimum block size, typical values of ~ 7 to 14 MHz (e.g. derived from a block of channels based on 3.5 MHz raster) or ~10 to 15 MHz (e.g. derived only from the 0.25 MHz slot raster) are considered practical for new wide/broad band services demand. Nevertheless the guidance given here is valid also for wider block sizes (e.g. up to ~ 28/30 MHz) that might be set up depending on the band availability in each country;

4. Taking due account of the technology choices and the constraints on spectrum access brought about by the need to share the band, consider the following guidelines in order to develop an appropriate frequency block assignment plan:

    - Paired equal blocks offset by 50 or 100 MHz[1] should be assigned to each operator irrespective of the technology.[2]

    - For FDD systems, the definition of a single duplex spacing for symmetric systems of 50 or 100 MHz also facilitates a reasonable, economically viable range of duplex spacings for asymmetric FDD systems, whilst allowing TDD.

    - Asymmetric FDD systems can be accommodated in the paired equal blocks if the up and downstream transmission directions are allowed to be mixed within a block.

    - Whilst contiguous frequency blocks for TDD would have been most advantageous in terms of equipment cost and spectrum efficiency, TDD systems do not necessarily require contiguous frequency blocks; therefore, in view of balancing flexibility and complexity into the assignment criteria, their use may be fitted in the general policy of paired symmetric block assignment.

---

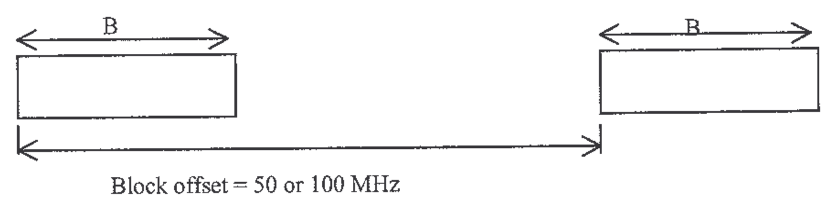
1 Depending on the band allocation in each country, these are the offset options provided by CEPT ERC Recommendations 14-03 and 12-08.

2 In the band 3.41 to 3.5 GHz or 3.41 to 3.6 GHz, the missing band 3.4 to 3.41 GHz will create unpaired corresponding band, 3.45 to 3.46 GHz or 3.5 to 3.51 GHz, respectively. This un-paired sub-band should either constitute a single unpaired assignment (i.e. for TDD system only) or be attached to one or both adjacent blocks forming an asymmetric paired assignment, see Figure 1.2a.

- For a generic coexistence enhancement and for harmonisation of the CEPT market, in absence of any different legacy or other constraints (e.g. at bi- or multi-lateral co-ordination agreements at country-borders), symmetric FDD PMP systems should use the lower sub-band for the transmission from the terminals to the central station and the upper sub-band for the transmission from the central station to the terminals.

The concept of paired equal blocks offset by 50 or 100 MHz is described in figure 1.1 below.

Figure 1.1: General concept of paired equal blocks



Each block will contain a technology specific channelisation scheme and guard bands as illustrated in Annex 2, Figure 2.1.

Figures 1.2a and 1.2b below give example schemes based on such principle where 5 different operators have been allocated paired blocks of different size. The examples are tailored to 100 MHz block offset arrangements in bands 3.6 to 3.8 GHz and 3.41 to 3.6 GHz, respectively.

Figure 1.2(a): Example scheme based on the concept of paired equal blocks 3.6 to 3.8 GHz band

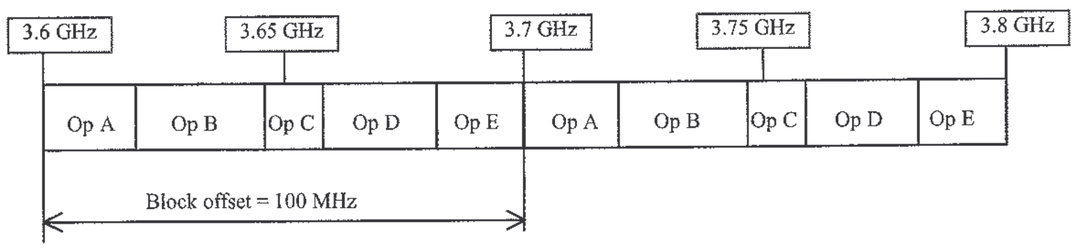
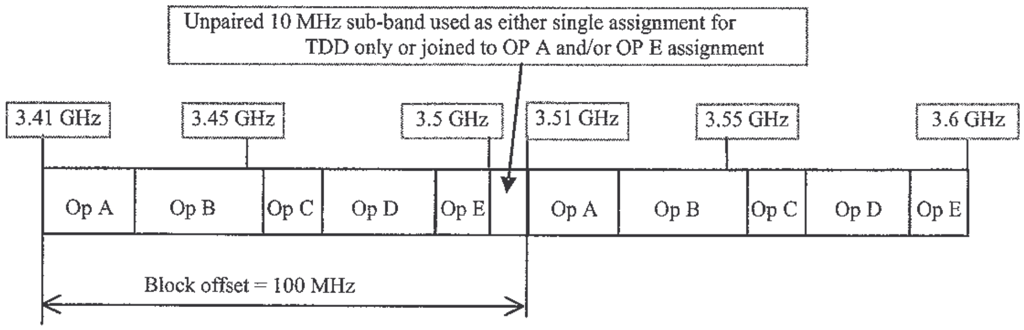


Figure 1.2(b): Example scheme based on the concept of paired equal blocks 3.41 to 3.6 GHz Band



The above arrangements provide regulators with the possibility to assign the spectrum without a need to pre-determine the technology to be used by the different operators, giving the latter the flexibility to deploy, mix or modify the technology they use:

- for FDD symmetric systems, it accommodates all systems with a duplex spacing of 100 MHz (or 50 MHz), see figure 1.3,
- for FDD asymmetric systems, it allows up-streams and down-streams to be implemented in the same block, see figure 1.4,
- for TDD systems, the two blocks are used separately by an operator to deploy same or different types of systems, see figure 1.5,
- a mixture of both FDD and TDD systems is possible either within blocks or in neighbouring blocks.

Figure 1.3: Application with FDD symmetric systems (for one operator)

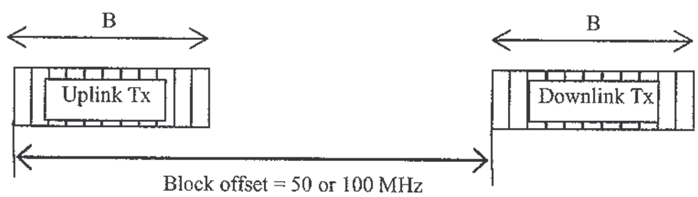
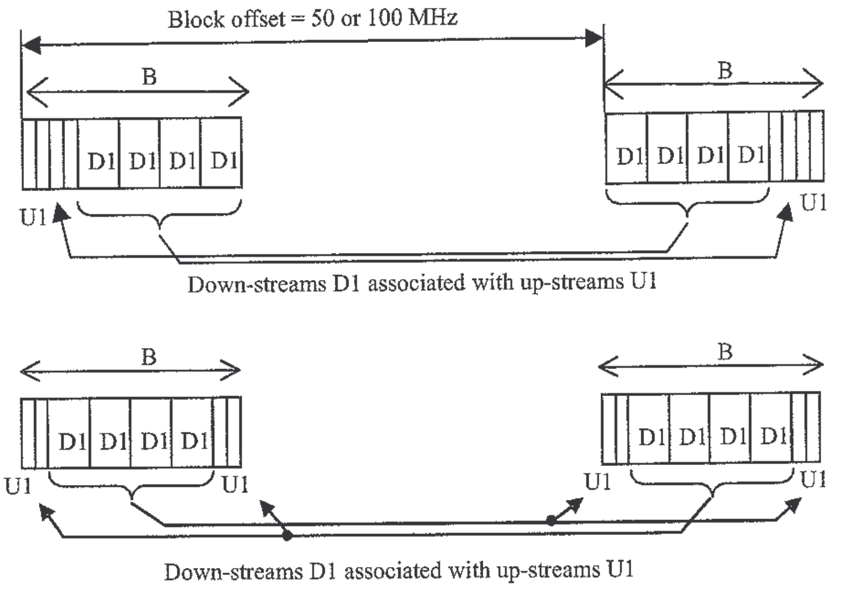
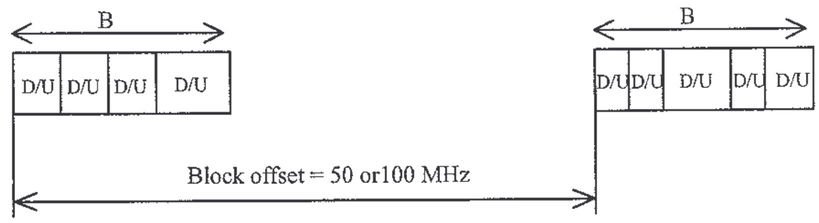


Figure 1.4: Examples of application with FDD asymmetric systems (See Note)



Note: According to the system characteristics, different mix of up-stream/down-stream channels is possible for enhancing the spectral efficiency.

Figure 1.5: Application with TDD systems (for one operator)



ANNEX 2

BLOCK BASED FREQUENCY ARRANGEMENT FOR 3.4-3.6 GHZ AND 3.6-3.8 GHZ BANDS

1 - Introduction

The flexibility of the 0.25 MHz slot raster plan or the basic 3.5 MHz radio frequency channel arrangement, both detailed in CEPT ERC Recommendations 14-03 and 12-08, is needed to facilitate assignments applicable to a number of technologies, some of which are highlighted in Annex 5. In addition the needs of legacy fixed service systems and other primary users of the band need to be respected. However there is a need for a trade-off between providing flexibility and a "standard" approach that minimises options and equipment variants. The approach recommended in this recommendation attempts to strike a balance between these two issues.

2 - Primary features of the frequency architecture

Ultimately the assigned blocks would contain a channelisation scheme(s) defined by the operators themselves according to the actual technology(-ies) adopted; channel centre frequencies should not be regulated, provided that they may be adjusted for meeting block-edge requirements given in Annex 3.

Note that:

- An assigned block shall contain an integral number of 0.25 MHz slots or basic 3.5 MHz channels.
- An assigned block may contain a number of actual channels, as defined by the operator independently from the actual slots or basic 3.5 channel centre frequencies, as well as some sub-bands needed to avoid inter-operator interference (i.e. the guard bands of Figure 2.1) (See Annexes 3 and 4).
- Free unassigned spectrum could be left between blocks for future assignment.

3 - Relationship between elements of the block assignment and of the underlying frequency plan(s)

The diagram in Figure 2.1 illustrates the relationship between elements of the frequency plan consisting of original frequency slots, blocks assigned to operators, as well as chosen by operators technology specific channelisation and guard-bands within the blocks.

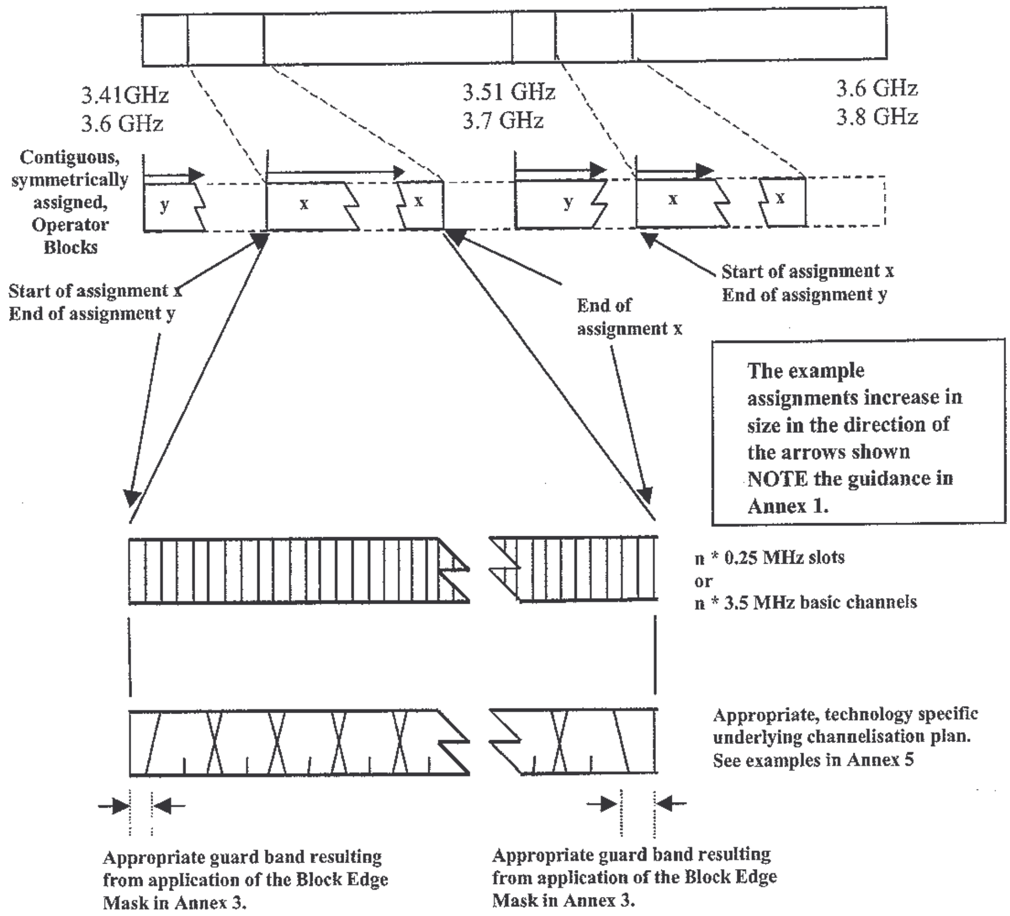


Figure 2.1: Frequency Plan Elements

ANNEX 3

GUIDANCE FOR FREQUENCY BLOCK EDGE AND EIRP DENSITY LIMITS

1. Introduction

Emissions from one operator's frequency block into another operator's neighbouring block will need to be controlled. This can be done by blindly imposing fixed guard bands between the assignments, as recommended in few other frequency bands. However, taking due account of the possible variety of wideband and broadband systems, different network and service requirements, and considering the expected broadening of the required bandwidth, it might be difficult to uniquely and efficiently set such guard bands.

Alternatively, in this recommendation, a so-called frequency block edge EIRP density emission mask is established to achieve limitation of emissions into a neighbouring block, by enabling the operators to place the outermost radio channels with suitable guard-bands, inside their assigned block, in order to avoid co-ordination with the neighbour blocks.

Transmitter EIRP density and outermost channel centre frequency could be traded-off in order to fulfil the block-edge requirement. In this way a more efficient use of the spectrum may be expected.

The block-edge mask is applicable also to the outermost block-edges at the boundary with adjacent allocated bands. This would guarantee, in EIRP terms, guard-bands at band edges to facilitate adjacent band inter-service compatibility and co-ordination, as appropriate.

2. Maximum EIRP density within a block

Maximum EIRP density is generally set by administrations in order to define pfd levels for co-ordination distances between different geographical areas or for cross-border agreements. The following table 3.1 gives guidance for possible maximum limits. It is based on information about currently available technology limits, but also takes into account and provides some allowance for future development of higher power transmitters.

Station Type (Note 1)	Max EIRP spectral density (dBW/MHz) (Including tolerances and ATPC range)	Typical informative assumptions for deriving the EIRP limits (Note 2)	
		Maximum Power Spectral Density at antenna port	Maximum Antenna Gain
CS (and RS down-links)	+ 13	+22 dBm/MHz	21 dB
TS (and RS up-links)	+ 23	+22 dBm/MHz	31 dB

NOTE 1: These in-band EIRP upper limits have been derived from the reference systems data used in ECC Report 33, which are already at or near the maximum power for practical technology. Some additional allowance for "higher gain" and/or "smart antennas" deployment (e.g. 5 dB more on CS and 15 dB more for TS, the latter considering e.g. a 2 m parabolic antenna in order to cope with special cases) may be permitted, noting that some specific systems may already exceed these EIRP limits.

NOTE 2: In actual applications trade off in these values is possible provided that EIRP limits are met.

Table 3.1: Possible Maximum Transmitter EIRP Spectral Density

3. Block edge EIRP density mask

For a sensible and cost-effective regulation, a block edge mask is generally designed on the bases of a small level of degradation in an assumed scenario with a low occurrence probability of a worst case (e.g. two directional antennas pointing exactly at each other).

It is not therefore excluded that in a limited number of cases specific mitigation techniques might be necessary.

In particular when CSs are co-located on the same building, the statistical approach is not applicable and it is assumed that common practice of site engineering (e.g. vertical decoupling) is implemented for improving antenna decoupling as much as possible.

Also adjacent block receiver rejection concurs to a reduced interference scenario, however this is not in the scope of this recommendation to set limits for it; nevertheless it is expected that ETSI standards will adequately cover the issue.

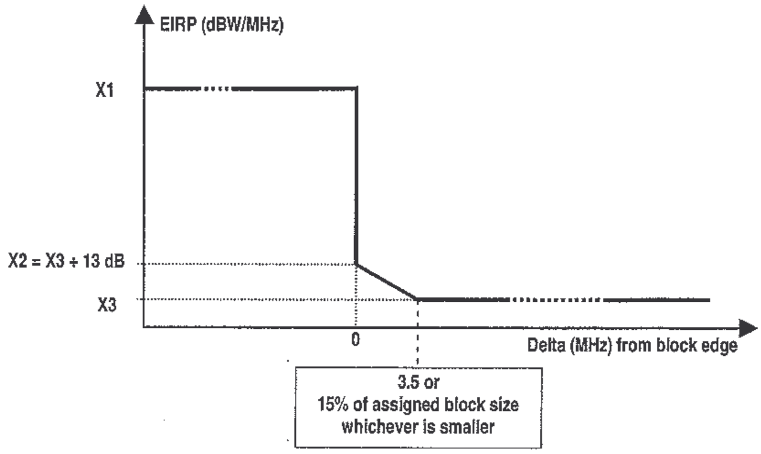
In these frequency bands two typical deployments are currently addressed:

- Rural: for remote areas, where large cell size is a major requirement for maximising the coverage; the paths between CS and TS (with RS possibly in between) are typically longer and not obstructed.

- Urban/suburban: where these bands are used for the possibility of linking stations also with paths partially obstructed, resulting in far smaller cell sizes.

According to ECC Report 33, which addresses both scenarios, the requirements for CS out-of-block emission in rural applications might be more relaxed due to the potential larger average distance and easiness of co-ordination/mitigation measures between different operators CS.

Figure 3.1 shows the required block edge mask; the limits shown are absolute maximum and intended to include tolerances and any ATPC range:



Station type	EIRP (dBW/MHz)		
	X1	X2	X3
CS	See Table 3.1	X3 + 13	–64 or –73 (NOTE 1)
TS	See Table 3.1	X3 + 13	– 37

NOTE 1: the – 64 dBW/MHz will result in a CS to CS minimum distance, for 1 dB maximum degradation of thresholds, of ~350 m (e.g. appropriate for rural deployments), while the – 73 dBW/MHz allows closer distance down to ~ 100 m (more appropriate for urban/suburban).

Figure 3.1: Block Edge Spectral Density Mask

The drop-down attenuation near the block edge has the scope of easing TX filtering. Its size (15% of the assigned block size or 3.5 MHz, whichever is the smaller) has been chosen taking into account the relatively small systems bandwidths. This value comes from practical considerations similar to those made in the 40 GHz MWS ECC Recommendation 01-04 (i.e. this 3.5 MHz will act as "soft" guard band, discouraging its use by narrow-band systems for the expected higher interference).

According to ECC Report 33, X_3 value for CSs is a function of the acceptable CS-to-CS minimum co-ordination distance and acceptable ISOP for CS to TS interference. The X_3 value for TSs has been derived from statistical interference protection factor (IPF) and NFD in TS to CS interference scenarios.

Moreover, for further enhancing the efficiency, after the block assignment procedure administrations are not expected to enforce the block-edge requirements for neighbouring operators who will apply mutual co-ordination at the block edge in view of optimising the guard bands internal to the blocks. In that case only the maximum "in-block" EIRP/power density apply while the "out-of-block" noise floor will apply only from a "mutually agreed" starting point within the adjacent block.

ANNEX 4

GUIDANCE FOR INTERFERENCE AVOIDANCE BETWEEN CO-FREQUENCY AND ADJACENT FREQUENCY ASSIGNMENTS

1 Introduction

In order to assign frequencies to a number of competing FWA operators in any given area or territory, certain guidelines are needed in order to ensure that interference probability between these operators is minimised. These operators may be deploying differing technologies requiring co-existence guidelines at the top level to be as generic as possible.

In addition, the inter-operator co-ordination burden should be minimised and flexibility provided to cater for specific scenarios in order to help minimising any deployment constraints.

The same concept may be used for developing international agreements on utilisation of subject bands between neighbouring countries.

2 Interference Scenarios

Work has been done in a number of groups, ETSI TM4[3], ECC Report 33[4], IEEE802.16.2[5] to examine the intra-service co-ordination requirements that could be appropriate to FWA in this band.

Two distinct co-ordination scenarios were addressed, namely:

- Co-existence between two or more Broadband FWA (BFWA) systems operating in the same geographic area but in adjacent frequency blocks (Scenario 1).
- Co-existence between two or more BFWA systems operating in the same frequency blocks but in adjacent geographic areas (Scenario 2)

The investigations have shown that co-existence is feasible in both scenarios providing measures are taken to minimise the risk of interference close to geographic boundaries and near frequency block edges.

Scenario 1

Frequency separation can be used as means of limiting the probability of a maximum acceptable amount of interference falling into a victim receiver in a neighbouring frequency block. This is achieved, for P-MP applications with directional terminal antennas, through application of the "Block Edge Mask" defined in Annex 3.

It is noted that in order to help minimising the risk of interference between operators in adjacent blocks, techniques known as autonomous or quasi-autonomous frequency assignment are under study by the relevant standards bodies.

It is further noted that the "Block Edge Mask" method is not the only one suitable for the purpose of licensing different operators with limited or no co-ordination. As an example, if more information is available on the systems deployed (e.g. FDD or TDD, bandwidth, etc), it could be possible to defining dedicated guard bands

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[3] TR 101 853: Rules for Co-existence of P-P and P-MP systems using different access methods in the same frequency band.

[4] ECC Report 33: The analysis of the coexistence of two FWA cells in the 3.4 to 3.8 GHz band.

[5] IEEE 802.16:Draft Recommended Practice for Coexistence of Broadband Wireless Access Systems.

between the frequencies assigned to the Operators. However in such case the account should be taken of any possible future change of technology or frequency re-assignment.

Scenario 2

Co-existence can be ensured upon limiting the amount of interference into a neighbouring victim receiver, based on an agreed level of interference below receiver thermal noise causing an increase in receiver noise floor with a consequent impact on link budget. The level of co-frequency interference is dependant mainly upon separation distance, interfering EIRP and victim receiving system parameters. Therefore the following steps can be taken to control the interference potential:

- Applying the limit on the power flux density (PFD) at the licensed service area boundary that individual FWA transmitters may generate.
- Depending on the local geographical conditions, possible limitation to antenna height for reducing the minimum separation distance (Note).
- A requirement to co-ordinate all transmitter stations where the specified PFD limit at the licensed service area boundary is exceeded.
- Determination of the actual PFD level at the service area boundary should take account the attenuation due to terrain and other obstructions.
- Geographical boundaries between neighbouring block assignments should be defined as far as possible to minimise the requirement for co-ordination, e.g. by avoiding major population centres and taking advantage of possible shielding by prominent terrain features.

Note: Provided that cell size is not generally limited by spherical diffraction attenuation, this may be done, at least in the rural locations, without significant reduction of cell coverage. However, this might not be strictly necessary due to the self-regulating criterion in section 4.1.1.

3 Applying the Co-ordination Triggers

There is no absolute solution for providing guaranteed interference-free environment without squandering spectrum or insisting on unnecessary constraints on deployment. There is a scope to apply the co-ordination triggers in ways that balance the requirement to control the interference environment with the need to make best use of the spectrum.

As an example, the scenario 2 approach above refers to separation distances and the protection of victim receivers by limiting the interference into those receivers. To minimise the impact on the victim operator the receivers located at the licensed area boundary can be protected with an appropriate PFD limit based upon an acceptable I/N criteria. Although this will maximise the "co-ordination separation distance" into the interferers operating area, but give the greatest level of comfort to the victim operator.

Alternatively, the burden of co-existence can be shared between the operators by increasing the PFD limit at the boundary to that equivalent to half the required separation distance based on calculations derived from the acceptable I/N at the receiver. This is illustrated in the figure 4.1. This fully protects receivers located in the victim operator's licensed area at a distance equivalent to half the separation distance, but increases the chance that the victim will receive unacceptable interference at distances less than this. This reduces the co-ordination burden within an interferer area and minimises "over-protection". Simulations of multiple interferer scenarios on victim receivers in the worst case locations show the probabilities of unacceptable interference to be low. Consideration of real world effects (terrain shielding, etc) help mitigating against unacceptable interference. Careful choice of distances and PFD triggers can minimise the chance of unacceptable interference.

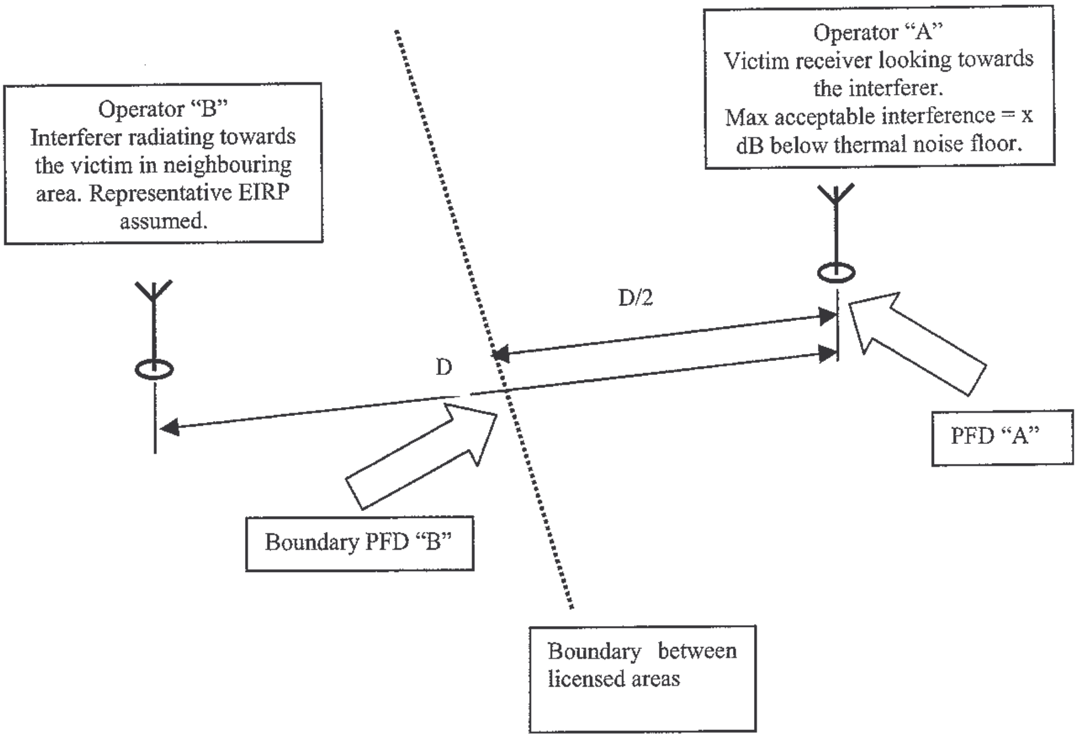
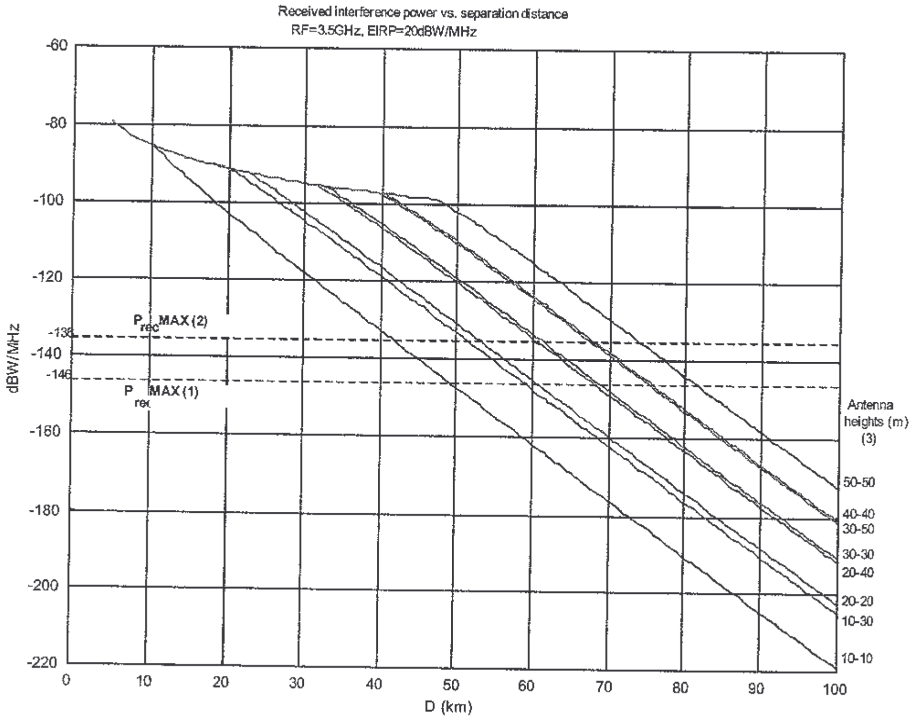


Figure 4.1. Defining PFD limit at geographical block assignment boundary

4 Boundary Power Flux Density limit (referring to Figure 4.1)

The specific propagation behaviour in 3.4 -3.8 GHz band is taken into account; in particular the spherical diffraction attenuation has been used as function of the antenna height. Due to the relatively large radius of first Fresnel zone (≈ 50 m) and the typical horizontal pointing of FWA antennas, the spherical diffraction attenuation will play significant role in defining the respective area and the PFD level for triggering co-ordination.

The interference level to the victim receiver could be evaluated from Figure 4.2 (reprinted from ECC Report 33) as function of victim distance D and for an EIRP density of +20 dBW/MHz. Different EIRP could be easily scaled on the vertical axis.



(1) P_{REC}MAX (victim) proposed for interfering CSs and TSs at nominal operating EIRP (6 dB above threshold)
(2) P_{REC}MAX (victim) proposed for interfering TSs (with ATPC enabled) at maximum EIRP
(3) The first value refers to transmit antenna. As it may be seen, mixed antenna heights show slight difference when the sum value of the heights is the same (e.g. 30-30 is close to 20-40, 20-30 is close to 25-25 and so on). Therefore values not shown could be extrapolated with small potential error.

Figure 4.2: Received interference power vs. separation distance for the CS to CS interference scenario (3.5 GHz, line of sight)

Obviously the spherical diffraction attenuation is function of the antenna heights of both interfering and victim stations. Therefore the recommended triggering pfd data, presented in this Annex will be parametric on $EIRP_{tx}$ and on antenna heights. Therefore, to reduce the co-ordination distance D, administrations may wish to limit $EIRP_{tx}$ of the deployed stations (in particular of CSs), see section 4.1.2. From the conclusions of Report 33, it might be derived that also a limitation in antenna height might be recommended at the boundary; however, from the interference protection point of view, this is not strictly necessary (see rationale in section 4.1.1).

For setting the recommended practice in this Annex, the system assumptions for both interfering TX and victim RX have been taken from ECC Report 33. In particular the CS antenna gain is assumed to be 16 dB, value considered significant for most applications in these bands.

Even considering spherical diffraction, the minimum separation distance for the protection of victim receivers is in general larger than typical cell coverage, which according ECC Report 33 might range from about 10 km to about 20 km.

Coverage of areas closer to the service (or international) boundary might be achieved either limiting $EIRP_{tx}$ or blanking sectors of relevant cells (see Figure 4.3).

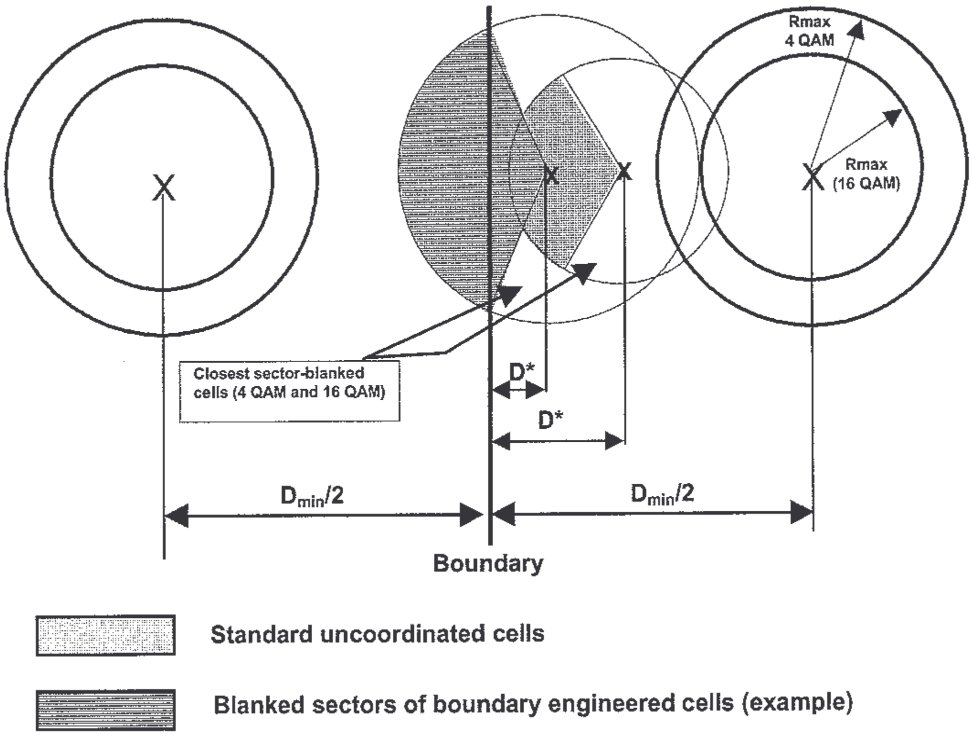


Figure 4.3: Example of cell sectors engineering at service boundary

In this scenario, for setting the recommended pfd co-ordination trigger level, two factors should be mostly taken into account, which should both result in acceptable interference:

1) The CS to CS interference

2) The TS to CS interference

The first evaluation will result in minimum coupling distance from the boundary ($D_{min}/2$ in Figure 4.3).

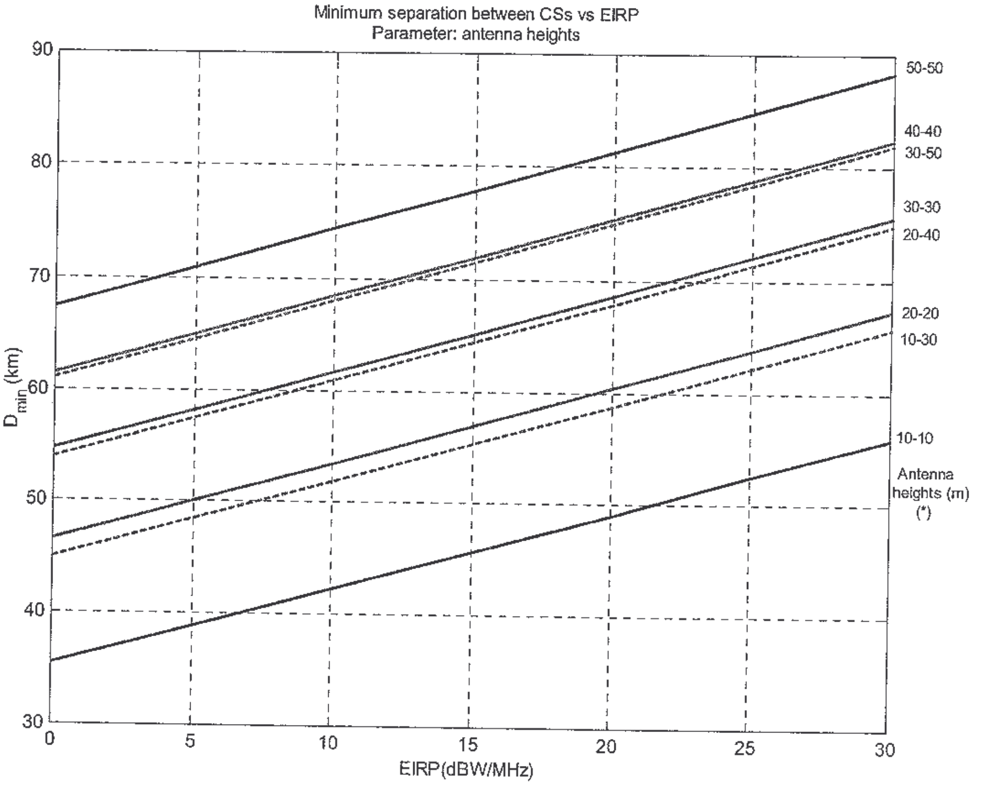
The second will further limit the minimum distance (D* in Figure 4.3) at which a CS (even in sector "blanked" cells) may be placed from the boundary so that its terminal stations would not interfere with a CS station placed in the neighbor service area at $D_{min}/2$ from the boundary.

4.1 CS to CS interference

With reference to Figure 4.1, based upon an acceptable I/N = −10dB (i.e. I=-146 dBW/MHz), the acceptable PFD at the victim receiver (PFD "A") is assumed to be:

PFD "A" ≤ -113.5 dBW/MHz/m^2

For satisfying such limit, Figure 4.4 (reprinted from Report 33), based on minimum coupling loss calculations, reports the minimum separation distance as a function of $EIRP_{TX}$ for different antenna heights.



(*) The first value refers to transmit antenna.

Figure 4.4: Minimum separation between CSs as a function of EIRP and antenna height

The impact of antenna height and EIRP for defining the boundary PFD co-ordination triggers should be evaluated separately.

4.1.1 Antenna height

Provided that the separation distance is dominated by spherical diffraction attenuation, Figure 4.4 shows that different mix of antenna heights produce little difference when the sum of the TX and victim RX antenna heights is the same (e.g. 30-30 is close to 20-40, 20-30 is close to 25-25 and so on). Therefore values not shown could be extrapolated with small potential error.

For the same reason the distance from the boundary ($D_{min}/2$) may be managed without knowing (and then imposing) the victim antenna height. Operator "B", once knowing its tower height and EIRP, should keep its own minimum distance $(D_{min}/2)_B$ evaluated assuming the same antenna height for neighbour victim of Operator "A". In fact, if the victim Operator "A" has higher or lower antenna height, the difference in D_{min} length will be balanced by its own $(D_{min}/2)_A$ portion (see example in Figure 4.5). Nevertheless the lower is the antenna height, the higher are the diffraction attenuation and all other attenuation due to obstacles such as building, trees etc. generally reducing the probability of worst case occurrence; therefore, as recommended by ECC Report 97, the use of low antenna heights should be encouraged at the boundary.

With the same assumption that equal antenna heights are relevant, the suitable value for the boundary PFD (PFD "B") dBW/MHz/m^2 could be derived from Figure 4.6 (reprinted from Report 33).

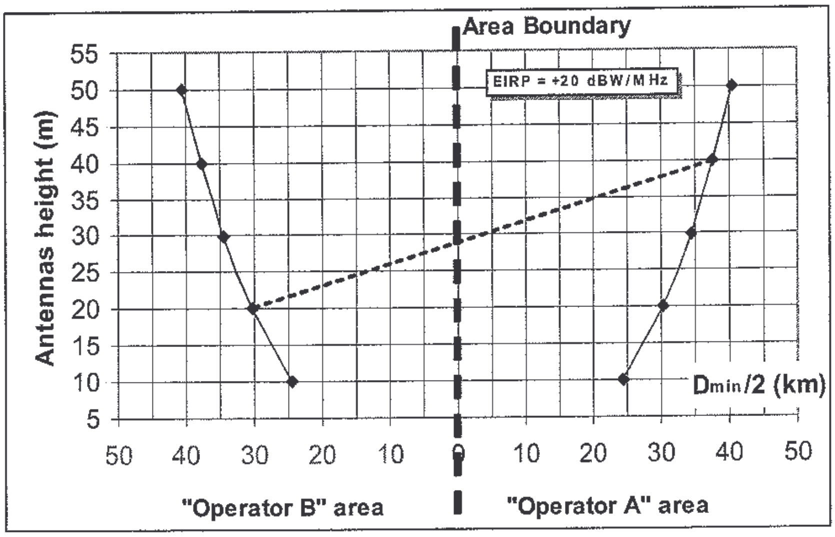
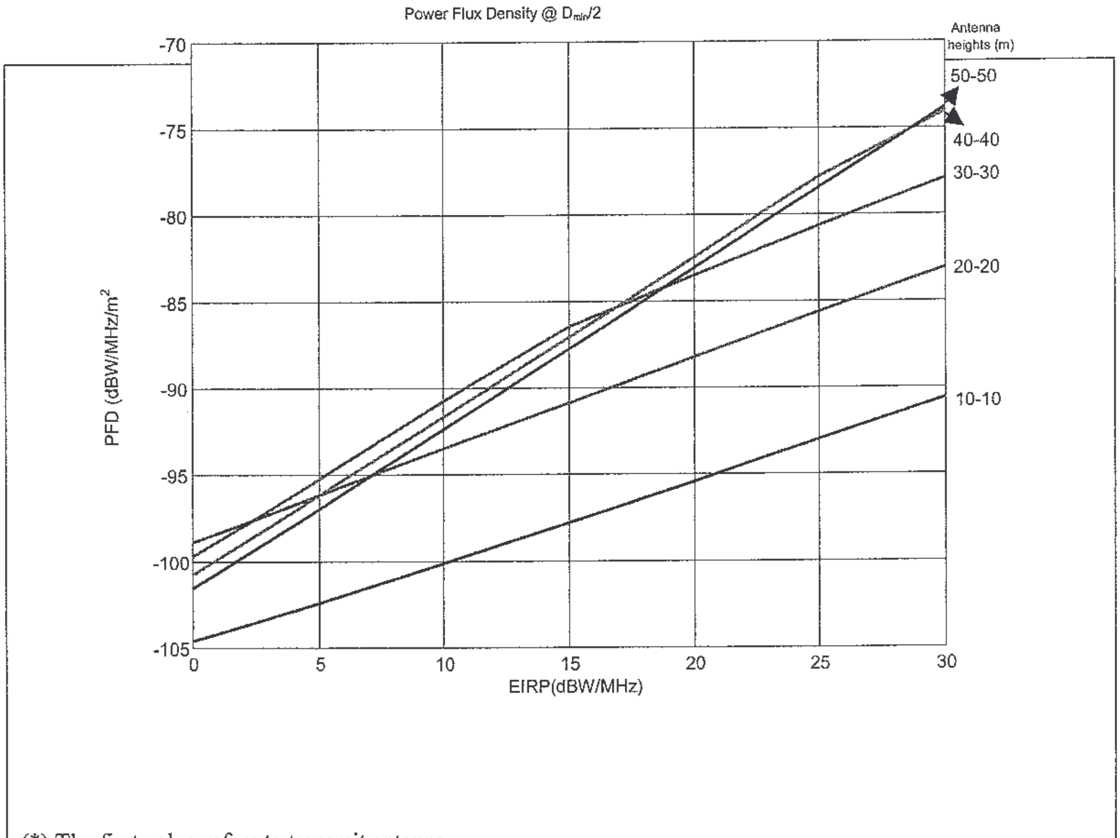


Figure 4.5: Example of balanced D_{min} obtained by different $D_{min}/2$ for different antenna heights (EIRP = +20 dBW/MHz) "B"/"A" antenna heights = 20/40 m (D_{min}= 30 + 38 = 68 m ≅ D_{min} for 20/40 m in Figure 4.4)



(*) The first value refers to transmit antenna.

Figure 4.6: PFD at $D_{min}/2$ (half the minimum CS separation distance derived from Figure 4.4) vs. $EIRP_{tx}$

Note: Figure 4.6 is derived evaluating the $D_{min}/2$ PFD at a virtual elevation equal to that of the victim RX antenna (see Figure 4.7). Then the graphs in Figure 4.6 show crossovers that are due to the different slopes of line-of-sight (linear with the distance) and spherical attenuation (non-linear with the distance). This impacts only the formal PFD evaluation (and its possible measurement) at $D_{min}/2$, while at D_{min} distance the maximum received interference is still satisfied.

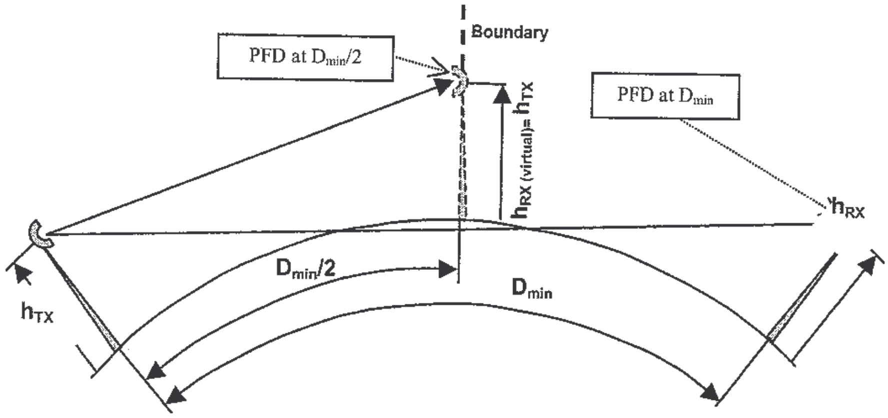


Figure 4.7: Principle for evaluating PFD at $D_{min}/2$ in Figure 4.5

4.1.2 Transmit EIRP

While the antenna height impact on D_{min} is self balancing without knowing the victim receiver side (see example of Figure 4.5), transmit EIRP, which also has impact on D_{min} does not have any intrinsic balancing mechanism.

In principle, as far as Operator "B" reduces EIRP, D_{min} becomes lower (see Figure 4.4) and the station, respecting the PFD at $(D_{min})_B$, could be placed closer to the boundary without coordination not risking interference to Operator "A" as far as the latter uses an equal or higher EIRP for evaluating $(D_{min})_A$; however the opposite is no longer true and Operator "B" receiver would be interfered because being too close to the boundary.

Therefore, a "minimum" EIRP, for evaluating PFD trigger should be defined, actual lower EIRP should be disregarded in this evaluation.

4.1.3 Recommendations for setting PFD coordination trigger for CS

Administrations should fix a "minimum" EIRP, as the lower bound for evaluating the PFD trigger value and the distance $D_{min}/2$ at which it should be evaluated.

At distance $D_{min}/2$, defined according Figure 4.4, for EIRP equal or higher than the "minimum", the PFD boundary, as given by Figure 4.6 for the same EIRP, should be adopted as trigger threshold for starting boundary co-ordination between the Operators concerned.

4.2 TS to CS interference

When a CS is placed at distance $\geq D_{min}/2$ from the boundary, as defined in previous sections, and considering that TSs with directional antennas in this frequency band are likely to have EIRP very close to or less than the CS one, no further requirement is necessary.

In case of deployment of "sector blanked" cells closer to the boundary (see Figure 4.3), additional requirements are necessary for ensuring that TS, pointing to the boundary, will not need specific coordination.

This will result in limiting the distance from the border of the CS of those cells so that the interference from its TSs will remain within acceptable levels, then not requiring coordination.

ECC Report 33 gives a set of examples on how to define such distance based on the current assumptions that signal fading from clear-air multipath on interfering and victim paths are uncorrelated and that TSs implement ATPC that typically keeps the receiver signal level ~6 dB above the threshold.

In ECC Report 33, for the worst-case interference scenario, it is assumed that the interfering TS is directed towards its CS located at the network service area boundary (therefore placed inside an active sector of Figure 4.3 and pointing towards service area boundary). The worst-case interference arises when the TS is at the maximum distance from its CS and is operating at its maximum EIRP (during the small percentage of time when ATPC is required to operate to counteract multipath attenuation).

With the assumption made on uncorrelated fading, two requirements need to be considered:

a) Interfering TS operating at the "normal" EIRP, possibly set by ATPC (unfaded percentage of time ~99.X %)
   $EIRP_{ATPC} = EIRP_{max} - FM_0 + FM_{ATPC}$
   FM_0 is the fade margin corresponding to maximum transmitted power (see typical values in ECC Report 33).
   In this case (most of the time) the received interference power into the victim CS, should not exceed the required limit (kTBF - 10dB) for not impairing the victim performance and availability.

b) Interfering TS operating at maximum EIRP (faded percentage of time ~ (100-99.X) %)
   Due to non-correlation, the victim CS would receive normal level, depending on the availability objective and the ATPC range, from the useful link (for a percentage of time usually less than 1%).
   In this case a higher interference level can be tolerated without impairments.
   Assuming that also victim system will work at 6 dB above threshold, we may tolerate up to 3 dB of noise floor degradation (i.e. up to kTBF= -136 dBW/MHz).

From the EIRP graphs in Figure 4.2 (reprinted from Report 33) and the examples proposed in ECC Report 33 the minimum distance of the CS could be derived.

In the unlike case that TSs do not implement ATPC, it might still be possible to evaluate the minimum distance of a CS from the border without requiring coordination between the operators; the approach will be the same setting in case a) above $EIRP_{ATPC} = EIRP_{max}$; while case b) would not be applicable.

4.3 Effect of Multiple Interferers

Statistical modelling of multiple interferer scenarios has shown that, when allowance is made for the limited probability of a line of sight path between interferers and victim, and of the deployment of down tilted base station antennas in PMP networks, application of the PFD limit will ensure substantially interference-free co-existence between adjacent service areas for both PMP and mesh architectures.

4.4 International Co-ordination

The process of applying a boundary co-ordination trigger can also be applied to international co-ordination. The mechanism for providing protection remains the same, being based upon a tolerable I/N and threshold degradation limit agreed between the administrations concerned for reference victim receiver.

Therefore, in the general case, the same guidance as used for the inter-operator boundary in previous sections of this Annex, could apply also to international co-ordination provided that neighbouring administrations would agree to the methodology.

In order to coordinate efficiently at an international boundary, it could be useful to consider that preferential frequency blocks are defined for use near to the boundary, with different blocks being used on each side of the boundary.

ANNEX 5

SOME EXAMPLES OF STANDARDISED FWA TECHNOLOGIES

1 Introduction

A number of ETSI Standards have been developed defining the "minimum requirements" (i.e. the basic radio-frequency interface parameters and receiver sensitivity and interference robustness).

Those standards (e.g. EN 301 080, EN 301 021, EN 301 253 and EN 301 124) were specific for some basic access technologies (e.g. FDMA, TDMA, CDMA) and represent basis for Harmonised EN 301 753, which defines the parameters relevant to R&TTE Directive Article 3.2 on essential requirements.

A number of new mixed technologies are also present on the market (e.g. TDMA/OFDMA) and more are expected to be designed for covering the increasing demand for new wide- and broadband services. ETSI has also initiated a harmonisation process, under the WI DEN/TM-04130, for combining all those technologies into a unique "technology neutral" new multipart EN (including a Harmonised Part); in due time this new ENs will supersede the above mentioned ones.

This annex notes some possibilities and their key characteristics based upon known (at the time of writing) standardisation activities. These key characteristics were kept in mind whilst developing the assignment plans detailed in the previous annexes. Their inclusion is not intended as a statement regarding their suitability, nor to grant them any "preferred" status, but merely serves to illustrate the degree of flexibility that needs to be included in the frequency planning for FWA.

2 EP BRAN HIPERMAN (HM)

ETSI EP BRAN TS 102 210 "*HIPERMAN; System profiles*" and TS 102 177 "*HIPERMAN; Physical (PHY) layer HIPERMAN PHY*" define basics for a standardized "multi-vendor" radio interface in bands from 2 to 11 GHz.

The main characteristics of HIPERMAN include:

- Provision of up to 75 Mb/s per cell;
- Channelisation and modulation scheme as follows:
- Down-link and Up-link 1.75, 3.5 and 7 MHz using OFDM with adaptive QPSK, 16 QAM and (optionally) 64 QAM multi-state formats; flexible channel separation is also considered.
- The system architecture is P-MP, but also MESH architectures are considered;
- Capable to operate in paired spectrum allocations employing TDD and/or FDD; FDD terminal stations can operate in either full or half-duplex.

3 IEEE 802.16 Standards

IEEE 802.16-2001 and 802.16a-2003: "Air Interface for Fixed Broadband Wireless Access Systems" also define a harmonized radio interface for multi-vendor applications very similar to the ETSI HIPERMAN.