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

COMPATIBILITY STUDY FOR UMTS OPERATING WITHIN THE GSM 900 AND GSM 1800 FREQUENCY BANDS

Roskilde, May 2006

Table of contents

1 EXECUTIVE SUMMARY

This report gives the description of the sharing study methodology, co-existence scenarios, simulation assumptions, and the simulation results for the deployment of UMTS operating in 900 MHz and in 1800 MHz bands in urban and in rural areas. Based on the sharing study results and the analysis, it can be concluded that UMTS900/1800 can be deployed in urban, sub-urban and rural areas in co-existence with UMTS and/or GSM under the following conditions:

1) UMTS900/1800 networks can co-exist with other UMTS900/1800 networks in the same geographical area with a carrier separation of 5 MHz. The recommended carrier separation between two uncoordinated UMTS networks is 5 MHz or more. The recommended carrier separation in coordinated operation, for example, multiple carriers over the same UMTS network, is 5 MHz or less, in the same way as for the core band.

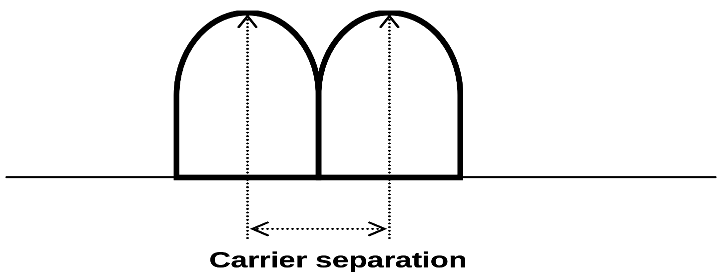

Figure 1: Carrier separation between two UMTS carriers

2) UMTS900/1800 can be deployed in urban, sub-urban and rural areas in co-existence with GSM900/1800 macrocells in coordinated operation and/or in uncoordinated operation. When UMTS900/1800 networks and GSM900/1800 networks are in uncoordinated operation, the recommended carrier separation between UMTS carrier frequency and the nearest GSM carrier frequency is 2.8 MHz or more. When UMTS900/1800 networks and GSM900/1800 networks are in coordinated operation (co-located sites), the recommended carrier separation between UMTS carrier frequency and the nearest GSM carrier frequency is 2.6 MHz or more.

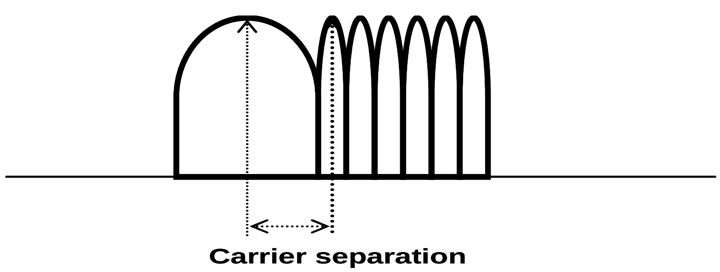

Figure 2: Carrier separation between UMTS carrier and GSM carriers

3) UMTS900/1800 can be deployed in urban, sub-urban areas in co-existence with GSM900/1800 microcell and/or picocell in uncoordinated (non-located sites between different networks) operation. The recommended carrier separation between the UMTS carrier frequency and the nearest GSM microcell and/or picocell carrier frequency is 2.8 MHz or more. It is suggested that the UMTS carrier should be placed as far as possible from GSM microcell and/or picocell carrier frequencies.

   One possible solution is for the operator to separate their UMTS carriers and their GSM microcell and/or picocell carrier frequency sub-band by the GSM macrocell carrier frequency sub-band.

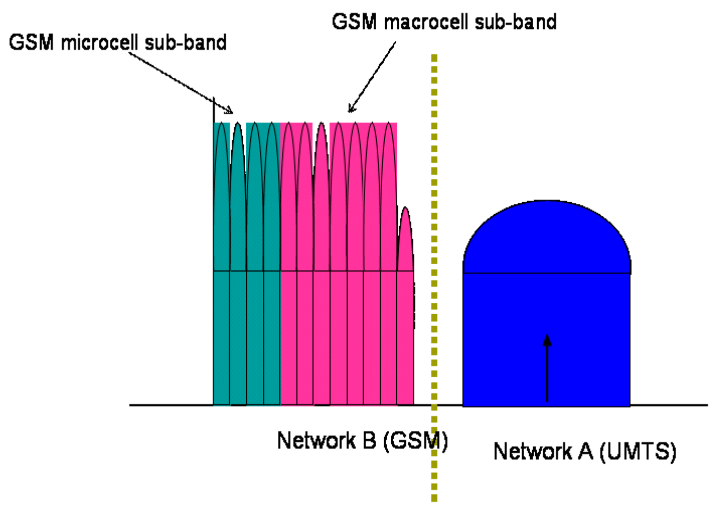

Figure 3: Suggested frequency arrangement between an UMTS carrier and GSM carriers

4) In order to avoid or minimise the interference between two operators, it is suggested for the operator who plans to deploy UMTS and GSM in the same band that it is better to use the so called "Sandwich" frequency arrangement as shown below.

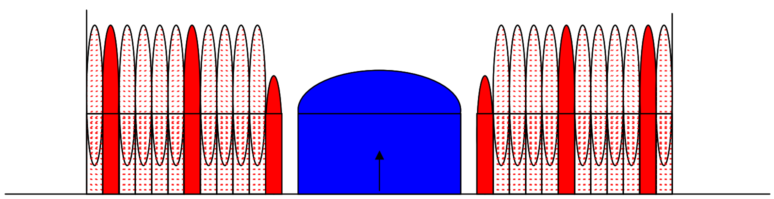

Figure 4a: Suggested frequency arrangement for an operator deploying one UMTS carrier

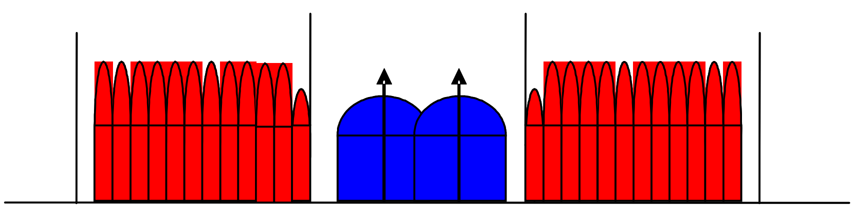

Figure 4b: Suggested frequency arrangement for an operator deploying two or more UMTS carriers

2 INTRODUCTION

The 900 MHz and 1800 MHz bands are being widely used by GSM systems in Europe. It is believed that GSM900 and GSM1800 systems will continue to exist for a long time. Deploying UMTS (UTRA-FDD) systems in the 900 MHz and 1800 MHz bands does not mean the immediate replacement of GSM systems by UMTS. UMTS will co-exist with GSM in the 900 MHz and 1800 MHz frequency bands in the future.

The main interest for some European operators to deploy UMTS in the 900 MHz band is the better coverage compared to UMTS at 2100 MHz, especially to provide coverage for rural areas. UMTS900 offers a considerably more cost efficient solution for operators to offer UMTS services in rural areas with low population density.

The total bandwidth of the 1800 MHz frequency band is 2 x 75 MHz. In some countries the 1800 MHz band is not totally used by GSM systems, especially in rural areas with low population density. Part of the 1800 MHz band can become a complementary band for deploying UMTS, the interest for operators to deploy UMTS in the 1800 MHz band comes also from the fact that it is easy to share the same GSM1800 radio sites by UMTS systems operating in the 1800 MHz band.

In this sharing study report, the co-existence between UMTS and GSM operating in the 900/1800 MHz bands and the potential interference between UMTS operating in 900/1800 MHz band is analyzed. This report can be used as the basis for the development of the channel arrangement Decision or a Recommendation for UMTS operating in the 900/1800 MHz bands.

The sharing study related to UMTS operating in the 900 MHz band is described in chapter 3. The description of the sharing study for UMTS operating in the 1800 MHz band can be found in chapter 4.

3 SHARING STUDY FOR UMTS OPERATING IN THE 900 MHZ BAND

3.1 900 MHz band plan

- 2 x 25 MHz are allocated as Standard or primary GSM 900 Band, P-GSM:
  - Uplink: 890 MHz to 915 MHz: mobile transmit, base receive;
  - Downlink: 935 MHz to 960 MHz: base transmit, mobile receive.
- Another 2 x 10 MHz are allocated as Extended GSM 900 Band, E-GSM, in total there are 2 x 35 MHz used by GSM900 (Standard GSM and Extended GSM):
  - Uplink: 880 MHz to 915 MHz: mobile transmit, base receive;
  - Downlink: 925 MHz to 960 MHz: base transmit, mobile receive.

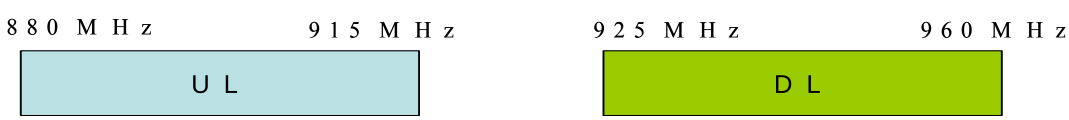

Figure 5: 900 MHz band plan

The 900 MHz frequency band has been allocated for GSM systems. In every European country, in average there are two or three GSM900 operators, each operator has a bandwidth between 2 x 10 MHz and 2 x 15 MHz.

3.2 UMTS900 system characteristics

UMTS900 technical specifications have been developed by 3GPP in release 7 [1, 2]. UMTS900 system characteristics are derived from the 3GPP UMTS900 technical specifications. The radio site parameters, such as antenna height, antenna gain, etc, are from the deployment scenarios used by 3GPP for sharing studies between UMTS and GSM in the 900 MHz band [3, 4].

UMTS900 system characteristics are summarized in table 1.

Table 1: UMTS system characteristics

	UMTS900	
Downlink band (MHz)	925 – 960	
Uplink band (MHz)	880 – 915	
Carrier separation (MHz)	5	
Channel raster (kHz)	200	
	BS	**UE**
Tx Power (Maximum) (dBm)	43	21
Antenna gain (dBi)	18 (rural) 15 (urban)	0
Feeder loss (dB)	3	0
Antenna height (m)	45 (Rural) 30 (Urban)	1.5
Antenna down-tilt (°)	3 (Urban)	-
BS-UE MCL (dB)	80 (Rural) 70 (Urban)	-
Spectrum mask	TS25.104	TS25.101
ACLR (±5MHz) (dB)	45	33
ACLR (±10 MHz) (dB)	50	43
Spurious emissions	TS25.104	TS25.101
Receiver Bandwidth (MHz)	3.84	3.84
Receiver Temperature (KBT) (dBm)	–108	–108
Receiver noise figure (dB)	5	12
Receiver Thermal Noise Level (dBm)	–103	-96
Receiver reference sensitivity*	-121	-114
Receiver ACS (dB)	46	33
Receiver in-band blocking	TS25.104	TS25.101
Receiver out-of-band blocking	TS25.104	TS25.101
Receiver Narrow band blocking at 2.8 MHz (dBm)	-47 (useful signal at -115 dBm)	-56 (useful signal at RefSens+10)
**Receiver reference sensitivity was defined for speech 12.2 kbps in TS25.104 and TS25.101.*		

3.3 UMTS900 deployment scenarios

The deployment of UMTS in the 900 MHz and 1800 MHz bands does not mean the immediate replacement of GSM networks by UMTS. Some operators may plan to deploy only UMTS in 900 MHz band. For some others (and it is believed for most of the existing GSM operators) the most probable transition strategy is to use part of the 900 MHz frequency band for deploying UMTS in order to offer 3G services, while keeping GSM networks in operation. GSM and UMTS will be in co-existence and operated in adjacent channels. Particularly, the deployment of UMTS in the 900 MHz band in rural areas allows providing 3G services at a much lower cost compared to the deployment of UMTS in 2.1 GHz band.

A preliminary study comparing the GSM and UMTS link budgets has shown that the cell range of GSM speech service is similar to that of UMTS CS64. This means for a GSM operator, by re-using the existing GSM sites without adding any new sites, UMTS CS64 video-telephony service can be offered by the co-location of GSM and UMTS sites.

For offering higher data rate services, such as PS128, CS128, PS384, some additional new sites could be required.

Considering these deployment scenarios, the following sharing scenarios should be studied:

1) Coordinated GSM and UMTS sites (co-located GSM and UMTS BS)
2) Uncoordinated GSM and UMTS sites
3) Uncoordinated UMTS networks sites.

In reference to the existing GSM900 networks, it can be reasonably assumed that the representative cell ranges of macrocells are respectively: i) 577 m in urban area; ii) 2400 m in sub-urban area; iii) 5000 m in rural area.

In fact, the actual GSM cell range in low population density rural area is in average at least 5 km, it can go up to 20 km. Therefore sharing study for rural areas with cell range of at least 5 km appears necessary and important.

Due to the better propagation conditions in the 900 MHz band compared to the 2 GHz band, deploying UMTS900 in urban areas can improve indoor coverage and offer deeper indoor penetration. By considering that in many European cities GSM900 has been deployed as macrocells, microcells and indoor picocells, the study of co-existence between UMTS900 and GSM900 in urban areas should take into account the scenarios of GSM900 microcells and picocells.

Six deployment scenarios for UMTS900 have been identified and studied:

- *Scenario_1: UMTS(macro)-GSM(macro) in Urban area with cell range of 577 m in uncoordinated operation*
- *Scenario_2: UMTS(macro)-GSM(macro) in Rural area with cell range of 5000 m in uncoordinated operation*
- *Scenario_3: UMTS(macro)-GSM(macro) in Rural area with cell range of 5000 m in coordinated operation*
- *Scenario_4: UMTS(macro)-UMTS(macro) in Rural area with cell range of 5000 m in uncoordinated operation*
- *Scenario_5: UMTS(macro)-GSM(micro) in Urban area in uncoordinated operation*
- *Scenario_6: UMTS(macro)-GSM(pico) in Urban area in uncoordinated operation*

The detailed description of simulation assumptions for these six deployment scenarios can be found in chapters 3.4 and 3.5, as well as in chapter 4.

3.4 Co-existence between UMTS networks in the 900 MHz band

3.4.1 Co-existence between UMTS networks in rural areas

3.4.1.1 Scenario (Scenario_4) description

- Scenario_4: UMTS(macro)-UMTS(macro) in Rural areas with cell ranges of 5000 m in uncoordinated operation
  - 2 x 5 MHz uncoordinated operation between UMTS macrocell and UMTS macrocell

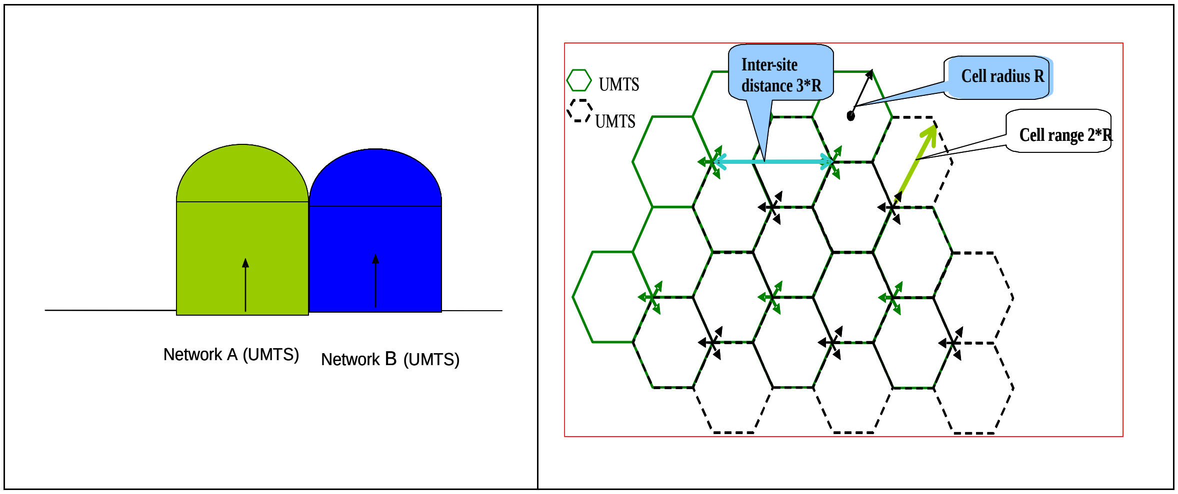

Figure 6: 2 x 5 MHz uncoordinated operation of two UMTS networks

Carrier separation between two UMTS networks is 5 MHz. The cell range is 5000 m. As shown in figure 6, the BS of network B is located at the cell edge of network A. The simulation assumptions for the co-existence scenario 4 are summarized in table 2.

Table 2: Summary of UMTS900/UMTS900 simulation parameters for Scenario 4

Scenario_4		**UMTS(macro)-UMTS(macro) in Rural area with cell range of 5000m in uncoordinated operation**
Simulation cases		UMTS victims on both uplink and downlink. 2 simulation cases. *1) Downlink* *-WCDMA victim* *2)Uplink* *- WCDMA victim* Run simulations with various ACIRs by considering a centre frequency separation of 5.0 MHz.
Network layout		*As shown in figure 6 above* *- Rural environment* *- 3-sector configuration* *-36 cells (i.e. 108 sectors) with wrap-around* *-Cell radius R=2500 m, cell range 2R=5000 m, inter-site distance 3R= 7500 m (as shown in figure 6)* *-Worst-case shift between operators, Operator A's WCDMA site is located at Operator B's WCDMA cell edge*
System parameters	*WCDMA*	- BS antenna gain with cable loss included = 15 dBi - BS antenna height H_{bs}=45 m - UE antenna height H_{ms}=1.5 m - BS-UE MCL=80 dB - BS antenna(65° horizontal opening) radiation pattern is referred to 3GPP TR 25.896 V6.0.0 (2004-03), Section A.3 - UE antenna gain 0 dBi (omni-directional)
Services	*WCDMA*	*8 kbps Speech (chip rate: 3.84 Mcps)* *- Eb/Nt target (downlink): 7.9 dB* - Eb/Nt target (uplink): 6.1 dB
Propagation Model	*WCDMA*	*Log_normal_Fading = 10 dB* Rural area propagation model (Hata model): $L(R) = 69.55 + 26.16 \log f - 13.82\log(H_b) + [44.9 - 6.55\log(H_b)]\log R - 4.78(\log f)^2 + 18.33 \log f - 40.94$ Hb is BS antenna height above ground in m, f is frequency in MHz, R is distance in km. With Hb = 45 m, f = 920 MHz, the propagation model is simplified as

		L (R)= 34.1 log(R)+ 95.6* The path loss from a transmitter antenna connector to a receiver antenna connector (including both antenna gains and cable losses) will be determined by: Path_Loss = max (L(R) + Log_normal_Fading - G_Tx – G_Rx, Free_Space_Loss + Log_normal_Fading - G_Tx – G_Rx, MCL) where G_Tx is the transmitter antenna gain in the direction toward the receiver antenna, which takes into account the transmitter antenna pattern and cable loss, G_Rx is the receiver antenna gain in the direction toward the transmitter antenna, which takes into account the receiver antenna pattern and cable loss, Log_normal_Fading is the shadowing fade following the log-normal distribution.
Cell selection	*WCDMA*	*As per TR 25.942*
SIR calculation	*WCDMA*	*As per TR 25.942, except for the following changes:* *- Processing gain is changed to 26.8 dB for 8 kbps* *- Thermal noise level is raised to -96 dBm for downlink*
Power Control assumption	*WCDMA*	*As per TR 25.942* *- 21 dBm terminals* *- Maximum BS power: 43 dBm* *- Maximum power per DL traffic channel: 30 dBm* *- Minimum BS power per user: 15 dBm.* *- Minimum UE power: –50 dBm.* *- Total CCH power: 33 dBm*
Capacity	*WCDMA*	*Capacity loss versus ACIR as per TR 25.942*
ACIR	*WCDMA to WCDMA*	*As per spectrum masks defined in TS 25.101, TS 25.104.*

3.4.1.2 Interference analysis method

Interference between UMTS networks operating in the 900 MHz band was analyzed with the method of Monte-Carlo simulations.

The objective of Monte-Carlo simulations is to determine the appropriate UMTS BS & UE RF system parameters, Spectrum mask, ACLR (Adjacent Channel power Leakage Ratio), ACS (Adjacent Channel Selectivity), etc. for ensuring the good co-existence of UMTS networks. In the simulation, the UMTS UL/DL capacity losses as function of ACIR (Adjacent Channel Interference Ratio) were simulated. The ACIR was used as a variable parameter.

In order to analyze the simulation results, it is supposed that the UMTS900 system (BS & UE) has the same RF characteristics, such as Tx spectrum mask, ACLR, ACS, as defined in TS25.104 and TS25.101 for UMTS850/1800 (band V, band III). The simulation results were analyzed based on these assumptions for checking if the assumed RF characteristics are sufficient or not for UMTS900 deployment in co-existence with other UMTS900 network.

The ACLR and ACS of UTRA-FDD BS and UTRA-FDD UE defined in TS25.104 and TS25.101 are summarized in the table 3 below.

Table 3. ACLR and ACS of UTRA-FDD BS and UE

	UTRA-FDD BS	**UTRA-FDD UE**
ACLR (dB)	45	33
ACS (dB)	46.3	33

The ACIR (Adjacent Channel Interference Ratio) can be calculated by the formula (1), the results are given in the table 4.

$$\mathrm{ACIR} = \frac{1}{\frac{1}{\mathrm{ACLR}} + \frac{1}{\mathrm{ACS}}} \qquad (1)$$

Table 4. ACIR for UMTS UL/DL as victim being interfered by UMTS UL/DL

	UMTS UL as victim	UMTS DL as victim
ACIR (dB)	32.8	32.7

3GPP agreed that the threshold for co-existence is that the UMTS UL/DL capacity loss due to interferences from the UMTS UL/DL should not be bigger than 5%.

3.4.1.3 Simulation result and analysis

Based on the agreed co-existence scenario 4 of 3GPP and simulation assumptions as described in section 3.4.1.1, two cases (UMTS UL & DL as victim) were simulated. The simulation results for this co-existence scenario 4 from several companies have been presented and discussed during the study, as summarised below.

- **UMTS DL Capacity Loss (%) due to interference from UMTS DL**

Figure 7 gives the simulation results (four simulation curves) of UMTS DL as victim, the UMTS downlink capacity loss due to interference from UMTS downlink as function of ACIR between UMTS carriers. All of the four simulation curves of the UMTS downlink capacity loss due to interference from the UMTS DL for the co-existence scenario 4, as given in figure 7 show that at the operating point of ACIR=32.7 dB, the UMTS DL capacity loss is below 1%.

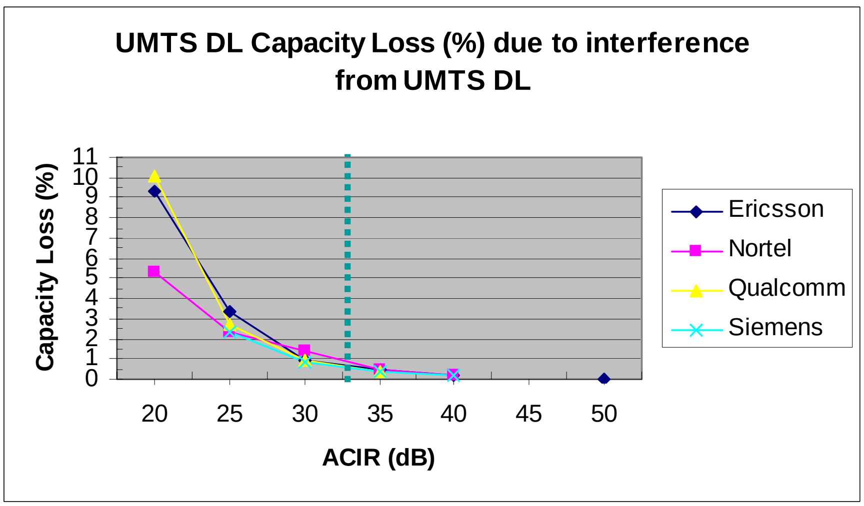

Figure 7. UMTS DL Capacity Loss (%) due to interference from UMTS DL (Scenario_4)

- **UMTS UL Capacity Loss (%) due to interference from UMTS UL**

The simulation results (three simulation curves) for the case of UMTS UL as victim, the UMTS UL capacity loss (%) due to interference from the UMTS uplink as function of ACIR are given in figure 8. As shown in figure 8, at the operating point of ACIR=32.8 dB, the UMTS UL capacity loss is smaller than 0.7%.

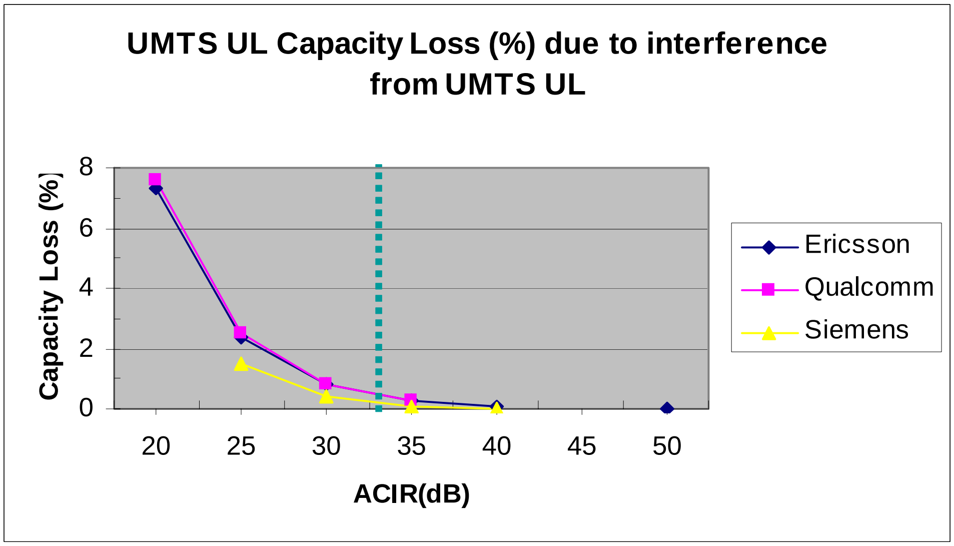

Figure 8: UMTS UL Capacity Loss (%) due to interference from UMTS UL (Scenario_4)

3.4.1.4 Conclusions

Based on the analysis of the simulation results for the co-existence scenario 4 between UMTS(macro) and UMTS(macro) in rural areas with cell range of 5000 m in uncoordinated operation , the following conclusions can be made :

- RF system characteristics assumed for UMTS900 are suitable and sufficient for UMTS900 to be deployed in rural environments with cell ranges of 5000 m in uncoordinated operation;
- UMTS networks in rural environments can co-exist in uncoordinated operation with 5 MHz carrier separation.

3.4.2 Co-existence between UMTS networks in urban area

The co-existence between UMTS networks in urban areas has been extensively studied by 3GPP for other bands than 900 MHz band, such as 2.1 GHz, 1.8 GHz, and the 850 MHz band. The simulation results in TR 25.942 [5] indicate that UMTS can be deployed in urban areas in co-existence with other UMTS networks at a carrier separation of 5 MHz or even less.

3.5 Co-existence between UMTS and GSM in the 900 MHz band

3.5.1 Co-existence between UMTS (macrocell) and GSM (macrocell) in urban area in uncoordinated operation

3.5.1.1 Scenario (Scenario 1) description

- **Scenario_1: UMTS(macro)-GSM(macro) in urban areas with cell ranges of 500 m in uncoordinated operation**

  - 2 x 5 MHz uncoordinated operation between UMTS macrocell and GSM macrocell

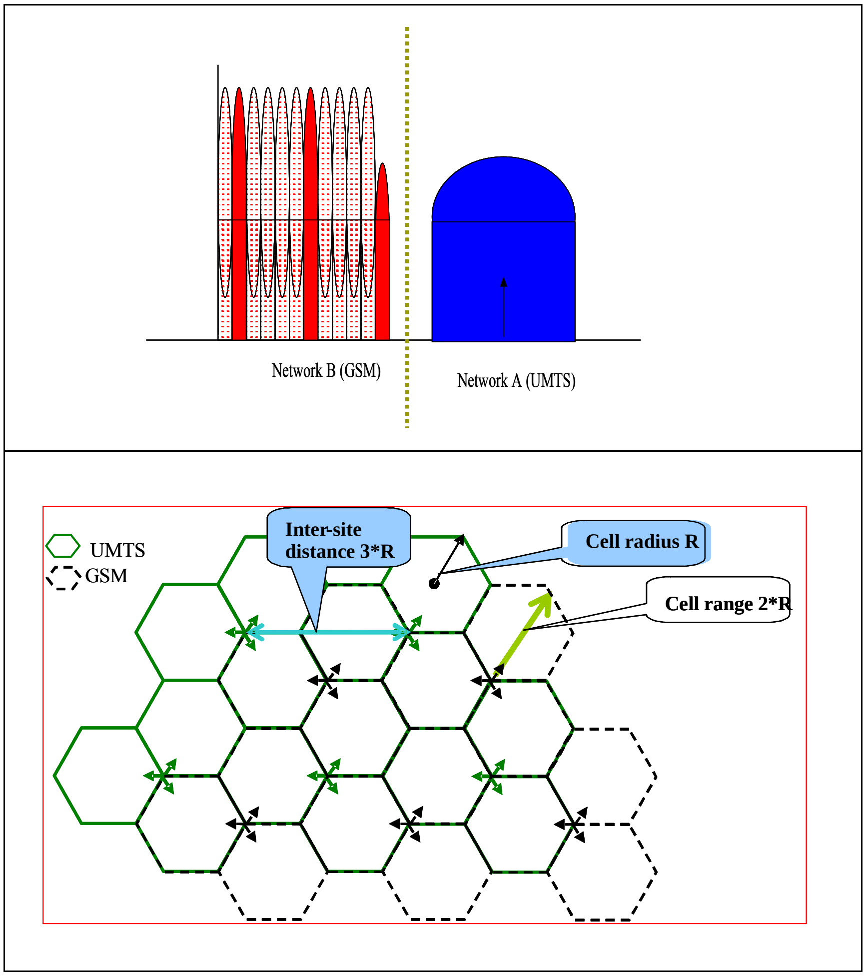

Figure 9: 2 x 5 MHz uncoordinated operation of UMTS vs GSM networks

The co-existence scenario is presented in figure 9. The UMTS carrier and GSM carriers are in adjacent placement. In this uncoordinated operation, GSM sites are located at the cell edge of UMTS cells as shown in figure 9. Simulation assumptions for this co-existence scenario are summarized in the table 5.

Table 5: Summary of UMTS900/GSM900 simulation parameters for Scenario 1

Scenario_1	**UMTS(macro)-GSM(macro) in Urban area with cell range of 500 m in uncoordinated operation**
Simulation cases	Both UMTS and GSM as victims in uplink and downlink. In total 4 simulation cases. *1) Downlink* *-GSM (BCCH only)/WCDMA for WCDMA victim* *-GSM (non-BCCH with PC)/WCDMA for GSM victim* *2) Uplink* *- WCDMA victim (GSM load maximum – all time slots in use. Simulate GSM system, then add UMTS users until the total noise rise hits 6 dB)* *- GSM victim (WCDMA loaded to 6 dB noise rise)* *No frequency hopping for GSM* *Both networks in macro environment* Run simulations with various ACIRs by considering a centre frequency separation of 2.8 MHz.
Network layout	*As shown in figure 6 above* *- Urban environment* *- 3-sector configuration* *-GSM cell reuse GSM: 4/12* *-36 cells (i.e., 108 sectors) with wrap-around* *-Cell radius R=250m, cell range 2R=500m, inter-site distance 3R= 750 m (as shown in figure 6)* *-Worst-case shift between operators, GSM site is located at WCDMA cell edge*

System parameters	*WCDMA*	- BS antenna gain with cable loss included = 12 dBi - BS antenna height Hbs=30 m - UE antenna height Hms=1.5 m - BS-UE MCL=70 dB - BS antenna(65° horizontal opening) radiation pattern is referred to 3GPP TR 25.896 V6.0.0 (2004-03), Section A.3 - UE antenna gain 0 dBi (omni-directional)
	GSM	- BS antenna gain with cable loss included = 12 dBi - BS antenna height Hbs=30 m - MS antenna height Hms=1.5 m - BS-MS MCL=70 dB - BS antenna(65° horizontal opening) radiation pattern is referred to 3GPP TR 25.896 V6.0.0 (2004-03), Section A.3 - UE antenna gain 0 dBi (omni-directional)
Services	*WCDMA*	*8 kbps Speech (chip rate: 3.84 Mcps)* *- Eb/Nt target (downlink): 7.9 dB* - Eb/Nt target (uplink): 6.1 dB
	GSM	*Speech* *- SINR target (downlink): 9 dB* *- SINR target (uplink): 6 dB*
Propagation Model	*WCDMA and GSM*	*As per TR 25.942* *Log_normal_Fading = 10 dB* Urban propagation model: L(R) = 40*(1-0.004*DHb)*LOG10(R)-18*LOG10(DHb)+21*LOG10(f)+80 DHb is BS antenna height above average building top, for urban area with Hbs = 30 m, DHb = 15 m, f is frequency in MHz, R is distance in km L(R) = 37.6* LOG10(R) + 121.1 The path loss from a transmitter antenna connector to a receiver antenna connector (including both antenna gains and cable losses) will be determined by: Path_Loss = max (L(R) + Log_normal_Fading - G_Tx – G_Rx, Free_Space_Loss + Log_normal_Fading - G_Tx – G_Rx, MCL) where: - G_Tx is the transmitter antenna gain in the direction toward the receiver antenna, which takes into account the transmitter antenna pattern and cable loss, - G_Rx is the receiver antenna gain in the direction toward the transmitter antenna, which takes into account the receiver antenna pattern and cable loss, Log_normal_Fading is the shadowing fade following the log-normal distribution.
Cell selection	*WCDMA*	*As per TR 25.942*
	GSM	*As for WCDMA in TR 25.942, but with only one link selected at random within a 3 dB handover margin*
SIR calculation	*WCDMA*	*As per TR 25.942, except for the following changes:* *- Interference contributions from GSM TRXs or MSs are added to the total noise-plus-interference.* *- Processing gain is changed to 26.8 dB for 8 kbps* *- Thermal noise level is raised to -96 dBm for downlink*
	GSM	*Total noise-plus-interference is sum of thermal noise, GSM co-channel, and WCDMA interference. Cells are synchronised on a time slot basis. Adjacent channel GSM interference is neglected.* *Noise floor (downlink): -111 dBm* *Noise floor (uplink): -113 dBm*

Power Control assumption	*WCDMA*	*As per TR 25.942* *- 21 dBm terminals* *- Maximum BS power: 43 dBm* *- Maximum power per DL traffic channel: 30 dBm* *- Minimum BS power per user: 15 dBm* *- Minimum UE power: –50 dBm* *- Total CCH power: 33 dBm*
	GSM	*Stabilization algorithm same as for WCDMA (C/I based) with a margin of 5 dB added to the SIR target.* *- Maximum power (TRx): 43 dBm* *- Minimum power (TRx): 10 dBm (non-BCCH)* *- Maximum power (MS): 33 dBm* *- Minimum power (MS): 5 dBm*
Capacity	*WCDMA*	*Capacity loss versus ACIR as per TR 25.942*
	GSM	*Load to maximum number of users and observe change in outage (i.e., 0.5 dB less than SINR target)*
ACIR	*WCDMA to GSM*	*As per spectrum masks defined in TS 25.101, TS 25.104 (applying the appropriate measurement BW correction), unless capacity loss is found to be significant.*
	GSM	$\mathrm{ACIR}(f) = C(f_0) + m\,(f - f_0)$ (dB) *GSM BTS to WCDMA UE:* *Consider 3GPP TS45005 GSM BTS transmitter emission mask for 900 band and WCDMA UE receiver selectivity slope, m = 0.8 dB / 200 kHz* *GSM MS to WCDMA BS:* *Consider 3GPP TS45005 GSM MS transmitter emission mask for 900 band and WCDMA BS receiver characteristics, m = 0.5 dB / 200 kHz*

3.5.1.2 Interference analysis method

Interference between GSM and UMTS operating in the 900 MHz band was analyzed with the Monte-Carlo simulation method.

The objective of the Monte-Carlo simulation is to determine the appropriate UMTS BS & UE RF system parameters, Spectrum mask, ACLR (Adjacent Channel power Leakage Ratio), ACS (Adjacent Channel Selectivity), receiver narrow band blocking, etc. for ensuring the good co-existence of UMTS and GSM. In the simulation, the UMTS UL/DL capacity losses as function of ACIR (Adjacent Channel Interference Ratio) were simulated, the GSM UL/DL system outage degradations at given ACIR values or as function of ACIR were also simulated. The ACIR was used as a variable parameter.

In order to analyze the simulation results, it was supposed that the UMTS900 system (BS & UE) has the same RF requirements, such as Tx spectrum mask, ACLR, ACS, narrow band blocking characteristics as defined in TS25.104 and TS25.101 for UMTS850/1800 (band V, band III), the spectrum masks of GSM BS & MS are defined in 3GPP TS45.005. Then the simulation results were analyzed based on these assumptions for checking if the assumed RF characteristics are sufficient or not for ensuring the required good co-existence between UMTS900 and GSM900 in the same geographical area.

The 3GPP agreed threshold for co-existence is that the UMTS UL/DL capacity loss due to interferences from GSM UL/DL should not be bigger than 5%. Concerning the impact on GSM network performance, since GSM network capacity is fixed, the evaluation criterion is the system outage degradation, that should be as small as possible.

For the co-existence between UMTS and GSM, the ACLR of the UMTS BS & UE were calculated with the BS & UE Tx spectrum mask by integration over a 200 kHz bandwidth centereed at the carrier separation between UMTS and GSM.

WCDMA node B emissions to GSM MS as a function of carrier separation are plotted in figure 10. WCDMA UE emissions to GSM BS as a function of carrier separation are given in figure 11.

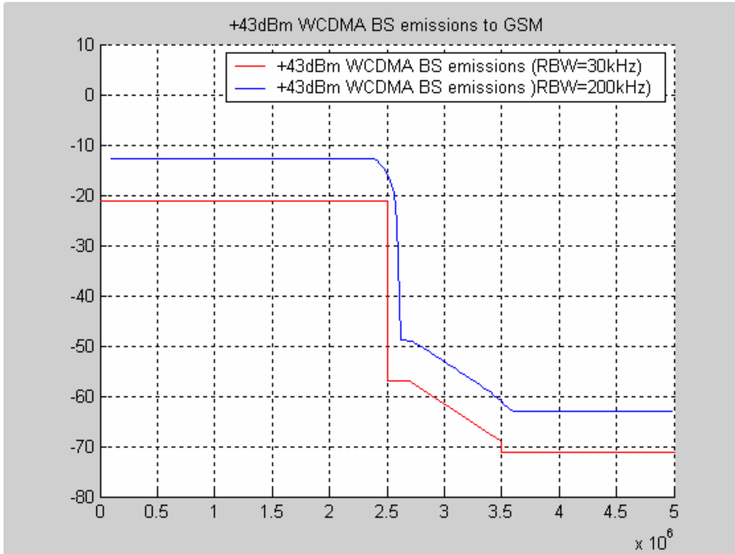

Figure 10: WCDMA Node B emissions to GSM MS as a function of carrier separation

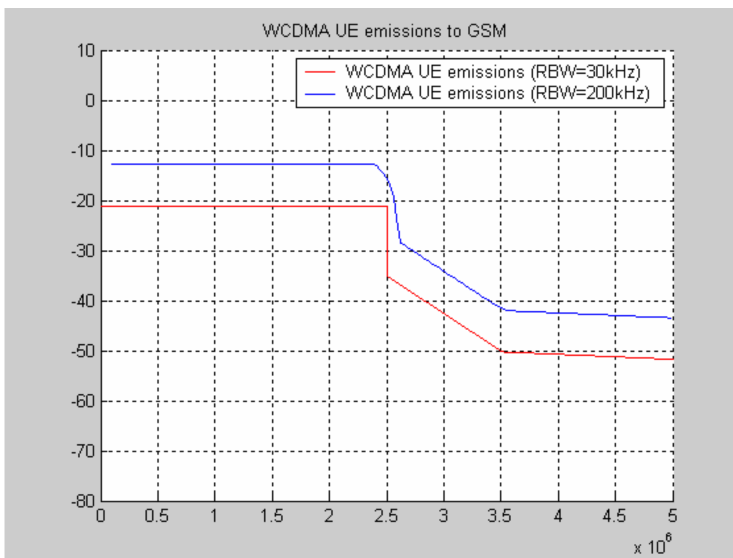

Figure 11: WCDMA UE emissions to GSM BS as a function of carrier separation

GSM BS emissions to WCDMA UE as a function of the carrier separation are plotted in figure 12 and the GSM MS emissions to WCDMA Node B as a function of the carrier separation are given in figure 13.

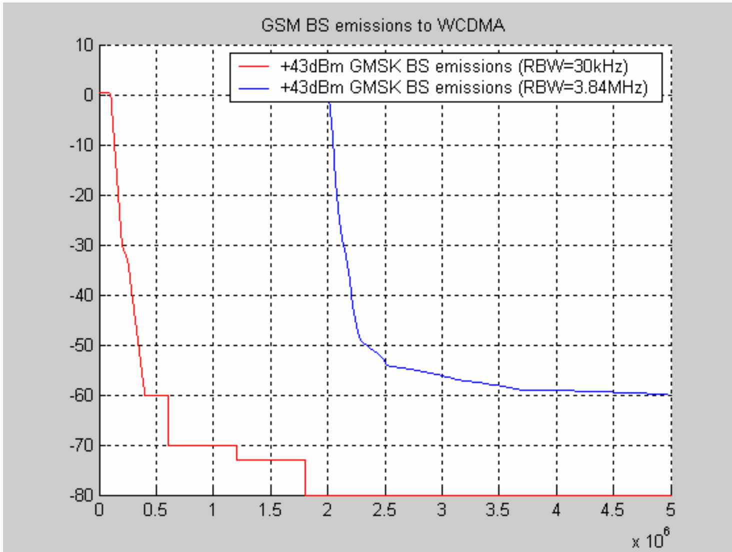

Figure 12: GSM BS emissions to WCDMA UE as a function of carrier separation

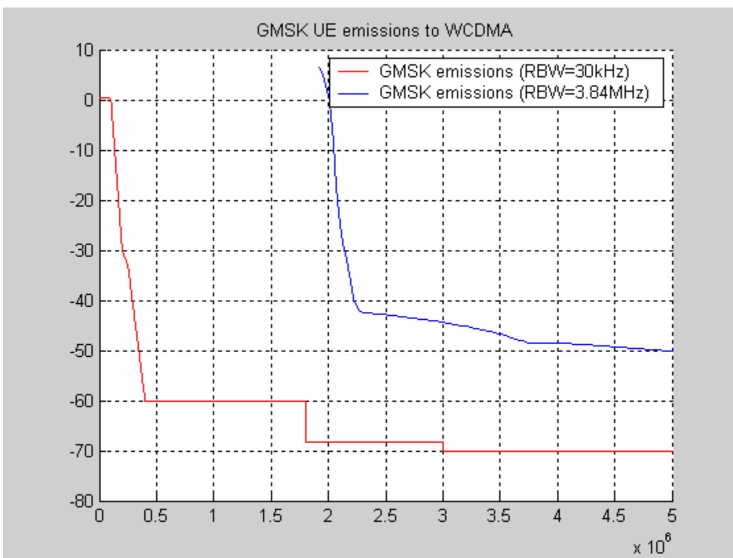

Figure 13: GSM MS emissions to WCDMA Node B as a function of carrier separation

The ACS of UMTS BS and UE were derived from the assumed narrow band blocking (GSM interferer) requirements at 2.8 MHz carrier separation. The narrow band blocking of WCDMA BS was defined in TS25.104 as -47 dBm at 2.8 MHz carrier separation which is measured with a useful signal at -115 dBm (6 dB above reference sensitivity level of WCDMA BS). The narrow band blocking of WCDMA UE was defined in TS25.101 as -56 dBm at 2.8 MHz carrier separation which was measured with useful signal at a level of 10 dB above UE reference sensitivity.

The ACLR and ACS of UMTS BS & UE for carrier separation of 2.8 MHz and 4.8 MHz are given in the table 6.

Table 6: ACLR and ACS of UMTS BS and UE for co-existence with GSM

Carrier separation →	2.8 MHz		4.8 MHz	
	UTRA-FDD BS	UTRA-FDD UE	UTRA-FDD BS	UTRA-FDD UE
ACLR (dB)	50	31.3	63	43.3
ACS (dB)	51.3	30.5*	> 51.3	> 30.5*

* ACS =30.5 dB is derived with the UMTS UE noise floor of -96 dBm. At the noise floor of -99 dBm, the UE ACS will be 33.5 dB.

The ACLR (over 3.84 MHz bandwidth) of GSM BS and MS can be derived from the GSM BS and MS transmission mask defined in 3GPP TS45.005. The derived ACLR of GSM900 BS and MS for the co-existence with UMTS at carrier separation of 2.8 MHz and 4.8 MHz are respectively given in the table 7.

Table 7: ACLR of GSM900 BS and MS for co-existence with UMTS

Carrier separation →	2.8 MHz		4.8 MHz	
	GSM900 BS	GSM900 MS	GSM900 BS	GSM900 MS
ACLR (dB) measured over 3.84 MHz bandwidth	55.2	43.8	59.8	49.7

The ACIR was calculated with the formula (1). The obtained ACIR values for UMTS UL as victim and for UMTS DL as victim for both 2.8 MHz and 4.8 MHz carrier separations are given in table 8.

Table 8: ACIR for UMTS UL/DL as victim when being interfered by GSM UL/DL

Carrier separation→	2.8 MHz		4.8 MHz	
	UMTS UL as victim	UMTS DL as victim	UMTS UL as victim	UMTS DL As victim
ACIR (dB)	43.1	30.5	> 47.4	> 30.5

The derived ACIR for GSM UL as victim and for GSM DL as victim when GSM UL/DL being interfered by UMTS UL/DL for the carrier separation of 2.8 MHz and 4.8 MHz are respectively given in the table 9.

Table 9: ACIR for GSM UL/DL as victim when being interfered by UMTS UL/DL

Carrier separation→	2.8 MHz		4.8 MHz	
	GSM UL as victim	GSM DL as victim	GSM UL as victim	GSM DL as victim
ACIR (dB)	31.3	50	43.3	63

3.5.1.3 Simulation result and analysis

Based on the agreed co-existence scenario from 3GPP and simulation assumptions described above, several Monte-Carlo simulation results have been presented and discussed during the study. These simulation results are put together and analyzed below.

- **UMTS DL Capacity Loss (%) due to interference from GSM DL**

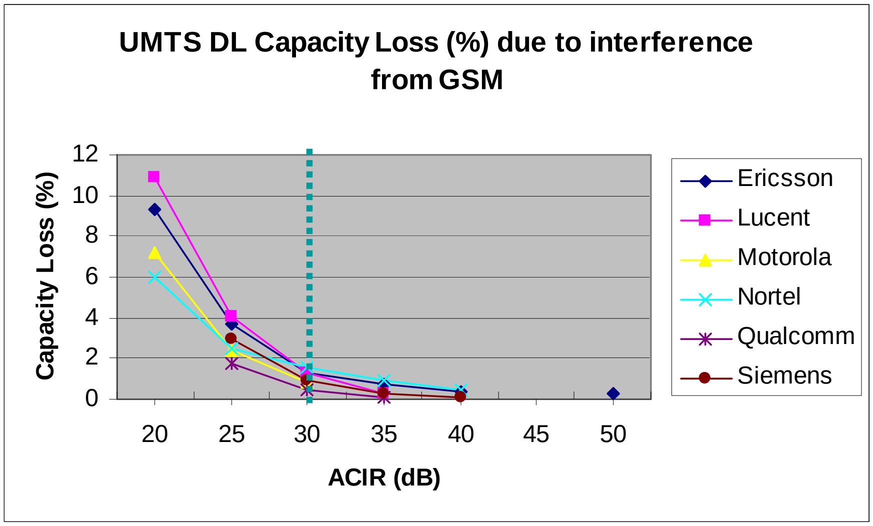

Figure 14: UMTS DL capacity loss due to interference from GSM DL (Scenario 1)

Figure 14 gives the simulation results of UMTS DL as victim, the UMTS downlink capacity loss (%) due to interference from GSM downlink as function of ACIR between UMTS carrier and the nearest GSM carrier. Six simulation curves plotted in figure 14 show that, at ACIR=30.5 dB, the UMTS downlink capacity loss due to interference from GSM downlink is smaller than 1.5%.

- **UMTS UL Capacity Loss (%) due to interference from GSM UL**

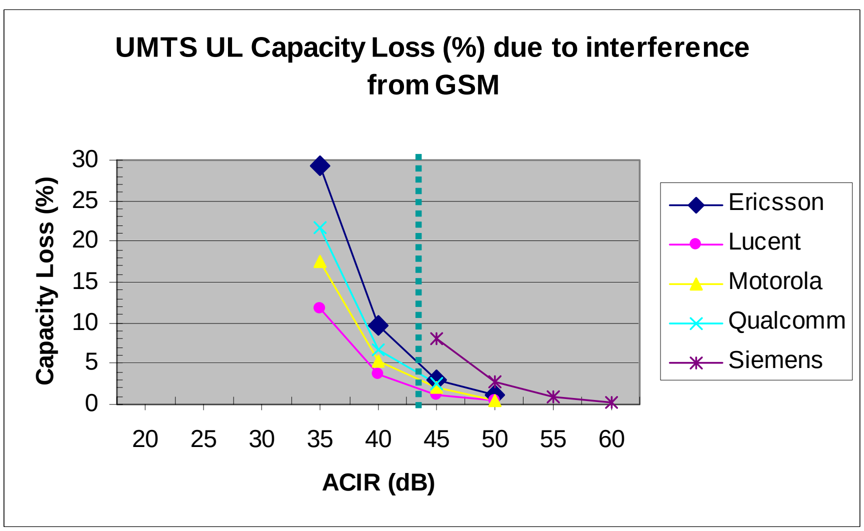

Figure 15: UMTS UL capacity loss due to interference from GSM UL (Scenario 1)

The simulation results for the case of UMTS UL as victim, the UMTS UL capacity loss (%) due to interference from GSM uplink as function of ACIR between UMTS carrier and the nearest GSM carrier, are given in figure 15.

Five simulation results are available for the case of the UMTS uplink as victim, as shown in figure 15. Taking the average of the results at the point of ACIR=43.1 dB , the UMTS uplink capacity loss due to interference from GSM uplink is expected to be smaller than 5%.

- **GSM DL System Outage Degradation (%) due to interference from UMTS DL**

The simulation results of GSM system downlink outage degradation due to interference from UMTS downlink are summarized in table 10. It can be seen that the GSM system downlink outage degradations are negligible.

Table 10: GSM system DL outage degradation (%)

	Lucent	Motorola	Qualcomm
Without WCDMA interference	0.01	0.06	
With WCDMA interference	0.014		
System Outage Increase		negligible	negligible

Three simulation curves of GSM downlink system outage degradation due to interference from UMTS downlink are plotted in figure 16. As shown in the figure 16, at the point of ACIR=50 dB, the GSM downlink system outage degradation is unnoticeable, which is in line with the results given in the table 10.

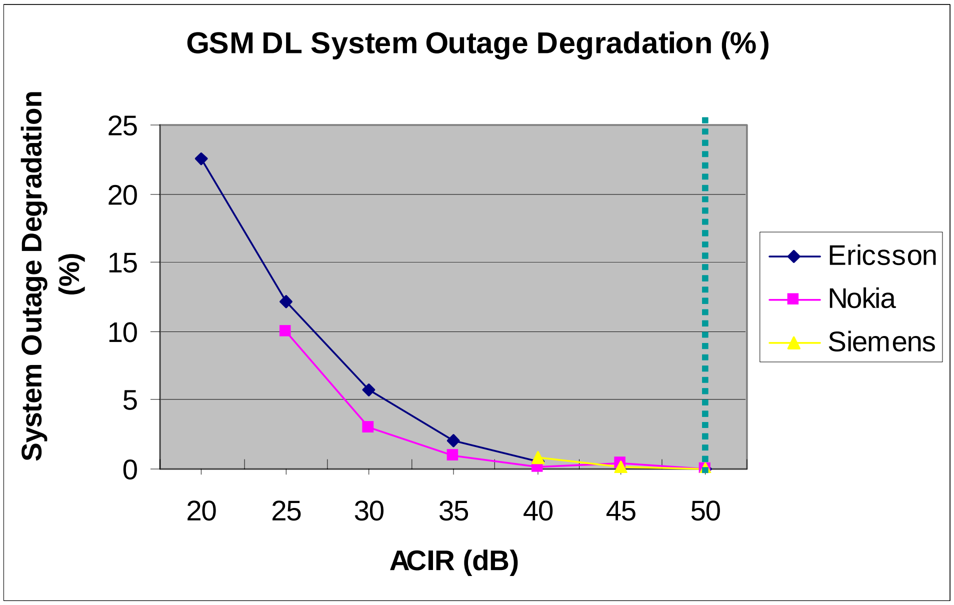

Figure 16: GSM DL System Outage Degradation (%) due to interference from UMTS DL (Scenario_1)

- **GSM UL System Outage Degradation (%) due to interference from UMTS UL**

4 simulation results of GSM system uplink outage degradation due to interference from UMTS uplink are summarized in table 11, all of these results show that the GSM system uplink outage degradation due to interference from UMTS uplink is negligible.

Table 11: GSM system UL outage degradation (%)

	Lucent	Motorola	Nokia	Qualcomm
Without WCDMA interference		0.04		
With WCDMA interference				
System Outage Degradation	negligible	Negligible	negligible	negligible

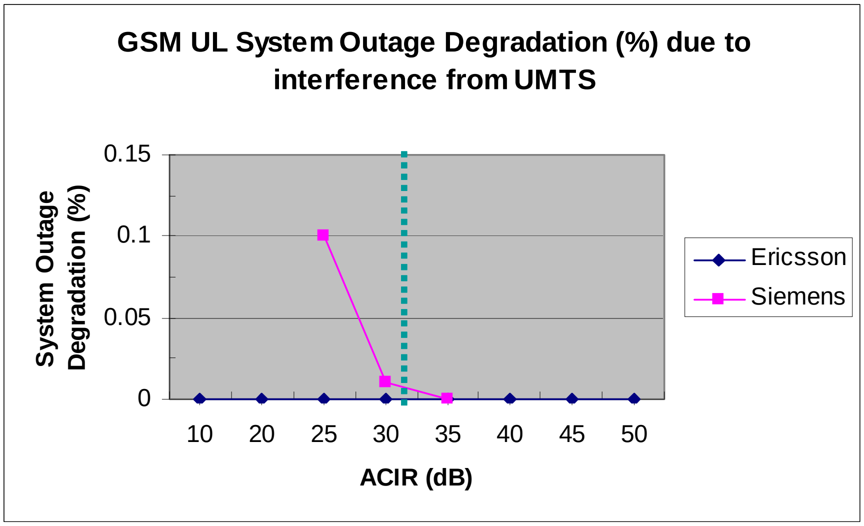

Figure 17: GSM UL System Outage Degradation (%) due to interference from UMTS UL (Scenario_1)

Two simulation results of GSM uplink system outage degradation (%) as function of ACIR are given in figure 17. For the carrier separation between the UMTS carrier and the nearest GSM carrier of 2.8 MHz, the GSM uplink as victim ACIR=31.3 dB. Both simulation curves indicate that the GSM uplink system outage degradation at ACIR=31.3 dB is negligible, which is in line with the simulation results presented in table 11.

3.5.1.4 Conclusions

Based on the analysis of the simulation results for the co-existence scenario 1 between UMTS(macro)-GSM(macro) in urban areas with cell ranges of 500 m in uncoordinated operation, the following conclusions can be made:

- RF system characteristics assumed for UMTS900 are suitable and sufficient for UMTS900 to be deployed in urban environment in co-existence with GSM;
- UMTS and GSM in urban environment can co-exist with 2.8 MHz carrier separation between UMTS carrier and the nearest GSM carrier.

3.5.2 Co-existence between UMTS (macrocell) and GSM (macrocell) in rural areas in uncoordinated operation

3.5.2.1 Scenario (Scenario 2) description

- **Scenario_2: UMTS(macro)-GSM(macro) in rural areas with cell ranges of 5000 m in uncoordinated operation**

Frequency arrangement and network layout for this scenario are identical to the scenario given in figure 6 above. Simulation parameters are summarized in table 12.

Table 12: Summary of UMTS900/GSM900 simulation parameters for Scenario 2

Scenario_2	**UMTS(macro)-GSM(macro) in Rural areas with cell ranges of 5000 m in uncoordinated operation**
Simulation cases	Both UMTS and GSM as victims in uplink and downlink. In total 4 simulation cases. *1) Downlink* *-GSM (BCCH only)/WCDMA for WCDMA victim* *-GSM (non-BCCH with PC)/WCDMA for GSM victim* *2) Uplink* *- WCDMA victim (GSM load maximum – all time slots in use. Simulate GSM system, then add UMTS users until the total noise rise hits 6 dB)* *- GSM victim (WCDMA loaded to 6 dB noise rise)* *-No frequency hopping for GSM* *-Both networks in macro environment*

	-Run simulations with various ACIRs by considering a centre frequency separation of 2.8 MHz.	
Network layout	As shown in figure 6 above **- Rural environment** *- 3-sector configuration* *-GSM cell reuse GSM: 4/12* *-36 cells (i.e., 108 sectors) with wrap-around* *-Cell radius R=2500m, cell range 2R=5000m, inter-site distance 3R= 7500 m (as shown in figure 6)* **-Worst-case shift between operators, GSM site is located at WCDMA cell edge**	
System parameters	*WCDMA*	- BS antenna gain with cable loss included = 15dBi - BS antenna height H_{bs}=45 m - UE antenna height H_{ms}=1.5 m - BS-UE MCL=80 dB - BS antenna(65° horizontal opening) radiation pattern is referred to 3GPP TR 25.896 V6.0.0 (2004-03), Section A.3 - UE antenna gain 0 dBi (omni-directional)
	GSM	- BS antenna gain with cable loss included = 15dBi - BS antenna height H_{bs}=45 m - UE antenna height H_{ms}=1.5 m - BS-MS MCL=80 dB - BS antenna(65° horizontal opening) radiation pattern is referred to 3GPP TR 25.896 V6.0.0 (2004-03), Section A.3 - UE antenna gain 0 dBi (omni-directional)
Services	*WCDMA*	*8 kbps Speech (chip rate: 3.84 Mcps)* *- Eb/Nt target (downlink): 7.9 dB* - Eb/Nt target (uplink): 6.1 dB
	GSM	*Speech* *- SINR target (downlink): 9 dB* *- SINR target (uplink): 6 dB*
Propagation model	*WCDMA and GSM*	*Log_normal_Fading = 10 dB* Rural area propagation model (Hata model): $L(R)= 69.55 + 26.16 \log f - 13.82\log(H_b) + [44.9 - 6.55\log(H_b)]\log R - 4.78(\log f)^2 + 18.33 \log f - 40.94$ Hb is BS antenna height above ground in m, f is frequency in MHz, R is distance in km. With Hb = 45 m, f = 920 MHz, the propagation model is simplified as L(R) =34.1*log(R) + 95.6 The path loss from a transmitter antenna connector to a receiver antenna connector (including both antenna gains and cable losses) will be determined by: Path_Loss = max (L(R) + Log_normal_Fading - G_Tx – G_Rx, Free_Space_Loss + Log_normal_Fading - G_Tx – G_Rx, MCL) Where: G_Tx is the transmitter antenna gain in the direction toward the receiver antenna, which takes into account the transmitter antenna pattern and cable loss, G_Rx is the receiver antenna gain in the direction toward the transmitter antenna, which takes into account the receiver antenna pattern and cable loss, Log_normal_Fading is the shadowing fade following the log-normal distribution.
Cell selection	*WCDMA*	*As per TR 25.942*
	GSM	*As for WCDMA in TR 25.942, but with only one link selected at random within a 3 dB handover margin*
SIR calculation	*WCDMA*	*As per TR 25.942, except for the following changes:* *- Interference contributions from GSM TRXs or MSs are added to the total noise-plus-interference.* *- Processing gain is changed to 26.8 dB for 8 kbps* *- Thermal noise level is raised to -96 dBm for downlink*

	GSM	*Total noise-plus-interference is sum of thermal noise, GSM co-channel, and WCDMA interference. Cells are synchronised on a time slot basis. Adjacent channel GSM interference is neglected.* *- Noise floor (downlink): -111 dBm* *- Noise floor (uplink): -113 dBm*
Power Control assumption	*WCDMA*	*As per TR 25.942* *- 21 dBm terminals* *- Maximum BS power: 43 dBm* *- Maximum power per DL traffic channel: 30 dBm* *- Minimum BS power per user: 15 dBm* *- Minimum UE power: –50 dBm* *- Total CCH power: 33 dBm*
	GSM	*Stabilization algorithm same as for WCDMA (C/I based) with a margin of 5 dB added to the SIR target.* *- Maximum power (TRx): 43 dBm* *- Minimum power (TRx): 10 dBm (non-BCCH)* *- Maximum power (MS): 33 dBm* *- Minimum power (MS): 5 dBm*
Capacity	*WCDMA*	*Capacity loss versus ACIR as per TR 25.942*
	GSM	*Load to maximum number of users and observe change in outage (i.e., 0.5 dB less than SINR target)*
ACIR	*WCDMA to GSM*	*As per spectrum masks defined in TS 25.101, TS 25.104 (applying the appropriate measurement BW correction), unless capacity loss is found to be significant.*
	GSM	$\mathrm{ACIR}(f) = C(f_0) + m\,(f - f_0)$ (dB) *GSM BTS to WCDMA UE:* *Consider 3GPP TS45005 GSM BTS transmitter emission mask for 900 band and WCDMA UE receiver selectivity slope, m = 0.8 dB / 200 kHz* *GSM MS to WCDMA BS:* *Consider 3GPP TS45005 GSM MS transmitter emission mask for 900 band and WCDMA BS receiver characteristics, m = 0.5 dB / 200 kHz*

3.5.2.2 Interference analysis method

Interference between GSM and UMTS operating in the 900 MHz band was analyzed by using Monte-Carlo simulations.

The objective of the Monte-Carlo simulations is to determine the appropriate UMTS BS & UE RF system parameters, Spectrum mask, ACLR (Adjacent Channel power Leakage Ratio), ACS (Adjacent Channel Selectivity), receiver narrow band blocking, etc. for ensuring the good co-existence of UMTS and GSM. In the simulation, the UMTS UL/DL capacity losses as function of ACIR (Adjacent Channel Interference Ratio) were simulated, the GSM UL/DL system outage degradations at given ACIR values or as function of ACIR were also simulated.The ACIR was used as a variable parameter.

The assumptions of UMTS BS & UE RF characteristics (Spectrum mask, ACLR, ACS) were described above in the section 3.5.1.2, the GSM system (BS & MS) RF characteristics and the derived ACIR values were also given in the section 3.5.1.2.

3GPP agreed threshold for co-existence is that UMTS UL/DL capacity loss due to interferences from GSM UL/DL should not be bigger than 5%. Concerning the impact on GSM network performance, since GSM network capacity is fixed, the evaluation criterion is the system outage degradation, the system outage degradation should be as small as possible.

3.5.2.3 Simulation result and analysis

Based on the agreed co-existence scenario 2 from 3GPP and simulation assumptions described in section 2.5.2.1, simulation results for this co-existence scenario 2 from several companies have been put together for analysis, as summarised below.

- **UMTS DL Capacity Loss (%) due to interference from GSM DL**

Figure 18 gives the simulation results (5 simulation curves) of UMTS DL as victim for the co-existence scenario 2, the UMTS downlink capacity loss due to interference from the GSM downlink as function of ACIR between UMTS carrier and the nearest GSM carrier. At the operating point of ACIR=30.5 dB, the UMTS downlink capacity loss is below 1.2%.

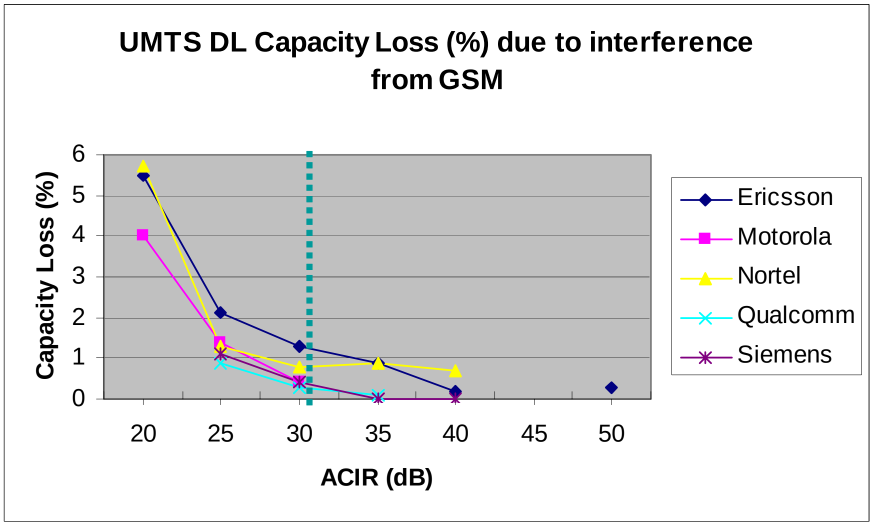

Figure 18: UMTS DL Capacity Loss (%) due to interference from GSM DL (Scenario_2)

- **UMTS UL Capacity Loss (%) due to interference from GSM UL**

The simulation results (4 simulation curves) for the case of UMTS UL as victim, the UMTS UL capacity loss (%) due to interference from GSM uplink as function of ACIR between UMTS carrier and the nearest GSM carrier, are given in figure 19. As shown in figure 19, all of the 4 simulation curves indicate that the UMTS uplink capacity loss due to interference from GSM MS at ACIR=43.1 dB is smaller than 3%.

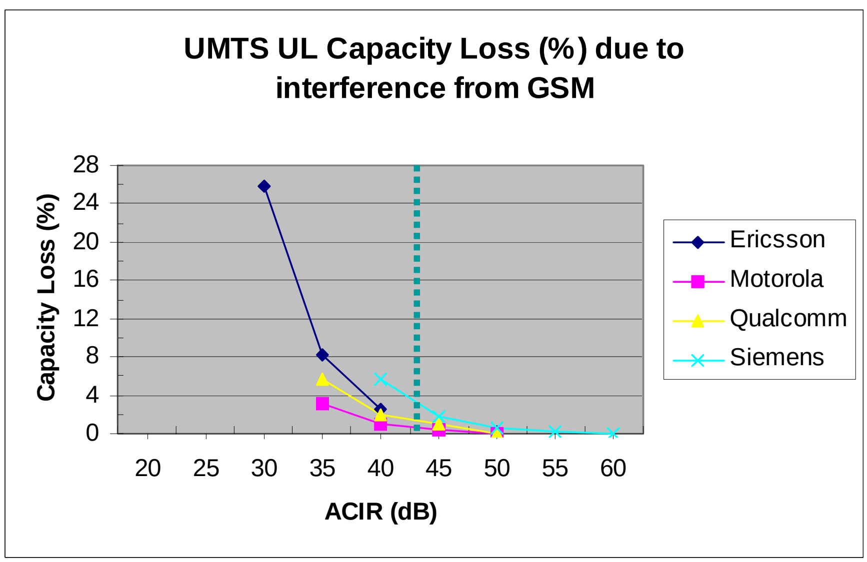

Figure 19: UMTS UL Capacity Loss (%) due to interference from GSM UL (Scenario_2)

- **GSM DL System Outage Degradation (%) due to interference from UMTS DL**

Two simulation results of GSM system downlink outage degradation due to interference from UMTS downlink are summarized in table 13. It can be seen that both results show the GSM system downlink outage degradations are negligible.

Table 13: GSM system DL outage degradation (%)

	Motorola	Qualcomm
Without WCDMA interference	0.2	
With WCDMA interference		
System Outage Increase	negligible	negligible

Three other simulation curves of GSM system downlink outage degradation as function of ACIR between UMTS carrier and the nearest GSM carrier are plotted in figure 20. At ACIR=50 dB, the GSM downlink system outage degradation is negligible as shown in the figure 20. It is in line with the two simulation results summarized in the table 13.

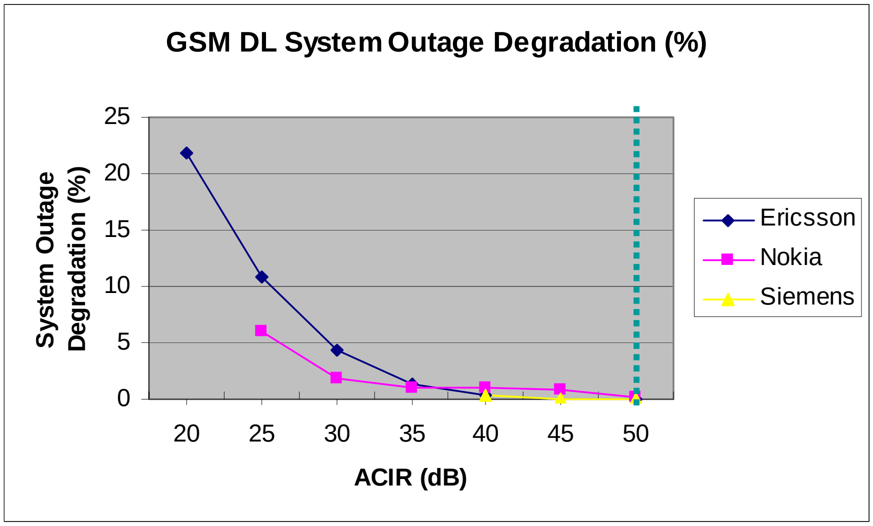

Figure 20: GSM DL System Outage Degradation (%) due to interference from UMTS DL (Scenario_2)

- **GSM UL System Outage Degradation (%) due to interference from UMTS UL**

Three simulation results of GSM system uplink outage degradation due to interference from UMTS uplink at the carrier separation of 2.8 MHz between UMTS carrier and the nearest GSM carrier are summarized in table 14, all of these three results show that the GSM system uplink outage degradation due to interference from UMTS uplink is negligible.

Table 14: GSM system UL outage degradation (%)

	Motorola	Nokia	Qualcomm
Without WCDMA interference	0.1		
With WCDMA interference			
System Outage Increase	negligible	negligible	negligible

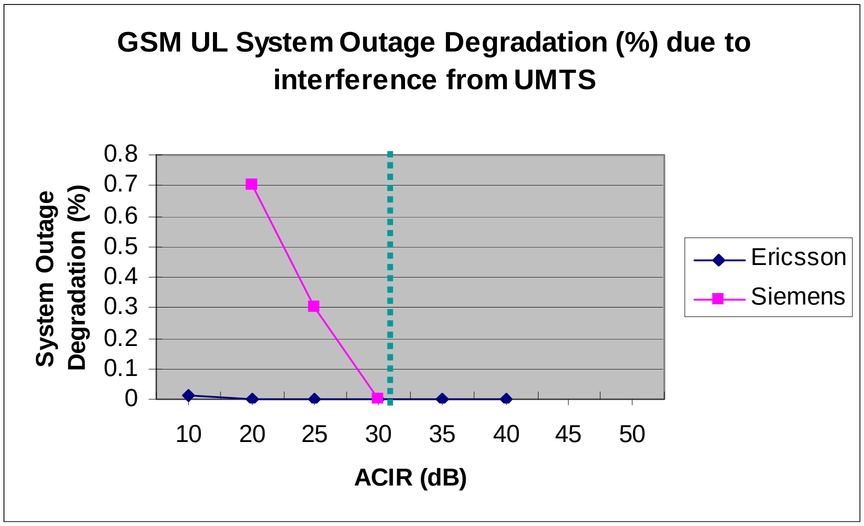

Figure 21: GSM UL System Outage Degradation (%) due to interference from UMTS UL (Scenario_2)

Two simulation results of GSM uplink system outage degradation due to interference from UMTS uplink as function of ACIR are given in the figure 21. As indicated in the figure 21, at ACIR=31.3 dB, the GSM uplink system outage degradation is negligible, they are in line with the three simulation results given in the table 14 above.

3.5.2.4 Conclusions

Based on the analysis of the simulation results for the co-existence scenario 2 between UMTS(macro)-GSM(macro) in rural areas with cell ranges of 5000 m in uncoordinated operation, the following conclusions can be drawn:

- RF system characteristics assumed for UMTS900 are suitable and sufficient for UMTS900 to be deployed in rural environments in co-existence with GSM in uncoordinated operation with cell ranges of 5000 m;
- UMTS and GSM can co-exist at 2.8 MHz carrier separation between the UMTS carrier and the nearest GSM carrier in the deployment scenario 2, described in section 3.5.2.1.

3.5.3 Co-existence between UMTS (macrocell) and GSM (macrocell) in rural area in coordinated operation

3.5.3.1 Scenario (Scenario 3) description

- **Scenario_3: UMTS(macro)-GSM(macro) in Rural area with cell range of 5000 m in coordinated operation**

- 2 x 10 MHz “sandwich” coordinated operation between UMTS macrocell and GSM macrocell

In this coordinated operation case, the UMTS and GSM base stations are co-located which represent the re-banding deployment within the same GSM network, see illustration in figure 22.

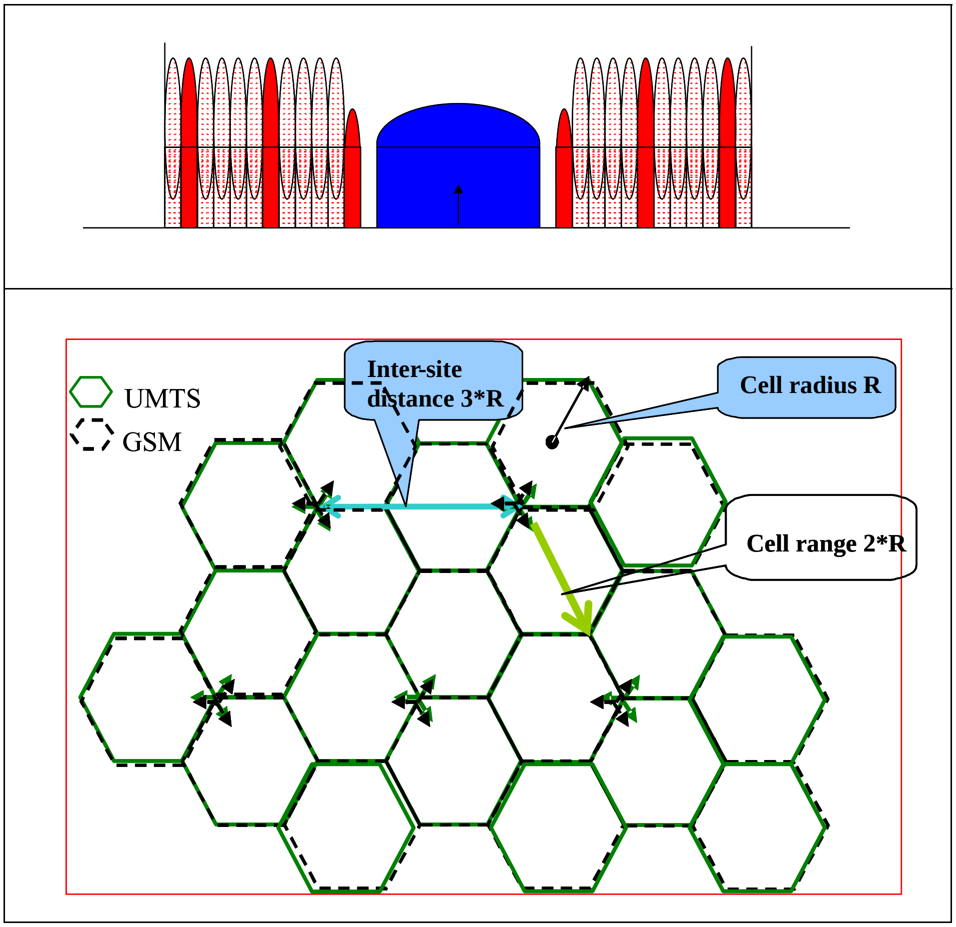

Figure 22: 2x10 MHz "sandwich" coordinated operation of UMTS vs GSM networks

Simulation assumptions for the co-existence scenario 3 are summarized in table 15.

Table 15: Summary of UMTS900 simulation parameters for Scenario 3

Scenario_3	**UMTS(macro)-GSM(macro) in Rural area with cell range of 5000m in coordinated operation**
Simulation cases	Interference from GSM to UMTS with no power control activated in GSM mobiles. Uplink is considered as limiting case, but it is considered useful to study downlink as well. There will be 2 simulation cases *: *1) Downlink* *-GSM (BCCH only)/WCDMA for WCDMA victim* *3) Uplink* *- WCDMA victim (GSM load maximum – all time slots in use. Simulate GSM system, then add UMTS users until the total noise rise hits 6 dB)* *-No frequency hopping* *Both networks in macro environment* Run simulations with various ACIRs by considering a centre frequency separation of 2.8 MHz. *Note: It was agreed that if the simulation results for scenario 1 and 2 show serious interferences from UMTS to GSM, then additional simulation cases of interference from UMTS to GSM with this scenario_3 will be studied.
Network layout	*As shown in figure 22 above, with WCDMA and GSM BSs are co-located* *- Rural environment* *- 3-sector configuration*

		-GSM cell reuse GSM: 4/12 *-36 cells (i.e., 108 sectors) with wrap-around-Cell radius R=2500m, cell range 2R=5000m, inter-site distance 3R= 7500 m (as shown in figure 22)*
System parameters	*WCDMA*	- BS antenna gain with cable loss included = 15 dBi - BS antenna height H_{bs}=45 m - UE antenna height H_{ms}=1.5 m - BS-UE MCL=80 dB - BS antenna(65° horizontal opening) radiation pattern is referred to 3GPP TR 25.896 V6.0.0 (2004-03), Section A.3 - UE antenna gain 0 dBi (omni-directional)
	GSM	- BS antenna gain with cable loss included = 15 dBi - BS antenna height H_{bs}=45 m - UE antenna height H_{ms}=1.5 m - BS-MS MCL=80 dB - BS antenna(65° horizontal opening) radiation pattern is referred to 3GPP TR 25.896 V6.0.0 (2004-03), Section A.3 - UE antenna gain 0 dBi (omni-directional)
Services	*WCDMA*	*8 kbps Speech (chip rate: 3.84 Mcps)* *- Eb/Nt target (downlink): 7.9 dB* - Eb/Nt target (uplink): 6.1 dB
	GSM	*Speech* *- SINR target (downlink): 9 dB* *- SINR target (uplink): 6 dB*
Propagation Model	*WCDMA and GSM*	*Log_normal_Fading = 10 dB* Rural area propagation model (Hata model): $L(R) = 69.55 + 26.16 \log f - 13.82\log(H_b) + [44.9 - 6.55\log(H_b)]\log R - 4.78(\log f)^2 + 18.33 \log f - 40.94$ Hb is BS antenna height above ground in m, f is frequency in MHz, R is distance in km. With Hb = 45 m, f = 920 MHz, the propagation model is simplified as $L(R) = 34.1 * \log(R) + 95.6$ The path loss from a transmitter antenna connector to a receiver antenna connector (including both antenna gains and cable losses) will be determined by: Path_Loss = max (L(R) + Log_normal_Fading - G_Tx – G_Rx, Free_Space_Loss + Log_normal_Fading - G_Tx – G_Rx, MCL) Where: G_Tx is the transmitter antenna gain in the direction toward the receiver antenna, which takes into account the transmitter antenna pattern and cable loss, G_Rx is the receiver antenna gain in the direction toward the transmitter antenna, which takes into account the receiver antenna pattern and cable loss, • Log_normal_Fading is the shadowing fade following the log-normal distribution.
Cell selection	*WCDMA*	*As per TR 25.942*
	GSM	As for WCDMA in TR 25.942, but with only one link selected at random within a 3 dB handover margin
SIR calculation	*WCDMA*	As per TR 25.942, except for the following changes: - Interference contributions from GSM TRXs or MSs are added to the total noise-plus-interference. - Processing gain is changed to 26.8 dB for 8 kbps - Thermal noise level is raised to –96 dBm for downlink
	GSM	*Total noise-plus-interference is sum of thermal noise, GSM co-channel, and WCDMA interference. Cells are synchronised on a time slot basis. Adjacent channel GSM interference is neglected.* *- Noise floor (downlink): -111 dBm* *- Noise floor (uplink): -113 dBm*

Power Control assumption	*WCDMA*	*As per TR 25.942* *- 21 dBm terminals* *- Maximum BS power: 43 dBm* *- Maximum power per DL traffic channel: 30 dBm* *- Minimum BS power per user: 15 dBm* *- Minimum UE power: –50 dBm* *- Total CCH power: 33 dBm*
	GSM	*Stabilization algorithm same as for WCDMA (C/I based) with a margin of 5 dB added to the SIR target.* *- Maximum power (TRx): 43 dBm* *- Minimum power (TRx): 10 dBm (non-BCCH)* *- Maximum power (MS): 33 dBm* *- Minimum power (MS): 5 dBm*
Capacity	*WCDMA*	*Capacity loss versus ACIR as per TR 25.942*
	GSM	*Load to maximum number of users and observe change in outage (i.e., 0.5 dB less than SINR target)*
ACIR	*WCDMA to GSM*	*As per spectrum masks defined in TS 25.101, TS 25.104 (applying the appropriate measurement BW correction), unless capacity loss is found to be significant.*
	GSM	$\mathrm{ACIR}(f) = C(f_0) + m\,(f - f_0)$ (dB) *GSM BTS to WCDMA UE:* *Consider 3GPP TS45005 GSM BTS transmitter emission mask for 900 band and WCDMA UE receiver selectivity slope, m = 0.8 dB / 200 kHz* *GSM MS to WCDMA BS:* *Consider 3GPP TS45005 GSM MS transmitter emission mask for 900 band and WCDMA BS receiver characteristics, m = 0.5 dB / 200 kHz*

3.5.3.2 Interference analysis method

Interference between UMTS and GSM in coordinated operation was analyzed by means of Monte-Carlo simulation.

The objective of Monte-Carlo simulations is to determine the appropriate UMTS BS & UE RF system parameters, Spectrum mask, ACLR (Adjacent Channel power Leakage Ratio), ACS (Adjacent Channel Selectivity), receiver narrow band blocking, etc. for ensuring the good co-existence of UMTS and GSM. In the simulation, the UMTS UL/DL capacity losses as function of ACIR (Adjacent Channel Interference Ratio) were simulated, the GSM UL/DL system outage degradations at given ACIR values or as function of ACIR were also simulated. The ACIR was used as a variable parameter.

The assumptions of UMTS BS & UE RF characteristics (Spectrum mask, ACLR, ACS) were described in section 3.5.1.2, the GSM system (BS & MS) RF characteristics and the derived ACIR values were also given in section 3.5.1.2.

The 3GPP agreed threshold for co-existence is that UMTS UL/DL capacity loss due to interferences from GSM UL/DL should not be bigger than 5%. Concerning the impact on GSM network performance, since GSM network capacity is fixed, the evaluation criterion is the system outage degradation, the system outage degradation should be as small as possible.

3.5.3.3 Simulation result and analysis

- **UMTS DL Capacity Loss (%) due to interference from GSM DL**

As described in the simulation assumption, two simulation cases (UMTS DL and UL as victim) were studied for this co-existence scenario 3.

Four simulation curves of simulation results of UMTS DL as victim are plotted in figure 23, the UMTS downlink capacity loss due to interference from GSM downlink as function of ACIR between UMTS carrier and the nearest GSM carrier. It is shown in figure 23 that at the operating point of ACIR=30.5 dB, the UMTS downlink capacity loss is below 1%.

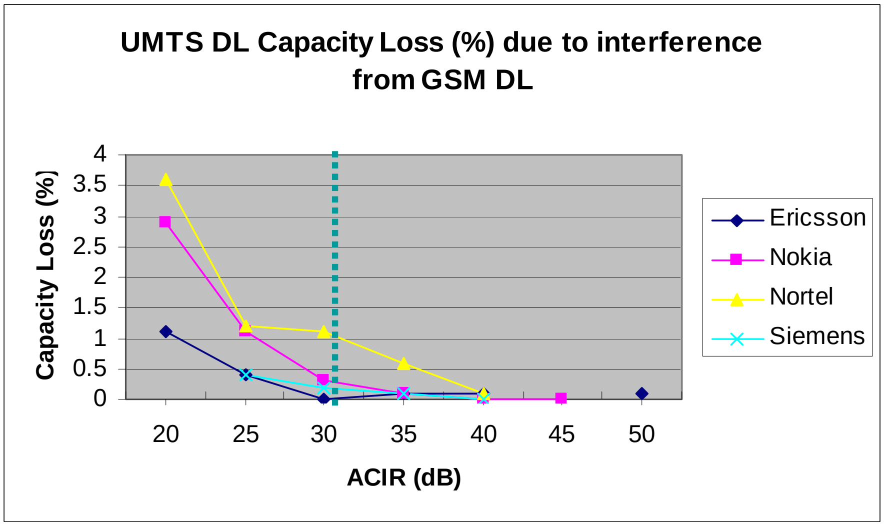

Figure 23: UMTS DL Capacity Loss (%) due to interference from GSM DL (Scenario_3)

- **UMTS UL Capacity Loss (%) due to interference from GSM UL**

The simulation results for the case of UMTS UL as victim, the UMTS UL capacity loss (%) due to interference from GSM uplink as function of ACIR between UMTS carrier and the nearest GSM carrier, are given in figure 24. Three simulation results/curves of UMTS uplink capacity loss due to interference from GSM uplink for the scenario 3 are plotted in figure 24. As shown in the figure 24, at ACIR=43.1 dB, the UMTS uplink capacity loss is very small, it is negligible.

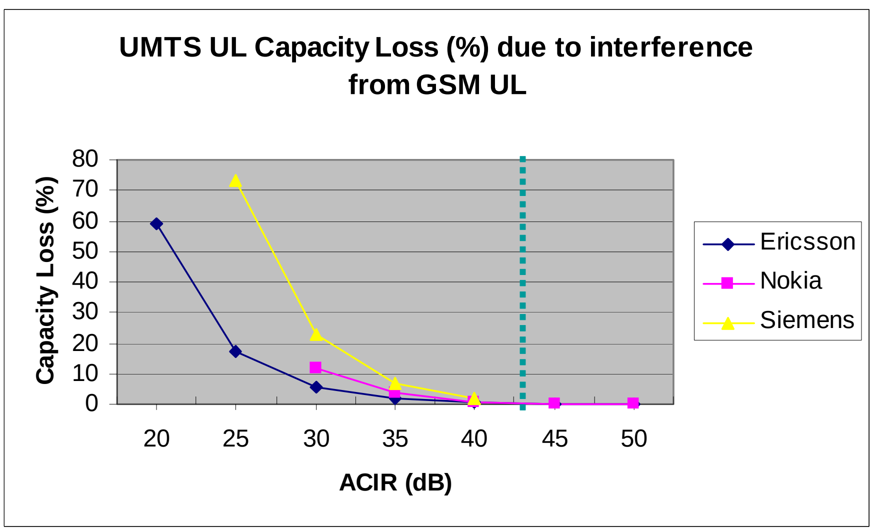

Figure 24: UMTS UL Capacity Loss (%) due to interference from GSM UL (Scenario_3)

3.5.3.4 Conclusions

The following conclusions can be made from the analysis of the simulation results for the co-existence scenario 3 between UMTS(macro)-GSM(macro) in rural areas with cell ranges of 5000 m in coordinated operation:

- RF system characteristics assumed for UMTS900 are suitable and sufficient for UMTS900 to be deployed in rural environments in co-existence with GSM at cell ranges of 5000 m in coordinated operation;
- UMTS and GSM in rural environments can be deployed in the same geographical area in coordinated operation with 2.8 MHz carrier separation between the UMTS carrier and the nearest GSM carrier.

3.5.4 Co-existence between UMTS (macrocell) and GSM (microcell) in urban areas in uncoordinated operation

3.5.4.1 Scenario (Scenario 5) description

- **Scenario_5: UMTS(macro)-GSM(micro) in Urban areas in uncoordinated operation**

Simulation assumptions for the co-existence scenario 5 are summarized in table 16 and illustrated in figures 25 and 26. As described in table 16, two simulation cases of GSM downlink and GSM uplink as victim were studied by Monte-Carlo simulation. Some of the UMTS UE and GSM MS were placed inside of the buildings (for UE and MS located on the building blocks). The UMTS UE and GSM MS located in the street were considered as outdoor UE.

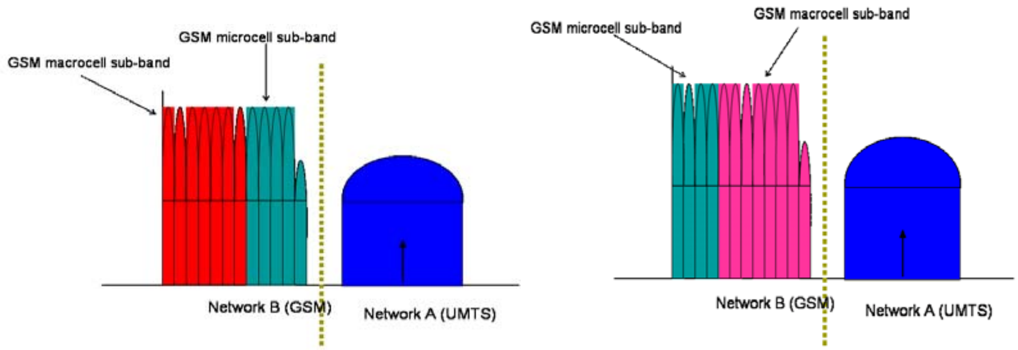

Figure 25: GSM(micro)-UMTS(macro) 2 x 5 MHz uncoordinated operation – band plan

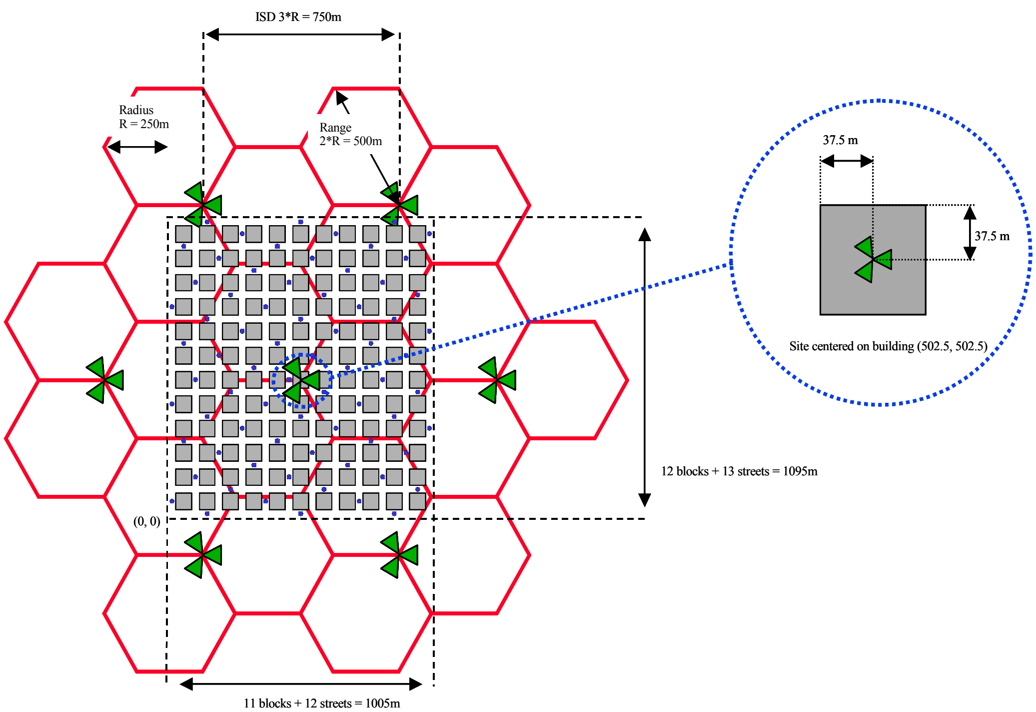

Figure 26: GSM(micro)-UMTS(macro) 2 x 5 MHz uncoordinated operation – networks layout

Table 16: Summary of UMTS900 simulation parameters for Scenario 5

<table>
<tr><td>Scenario_5</td><td colspan="2">UMTS(macro)-GSM(micro) in urban area in uncoordinated operation</td></tr>
<tr><td>Simulation cases</td><td colspan="2">GSM victims on both uplink and downlink. 2 simulation cases.
1) Downlink
-GSM (non-BCCH with PC)/WCDMA for GSM victim

2) Uplink
- GSM victim (WCDMA loaded to 6 dB noise rise)

No frequency hopping for GSM
WCDMA network in macro environment, GSM in microcellular environment
Run simulations with various ACIRs by considering a centre frequency separation of 2.8 MHz and 4.8 MHz (see Figure 25).</td></tr>
<tr><td>Network layout</td><td colspan="2">As shown in Figure 26.

- Urban environment, UMTS macrocells
- 3-sector configuration
-7 sites (i.e., 21 sectors), the position (coordinates in meters related to the left-low corner) of the central macrocellular site are indicated on the figure 26 as (502.5, 502.5)
-Cell radius R=250m, cell range 2R=500m, inter-site distance 3R= 750 m

-Urban environment, GSM microcells
-omni-directional GSM microcell configuration
-GSM microcells are placed in the middle of street as shown in figure 26
-GSM cell frequency reuse : 8 as shown in figures 29a, 29b, and 29c.</td></tr>
<tr><td rowspan="2">System parameters</td><td>WCDMA</td><td>- BS antenna gain with cable loss included = 12 dBi
- BS antenna height H_{bs}=30 m
- UE antenna height H_{UE}=1.5 m
- BS-UE MCL=70 dB
- BS antenna(65° horizontal opening) radiation pattern is referred to 3GPP TR 25.896 V6.0.0 (2004-03), Section A.3
- UE antenna gain 0 dBi (omni-directional)</td></tr>
<tr><td>GSM</td><td>- BS antenna gain with cable loss included = 6 dBi
- BS antenna height H_{bs}=7 m
- MS antenna height H_{ms}=1.5 m
- BS-MS MCL=53 dB
- BS antenna omni-directional
- UE antenna gain 0 dBi (omni-directional)</td></tr>
<tr><td rowspan="2">Services</td><td>WCDMA</td><td>- 8 kbps Speech (chip rate: 3.84 Mcps)
- Eb/Nt target (downlink): 7.9 dB
- Eb/Nt target (uplink): 6.1 dB
-UEs are uniformly distributed over the macro cell area, within the GSM microcellular zone where building blocks are present as shown in figure 26, WCDMA UEs situated on the building blocks are considered as indoor UEs, on the streets are considered as outdoor UEs</td></tr>
<tr><td>GSM</td><td>Speech
- SINR target (downlink): 9 dB
- SINR target (uplink): 6 dB
- MSs are uniformly distributed over the micro cell area, that means 67.5% of UEs are located in indoor area, and 32.5% of UEs are located in outdoor area</td></tr>
</table>

Outdoor Propagation model	*WCDMA and GSM*	As per TR 25.942, but modified for 920 MHz. Log_normal_Fading logF = 10 dB for WCDMA macrocell and GSM microcell Urban area propagation model for WCDMA macrocells: L(R) = 40*(1-0.004*DHb)*LOG10(R)-18*LOG10(DHb)+21*LOG10(f)+80 DHb is BS antenna height above average building top, for urban area with Hbs=30m, DHb=15m, f is frequency in MHz (f = 920 MHz) , R is distance in km. L(R) = 37.6* LOG10(R) + 121.1 The path loss from a transmitter antenna connector to a receiver antenna connector (including both antenna gains and cable losses) will be determined by: (1a) Path_Loss_a = max {L(R) , Free_Space_Loss}+ LogF (1b) Path_Loss_b = max {Path_Loss_a , Free_Space_Loss} – G_Tx – G_Rx (1c) Path_Loss = max {Path_Loss_b, MCL} where G_Tx is the transmitter antenna gain in the direction toward the receiver antenna, which takes into account the transmitter antenna pattern and cable loss, G_Rx is the receiver antenna gain in the direction toward the transmitter antenna, which takes into account the receiver antenna pattern and cable loss, logF, Log_normal_Fading is the shadowing fade following the log-normal distribution, it is to be added as a random variable with 10 dB standard deviation In calculating the total path loss in figures 27 and 28, lognormal fading should be drawn as one single random value that is used for all 4 paths. Microcellular propagation model for GSM microcell Manhattan path loss (Dual Slope model in TR25.942 section 5.1.4.3) $$Manhatten\_pathloss = 20 \cdot \log_{10}\left(\frac{4\pi d_n}{\lambda} \cdot D\left(\sum_{j=1}^{n} s_{j-1}\right)\right)$$ (2) $$D(x) = \begin{cases} x / x_{br}, x > x_{br} \\ 1, x \le x_{br} \end{cases}$$ The path loss slope before the break point xbr is 2, after the break point it increases to 4. The break point xbr is set to 300 m. x is the distance from the transmitter to the receiver. Where: - dn is the "illusory" distance; - λ is the wavelength; - n is the number of straight street segments between BS and UE (along the shortest path). The illusory distance is the sum of these street segments and can be obtained by recursively using the expressions $k_n = k_{n-1} + d_{n-1} \cdot c$ and $d_n = k_n \cdot s_{n-1} + d_{n-1}$ where c is a function of the angle of the street crossing. For a 90° street crossing the value c should be set to 0,5. Further, sn-1 is the length in meters of the last segment. A segment is a straight path. The initial values are set according to: k0 is set to 1 and d0 is set to 0. The illusory distance is obtained as the final dn when the last segment has been added. Small macrocell path loss model for propagation below rooftop macrocell path loss = 8.3 + 46 log (d) Where d is the distance in meters. (3) Pathloss_micro = max {min (Manhattan_pathloss, macrocell pathloss) + LogF - G_Tx – G_Rx, MCL}. Detailed path loss calculation method is described in TR25.942 section 5.1.4.3.

<table>
<tr>
<td rowspan="3">Indoor propagation model, Building Penetration Loss (BPL)</td>
<td>Towards WCDMA macrocell</td>
<td>See Figure 27 for the geometry.
For the meaning and values of the following parameters, please refer to Table 1 below.

Compute macro cell Path_Loss(i) according to eqn (1) for each of the 4 “virtual transmitter” locations x(i), i = 1, …4 (to be used as outdoor reference values).
$BPL(i) := W_e + W_{ge} - G_{FH} + a * R_i$
(4) $Total\_Path\_loss := \min_{1 \le i \le 4} \left\{ \text{Path\_Loss(i)+BPL(i)} \right\}$</td>
</tr>
<tr>
<td>Towards GSM microcell</td>
<td>See Figure 28 for the geometry.
For the meaning and values of the following parameters, please refer to BPL parameters table below.

Compute micro cell Pathloss_micro(i) according to eqn (3) for each of the 4 “virtual transmitter” locations x(i), i = 1, …4 (to be used as outdoor reference values).
The BPL for the LOS and the NLOS paths is computed separately:
For the LOS path: $BPL(i_{LOS}) := W_e + WG_e \left(1 - \frac{D}{S}\right)^2 + a * R_{i_{LOS}}$
For the NLOS paths: $BPL(i) := W_e + W_{ge} + a * R_i$

(5) $Total\_Path\_loss := \min_{1 \le i \le 4} \left\{ \text{Pathloss\_micro(i)+BPL(i)} \right\}$</td>
</tr>
<tr>
<td>BPL Parameters</td>
<td>Parameters to be used for computing the BPL (please refer to “Final report of the COST Action 231, Chapter 4.6.” for a description of these parameters):

Parameters.
<table>
<tr><td>Parameter</td><td>Value</td><td>Comment</td></tr>
<tr><td>W_e</td><td>7 dB</td><td>External wall loss in dB at perpendicular penetration</td></tr>
<tr><td>W_{ge}</td><td>3 dB</td><td>Additional external wall loss in dB for NLOS conditions due to non-perpendicular penetration of the impinging waves</td></tr>
<tr><td>WG_e</td><td>20 dB</td><td>Additional external wall loss in dB at 0 deg grazing angle</td></tr>
<tr><td>A</td><td>0.6 dB / m</td><td>Additional internal building loss in dB/m</td></tr>
<tr><td>D, S</td><td>Depends on the geometry, see Fig. 28</td><td></td></tr>
<tr><td>G_{FH}</td><td>5.0 dB</td><td>Floor height gain; assumed to be 1.75 dB/floor</td></tr>
</table>
</td>
</tr>
<tr>
<td rowspan="2">Cell selection</td>
<td>WCDMA</td>
<td>As per TR 25.942</td>
</tr>
<tr>
<td>GSM</td>
<td>As for WCDMA in TR 25.942, but with only one link selected at random within a 3 dB handover margin</td>
</tr>
<tr>
<td rowspan="2">SIR calculation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GSM</td>
<td>Total noise-plus-interference is sum of thermal noise, GSM co-channel, and WCDMA interference. Cells are synchronised on a time slot basis. Adjacent channel GSM interference is neglected.
Noise floor (downlink): -111 dBm
Noise floor (uplink): -106 dBm</td>
</tr>
</table>

Power Control assumption	*WCDMA*	*As per TR 25.942* *- BS maximum Tx power: 43 dBm* *- 21 dBm terminals* *- Minimum BS power per user: 15 dBm* *- Minimum UE power: –50 dBm* *- Total CCH power: 33 dBm*
	GSM	*Stabilization algorithm same as for WCDMA (C/I based) with a margin of 5 dB added to the SIR target.* *- Maximum power (TRx): 24 dBm* *- Minimum power (TRx): 0 dBm (non-BCCH)* *- Maximum power (MS): 33 dBm* *- Minimum power (MS): 5 dBm*
Capacity	*WCDMA*	*The WCDMA macro cellular network should be loaded as per TR 25.942 (5% outage on the DL, 6dB noise rise on the UL). Considering the cell edge affects and the impact of the Manhattan grid, the WCDMA macro cellular network load will be set based on the cell loading of the three central sectors. That is:* *-For the WCDMA DL: the WCDMA macro cellular network is loaded so that 95 % of the users within the three central sectors achieve an Eb/No of (target Eb/No -0.5 dB).* *-For the WCDMA UL: the WCDMA macro cellular network is loaded to obtain an average (linear) noise rise for the centre three sectors of 6dB over thermal noise.* *UEs are considered to belong to the three central sectors if they meet the following criteria:* *- The UE is affiliated to one of the centre three sectors, but not in soft handover.* *- The UE is in soft handover with two of the three central sectors.* *- The UE is in soft handover with one of the centre three sectors and the propagation loss between the UE and the centre sector is less than the propagation loss between the UE and the other sector involved in the handover. In the unlikely event that the propagation losses to both sectors in the handover are equal a random allocation between the two sectors should be made.*
	GSM	*Load to maximum number of users and observe change in outage (i.e., 0.5 dB less than SINR target)*
ACIR	*WCDMA to GSM*	As per spectrum masks defined in TS 25.101, TS 25.104 (applying the appropriate measurement BW correction), unless capacity loss is found to be significant.

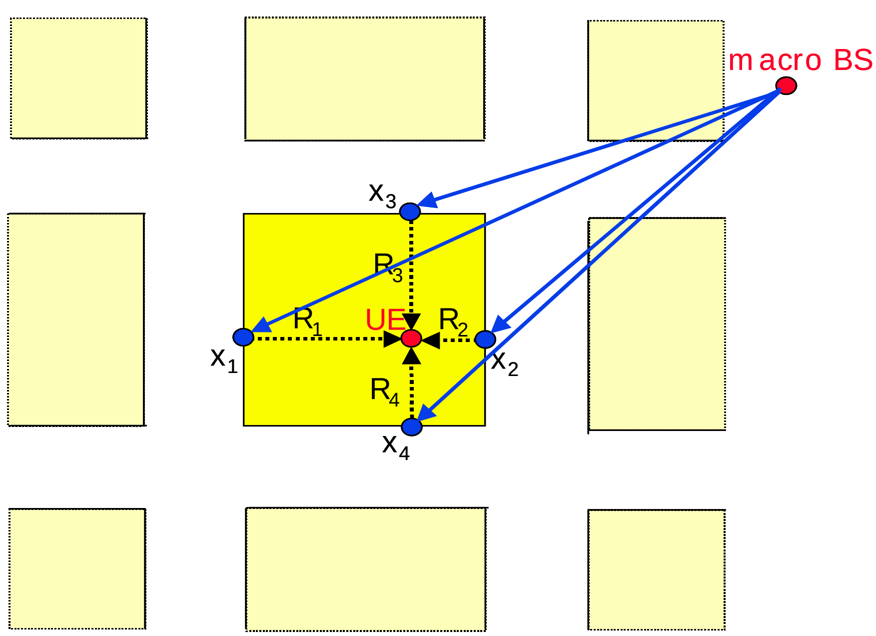

Figure 27: Calculation of BPL towards a macro cell

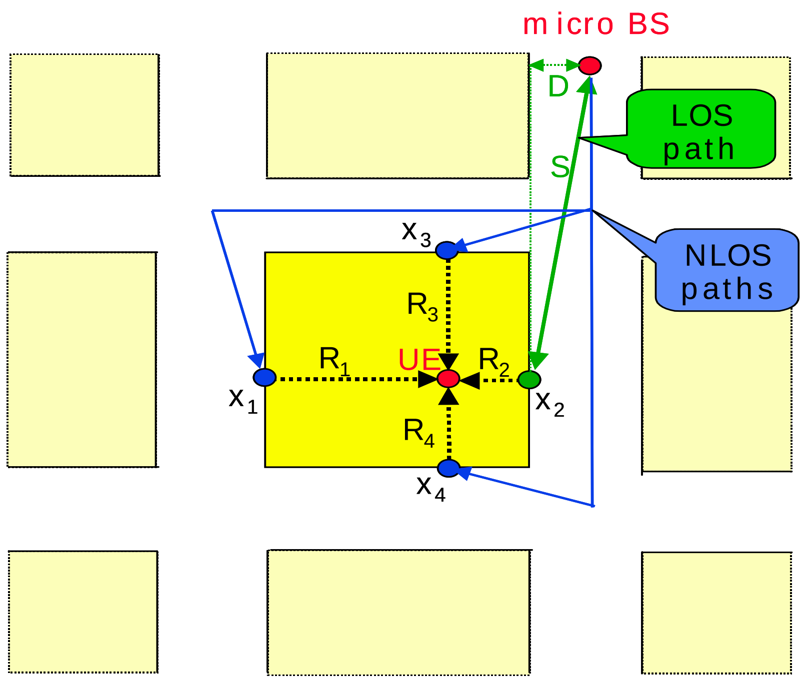

Figure 28: Calculation of BPL towards a micro cell

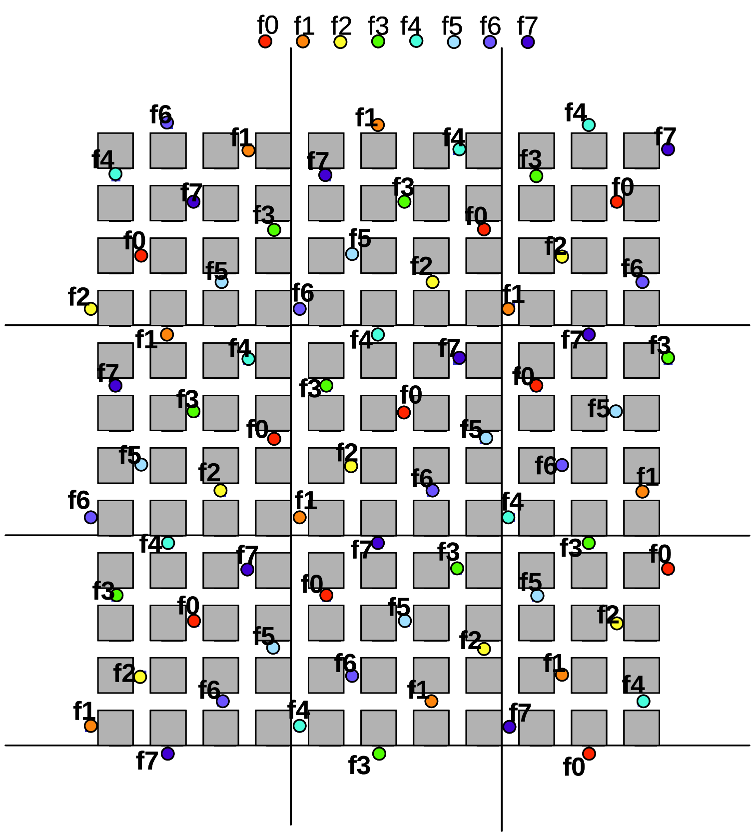

Figure 29a: GSM microcell frequency reuse pattern

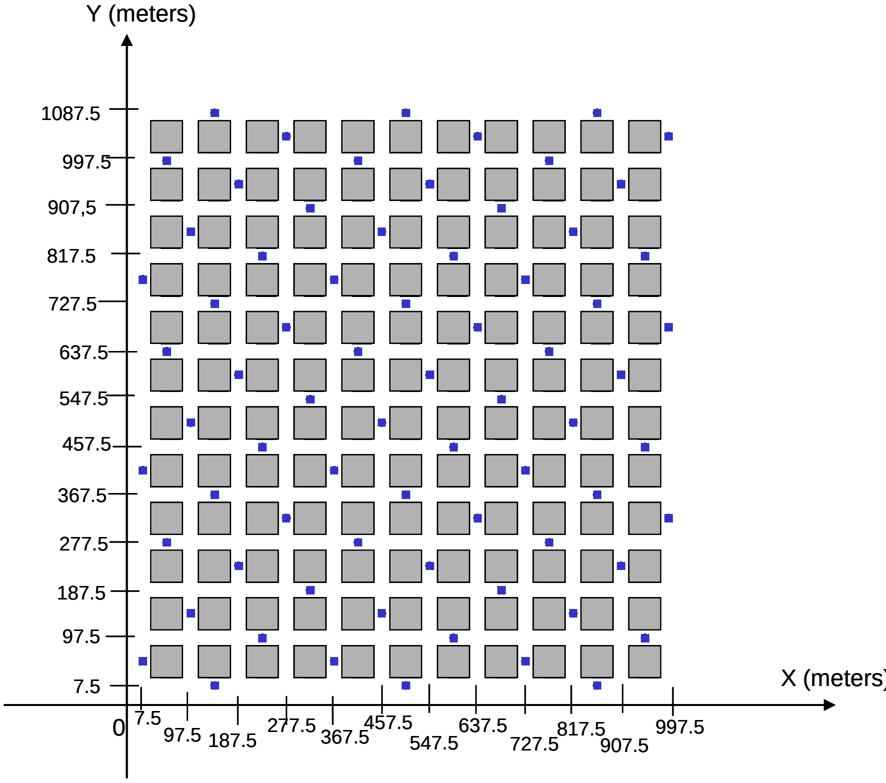

Figure 29b: GSM microcell sites positions and frequencies

Frequency	X	Y	Frequency	X	Y	Frequency	X	Y
f6	142.5	1087.5	f1	502.5	1087.5	f4	862.5	1087.5
f1	277.5	1042.5	f4	637.5	1042.5	f7	997.5	1042.5
f4	52.5	997.5	f7	412.5	997.5	f3	772.5	997.5
f7	187.5	952.5	f3	547.5	952.5	f0	907.5	952.5
f3	322.5	907.5	f0	682.5	907.5	f2	817.5	862.5
f0	97.5	862.5	f5	457.5	862.5	f6	952.5	817.5
f5	232.5	817.5	f2	592.5	817.5	f1	727.5	772.5
f2	7.5	772.5	f6	367.5	772.5			
f1	142.5	727.5	f4	502.5	727.5	f7	862.5	727.5
f4	277.5	682.5	f7	637.5	682.5	f3	997.5	682.5
f7	52.5	637.5	f3	412.5	637.5	f0	772.5	637.5
f3	187.5	592.5	f0	547.5	592.5	f5	907.5	592.5
f0	322.5	547.5	f5	682.5	547.5	f6	817.5	502.5
f5	97.5	502.5	f2	457.5	502.5	f1	952.5	457.5
f2	232.5	457.5	f6	592.5	457.5	f4	727.5	412.5
f6	7.5	412.5	f1	367.5	412.5			
f4	142.5	367.5	f7	502.5	367.5	f3	862.5	367.5
f7	277.5	322.5	f3	637.5	322.5	f0	997.5	322.5
f3	52.5	277.5	f0	412.5	277.5	f5	772.5	277.5
f0	187.5	232.5	f5	547.5	232.5	f2	907.5	232.5
f5	322.5	187.5	f2	682.5	187.5	f1	817.5	142.5
f2	97.5	142.5	f6	457.5	142.5	f4	952.5	97.5
f6	232.5	97.5	f1	592.5	97.5	f7	727.5	52.5
f1	7.5	52.5	f4	367.5	52.5			
f7	142.5	7.5	f3	502.5	7.5	f0	862.5	7.5

Figure 29c: GSM microcell sites positions and frequencies

3.5.4.2 Interference analysis method

Interference between macrocellular UMTS and microcellular GSM networks deployment was studied by using Monte-Carlo simulations.

The objective of Monte-Carlo simulations is to determine the appropriate UMTS BS & UE RF system parameters, Spectrum mask, ACLR (Adjacent Channel power Leakage Ratio), ACS (Adjacent Channel Selectivity), receiver narrow band blocking, etc. for ensuring co-existence of UMTS and GSM. In the simulation, the GSM UL/DL system outage degradations at given ACIR values or as function of ACIR were simulated. The ACIR was used as a variable parameter.

The assumptions of UMTS BS & UE RF characteristics (Spectrum mask, ACLR, ACS) are described in section 3.5.1.2, the GSM system (BS & MS) RF characteristics (ACLR, ACS) are also given in section 3.5.1.2. The derived ACIR of GSM DL/UL for the carrier separation of 2.8 MHz and 4.8 MHz between UMTS carrier and the nearest GSM carrier are described in the section 3.5.1.2.

The threshold used for the evaluation of the impact on GSM network performance due to interference from UMTS is the system outage degradation. The system outage degradation should be as small as possible.

3.5.4.3 Simulation result and analysis

- GSM microcell DL System Outage Degradation (%) due to interference from UMTS macrocell DL

Six simulation curves of GSM downlink system outage degradation as function of ACIR between the UMTS carrier and the nearest GSM carrier for the co-existence scenario 5 are plotted in figure 30.

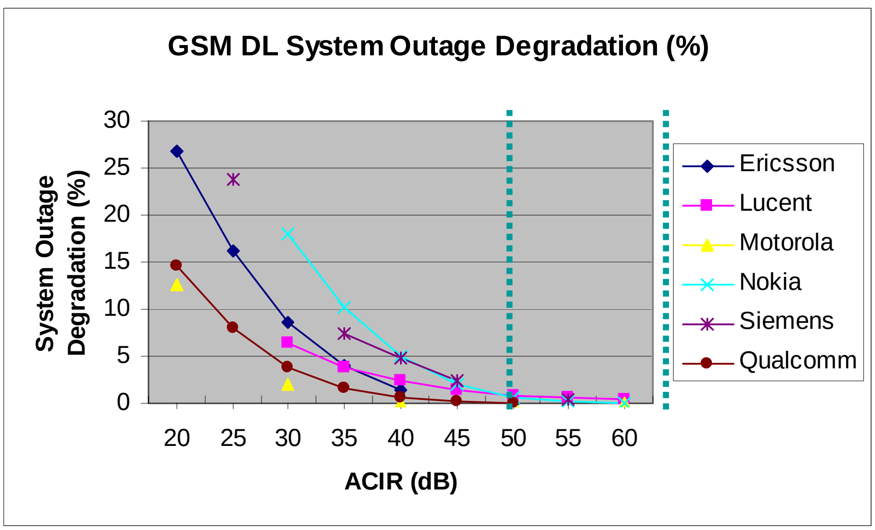

Figure 30: GSM DL System Outage Degradation (%) due to interference from UMTS DL (Scenario_5)

The calculated ACIR of the GSM DL for the carrier separation of 2.8 MHz and 4.8 MHz between the UMTS carrier and the nearest GSM carrier are described in section 3.5.1.2, they are 50 dB for 2.8 MHz and 63 dB for 4.8 MHz carrier separation. As shown in figure 30, the GSM DL system outage degradation at ACIR=50 dB is below 0.9%, at ACIR=63 dB is smaller than 0.3%.

- GSM microcell UL System Outage Degradation (%) due to interference from UMTS macrocell UL

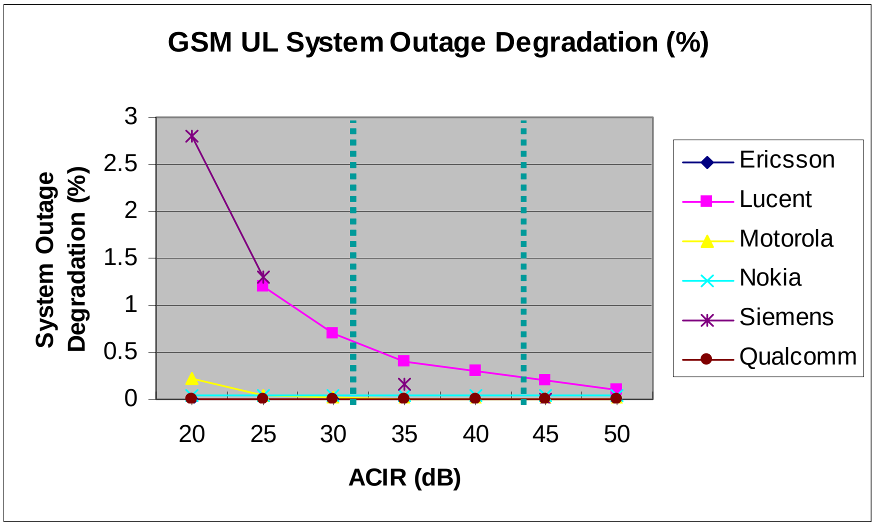

Figure 31: GSM UL System Outage Degradation (%) due to interference from UMTS UL (Scenario_5)

Six simulation results of GSM uplink system outage degradation due to interference from UMTS uplink for the co-existence scenario 5 as function of ACIR between UMTS carrier and the nearest GSM carrier are plotted in figure 31.

The derived ACIR of GSM UL for the carrier separation of 2.8 MHz and 4.8 MHz between the UMTS carrier and the nearest GSM carrier are described in section 3.5.1.2, they are 31.3 dB for 2.8 MHz and 43.3 dB for 4.8 MHz carrier separation. As shown in figure 31, the GSM microcell UL system outage degradation for an ACIR=31.3 dB corresponding to 2.8 MHz carrier separation is below 0.6%, and for an ACIR=43.3 dB corresponding to 4.8 MHz carrier separation is smaller than 0.25%.

It can be observed that GSM microcell DL/UL system outage degradation due to interference from UMTS DL/UL is bigger than that for the co-existence case between UMTS macrocell and GSM macrocell in urban environment. There are several possible reasons for this GSM microcell DL/UL system outage degradation increase:

- GSM microcell BS antenna height is lower, the MCL and propagation loss between GSM BS and MS is smaller, it is also smaller between GSM BS and UMTS UE;
- Distribution of GSM MS and UMTS UE inside of the buildings was considered in the simulation for this microcellular scenario.

It can also be seen that the GSM downlink system outage degradation is higher than that of the GSM uplink, even for a GSM microcellular base station antenna it is much lower than for a GSM macrocellular base station antenna, the distance between GSM microcell BS and the interfering UMTS UE is relatively small.

The simulation results show that the GSM DL/UL system outage degradation at carrier separation of 4.8 MHz is much smaller than that at a carrier separation of 2.8 MHz.

3.5.4.4 Conclusions

Based on the analysis of the simulation results for the co-existence scenario 5 between UMTS(macro) and GSM(micro) in urban areas in uncoordinated operation, it can be concluded that:

1) GSM DL/UL system outage degradation due to interference from UMTS DL/UL for GSM microcellular case is higher than that for GSM macrocell case;

2) The GSM microcell DL/UL system outage degradation due to interference from UMTS macrocell DL/UL at carrier separation between UMTS carrier and the nearest GSM carrier of 4.8 MHz is much smaller than that at a carrier separation of 2.8 MHz;

3) RF system characteristics assumed for UMTS900 seem to be sufficient, there could be some impact on GSM microcell DL/UL system performance, but the impact is limited and small. The increase of carrier separation between the UMTS carrier and the nearest GSM microcell carrier will help to reduce the GSM microcellular system outage degradation. It is recommended to place a GSM microcell carriers' sub-band as far as possible from UMTS carrier.

4) In order to minimise the impact on GSM microcell network outage degradation due to UMTS, the recommended frequency band plan is shown below in Figure 32, GSM macrocell sub-band should be placed between the GSM microcell sub-band and the UMTS carrier.

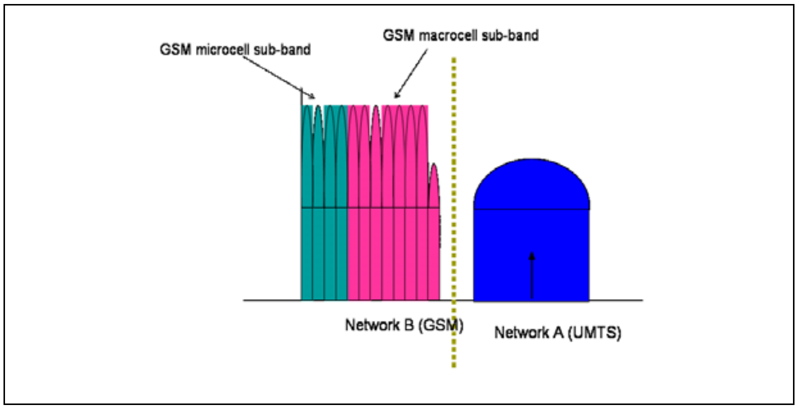

Figure 32: Recommended band plan for UMTS macrocell, GSM macrocell, and GSM microcell

3.5.5 Co-existence between UMTS (macrocell) and GSM (piccell) in urban areas in uncoordinated operation

3.5.5.1 Scenario (Scenario 6) description

- **Scenario_6: UMTS (macro) – GSM (pico) in Urban areas in uncoordinated operation**

The co-existence scenario 6 of UMTS macrocell vs GSM picocell is indicated in figure 33. In urban areas, the UMTS macrocellular network layout is defined in scenario 1 in section 3.5.1. GSM pico-BTS is situated inside a building. UMTS macro-BTS antenna is installed on the top of a different building, as shown in figure 33. Both GSM MS and UMTS UE are located inside the building within the GSM picocell coverage area.

The interference from UMTS UE to GSM pico-BTS will be analyzed in this scenario.

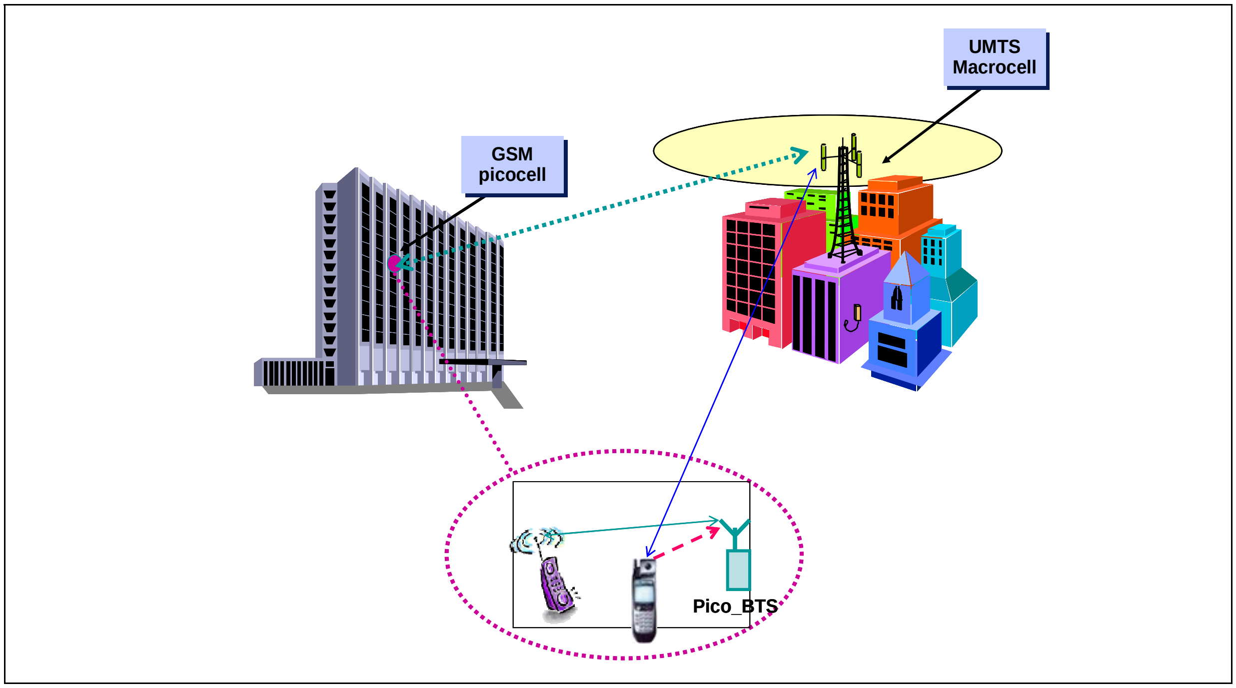

Figure 33: UMTS macrocell and GSM picocell co-existence scenario

3.5.5.2 Interference analysis assumptions

The interference analysis assumptions for scenario 6 are summarized in table 17.

Table 17: Interference analysis assumptions for scenario 6

	UMTS macrocell		GSM picocell	
	BS	UE	BTS	MS
Maximum Tx power (dBm)	43	21	20	33
Antenna height (m)	TR25.816 Section 1	TR25.816 Section 1	3	1.5
Antenna gain (dBi)	TR25.816 Section 1	TR25.816 Section 1	0	0
Reference sensitivity (dBm)	TR25.816 Section 1	TR25.816 Section 1	-88	-102
Noise floor (dBm)	-103 dBm/3.84 MHz	-96 dBm/3.84 MHz	-94 dBm/200 kHz	-111 dBm/200 kHz
Spectrum mask	TS25.104	TS25.101	TS45005	TS45005
Blocking characteristics	TS25.104	TS25.101	TS45005	TS45005
Cell range (m)	TR25.816 Section 1		50	
UMTS UE Tx power typical values from the scenario 1 or scenario 5 simulations	90% 50%			
Carrier separation (MHz)	2.8 4.8			
Distance between UMTS UE and GSM pico_BTS (m)	3 15			

3.5.5.3 Interference analysis

3.5.5.3.1 Interference analysis with simulated outdoor UE Tx power

A. Simulated outdoor UE Tx power

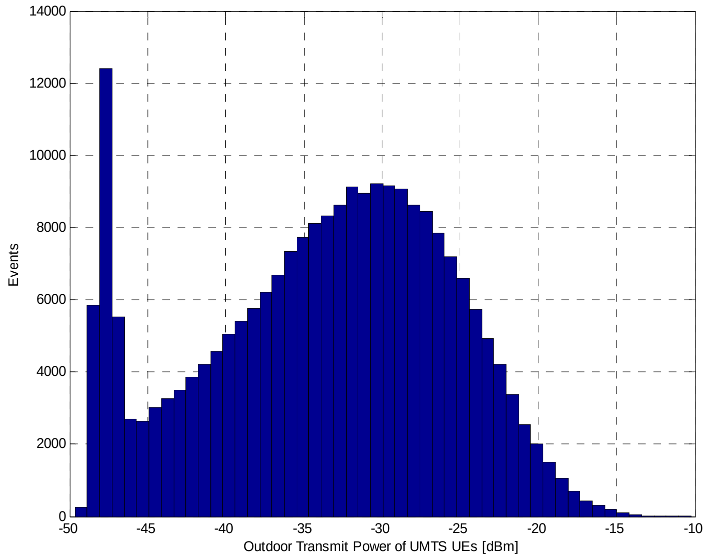

Figure 34: Outdoor UMTS UE Transmit Power distribution

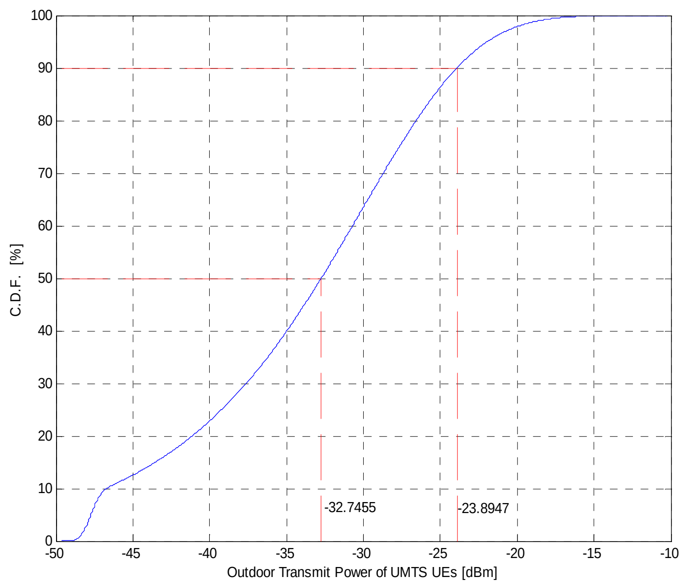

Figure 35: CDF of Outdoor Transmit Power of UMTS UE

Outdoor UMTS UE Tx power distribution was simulated based on co-existence scenario 1 described in section 3.5.1.1. It was simulated without interference from GSM.

Figure 34 gives an example of the simulated outdoor UE Tx power distribution. An example of the cumulative probability of outdoor UE Tx power is plotted in figure 35.

Table 18 summarizes the outdoor UMTS UE Tx power values at 50th percentile and 90th percentile from simulations performed by different companies. It was agreed to use the averaged values for interference analysis.

Table 18: Simulated outdoor UMTS UE transmit powers at 90% and 50%

Percentile	90%	50%
Ericsson	-23.7 dBm	-32.6 dBm
Nokia	-24.0 dBm	-32.5 dBm
Nortel	-19.6 dBm	-30.4 dBm
Qualcomm	-23.9 dBm	-32.7 dBm
Lucent	-21.0 dBm	-30.6 dBm
Average	-22.4 dBm	-31.8 dBm

B. Interference analysis

a) Tx power of Indoor UMTS UEs

The Tx power of Indoor UMTS UEs for in-building penetration factor (IPF) of 10 dB and 15 dB is given in Table 19.

Table 19: Indoor Tx power of UMTS Ues for different IPF

CDF	90%		50%	
Outdoor Tx power [dBm]	-22.4		-31.8	
IPF [dB]	10	15	10	15
Indoor Tx power [dBm]	-12.4	-7.4	-21.8	-16.8

b) Determination of UMTS UE Tx power in GSM BS receiving channel

The frequency separation between the carriers of UMTS UE and GSM BS is denoted by *df*. In this study, it was assumed that *df* is either 2.8 MHz or 4.8 MHz. The adjacent channel leakage ratio (ACLR) of UMTS UE for these carrier separations in Table 20 is obtained from the spectrum emission mask of UMTS UE defined in TS25.101, as shown in figure 36.

Table 20: ACLR at carrier separations 2.8MHz and 4.8MHz

Frequency separation	2.8 MHz	4.8 MHz
ACLR [dB]	31.3	43.3

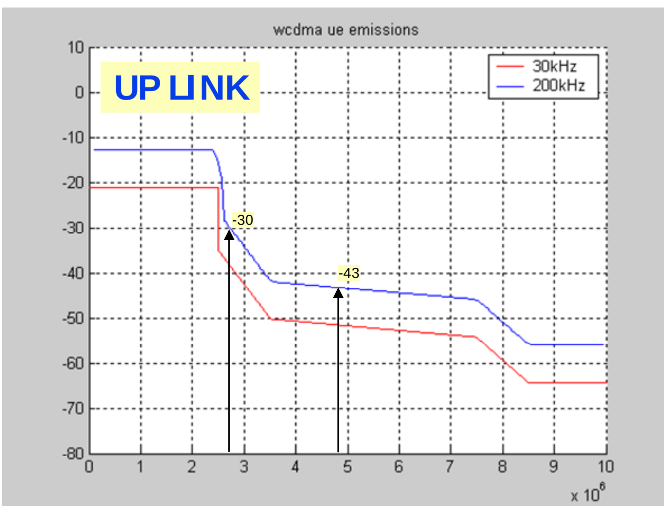

Figure 36: WCDMA UE emissions to GSM

The power of UMTS UE emissions in the GSM uplink channel for considered *df* values is calculated in tables 21 and 22.

Table 21: Tx Power of UMTS UE in GSM BS channel for *df* = 2.8 MHz

CDF	90%		50%	
Outdoor Tx power [dBm]	-22.4		-31.8	
IPF [dB]	10	15	10	15
Indoor Tx power [dBm]	-12.4	-7.4	-21.8	-16.8
Tx power in GSM channel [dBm/200kHz]	-43.7	-38.7	-53.1	-48.1

Table 22: Tx Power of UMTS UE in GSM channel for *df* = 4.8 MHz

CDF	90%		50%	
Outdoor Tx power [dBm]	-22.4		-31.8	
IPF [dB]	10	15	10	15
Indoor Tx power [dBm]	-12.4	-7.4	-21.8	-16.8
Tx power in GSM channel [dBm/200kHz]	-55,7	-50.7	-65.1	-60.1

c) Typical GSM picocell cell range

It is assumed that the typical cell range of the GSM picocellular is 50 m, as shown in figure 37. In addition, the separation distance between UMTS UE and GSM pico-BS is considered to be 3 m and 15 m.

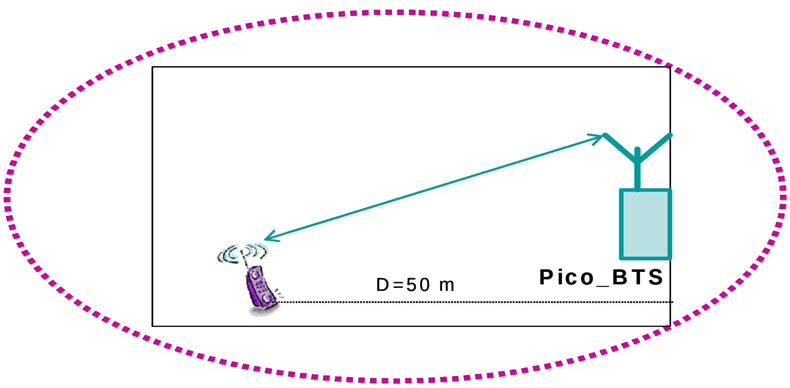

Figure 37: Illustration of relative position of GSM MS and GSM pico-BS

d) Indoor propagation model and COST231 indoor propagation model is used for the indoor pathloss calculation

$$PL(D)\ (dB) = 37 + 30 \operatorname{Log}(D) \qquad (2)$$

Where D is the distance in meter.

The pathloss as function of distance D(m) calculated by the equation (2) is plotted in figure 38. The pathloss values for three typical distances are given in table 23.

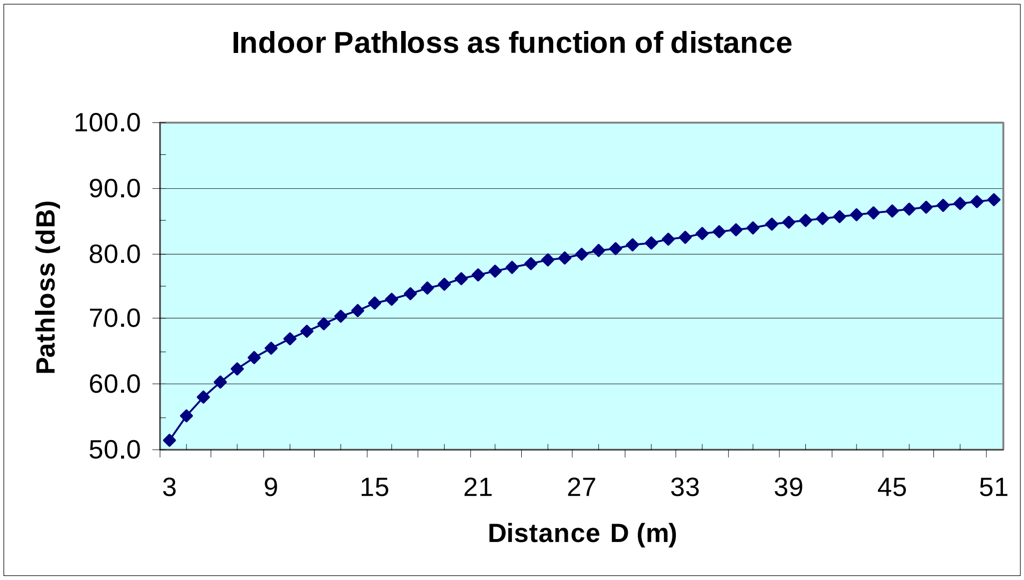

Figure 38: Indoor propagation pathloss in function of distance D(m)

Table 23: Pathloss for three typical distances

D (m)	Pathloss (dB)
3	51.3
15	72.3
50	88.0

e) Determination of interference level on GSM uplink

The Interference level (I_{ext}) from UMTS UE emissions to the GSM pico-cell uplink for the considered separation distances is presented in tables 24 and 25.

Table 24: Interference Power in GSM channel from UMTS UE (*Iext*) for *df* = 2.8MHz

CDF	90%				50%			
Outdoor Tx power [dBm]	-22.4				-31.8			
IPF [dB]	10		15		10		15	
Indoor Tx power [dBm]	-12.4		-7.4		-21.8		-16.8	
Tx power in GSM channel [dBm/200kHz]	-43.7		-38.7		-53.1		-48.1	
D [m]	3	15	3	15	3	15	3	15
Iext [dBm/200kHz]	-95	-116	-90	-111	-104.4	-125.4	-99.4	-120.4

Table 25: Interference Power in GSM channel from UMTS UE (*Iext*) for *df* = 4.8MHz

CDF	90%				50%			
Outdoor Tx power [dBm]	-22.4				-31.8			
IPF [dB]	10		15		10		15	
Indoor Tx power [dBm]	-12.4		-7.4		-21.8		-16.8	
Tx power in GSM channel [dBm/200kHz]	-55,7		-50.7		-65.1		-60.1	
D [m]	3	15	3	15	3	15	3	15
Iext [dBm/200kHz]	-107	-128	-102	-123	-116.4	-137.4	-111.4	-132.4

f) Analysis of the impact on GSM picocell uplink

The GSM picocell uplink performance should be analyzed in the cases with and without the presence of interference from the UMTS UE for the assumptions given above; i.e. *df* = 2.8 MHz & 4.8 MHz, *IPF* = 10 dB & 15 dB and separation distance between UMTS UE and GSM pico-BS = 3 m & 15 m. It is assumed that GSM uplink is power controlled and the link performance is achieved at 6 dB target *SIR*. In addition, the thermal noise floor is N_t = -94 dBm/200 kHz and 10 dB margin is assumed for interference and shadow fading denoted by *M*.

g) GSM picocell uplink without UMTS UE interference

The required received power at the GSM pico-BS to achieve the target SIR is denoted by *Rx_required* and given as

$$Rx\_required = Nt + M + SIR = -78\ dBm$$

Hence, the required transmit power of GSM MS at the cell edge denoted by *Tx_required* in dBm is

$$Tx\_required = Rx\_required + Pathloss(D = 50) = 10\ dBm$$

Table 26 summarizes these results.

Table 26: Required Tx and Rx power at the cell edge without UMTS UE interference

GSM picocell uplink without interference	
Rx_required [dBm]	-78
Tx_required [dBm]	10

h) GSM picocell uplink with UMTS UE interference (*Iext*)

When the interference from UMTS UE is introduced, the required receive power at GSM BS from GSM MS at the cell edge is:

$$Rx\_required = (N_t + I_{ext}) + M + SIR,$$

Where ($N_t + I_{ext}$) in dBm is the sum of noise floor and the interference caused by UMTS UE. The required transmit power of GSM MS is then again calculated as:

$$Tx\_required = Rx\_required + Pathloss(D=50)$$

Rx_required and *Tx_required* are determined in the following tables 27 and 28.

Table 27: Required Tx and Rx power at the cell edge for df = 2.8 MHz with the presence of Iext

CDF	90%				50%			
Outdoor Tx power [dBm]	-22.4				-31.8			
IPF [dB]	10		15		10		15	
Indoor Tx power [dBm]	-12.4		-7.4		-21.8		-16.8	
Tx power in GSM channel [dBm/200kHz]	-43.7		-38.7		-53.1		-48.1	
D [m]	3	15	3	15	3	15	3	15
Iext [dBm/200kHz]	-95	-116	-90	-111	-104.4	-125.4	-99.4	-120.4
Nt+Iext [dBm/200kHz]	-91.5	-94.0	-88.5	-93.9	-93.6	-94.0	-92.9	-94.0
Rx_required [dBm]	-75.5	-78.0	-72.5	-77.9	-77.6	-78.0	-76.9	-78.0
Tx_required [dBm]	12.5	10.0	15.5	10.1	10.4	10.0	11.1	10.0

Table 28: Required Tx and Rx power at the cell edge for df = 4.8 MHz with the presence of Iext

CDF	90%				50%			
Outdoor Tx power [dBm]	-22.4				-31.8			
IPF [dB]	10		15		10		15	
Indoor Tx power [dBm]	-12.4		-7.4		-21.8		-16.8	
Tx power in GSM channel[dBm/200kHz]	-55.7		-50.7		-65.1		-60.1	
D [m]	3	15	3	15	3	15	3	15
Iext [dBm/200kHz]	-107	-128	-102	-123	-116.4	-137.4	-111.4	-132.4
Nt+Iext [dBm/200kHz]	-93.8	-94.0	-93.4	-94.0	-94.0	-94.0	-93.9	-94.0
Rx_required [dBm]	-77.8	-78.0	-77.4	-78.0	-78.0	-78.0	-77.9	-78.0
Tx_required [dBm]	10.2	10.0	10.6	10.0	10.0	10.0	10.1	10.0

3.5.5.3.2 Interference analysis with simulated indoor UE Tx power

a) Indoor UMTS UE Tx power

The CDF of WCDMA Indoor UE Tx power is simulated in scenario 5, an example of the cumulative probability of simulated indoor UMTS UE Tx power is shown in Figure 39. 90th-percentile and 50th-percentile points of the distribution from simulations are summarized in Table 29.

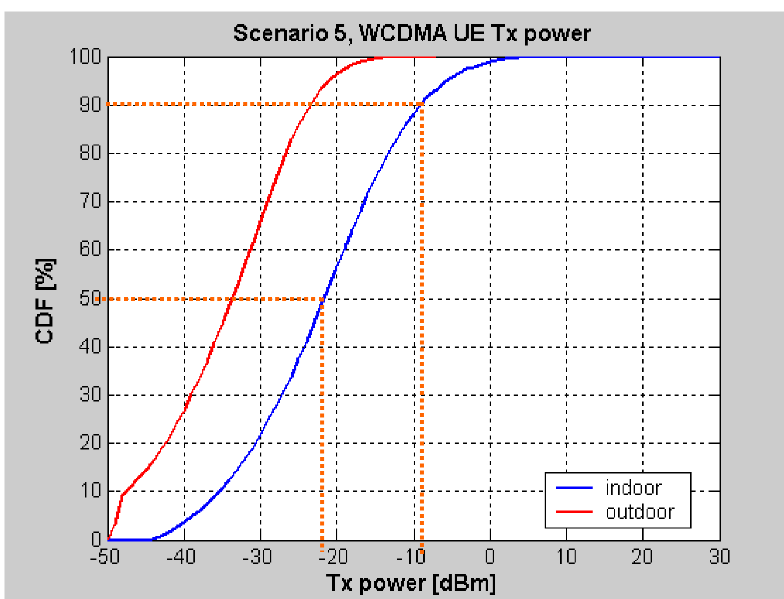

Figure 39: CDF of Indoor Transmit Power of UMTS UE

Table 29: Simulated indoor UMTS UE transmit powers at 90% and 50%

Percentile	90%	50%
Ericsson	-9.1 dBm	-21.7 dBm
Lucent	0 dBm	-9.7 dBm
Average	**-4.5 dBm**	**-15.7 dBm**

b) UMTS UE Tx power in GSM channel

The UE Tx power falling into the GSM Base Station (BS) receive channel can be determined by the following equation:

$$\text{UE Tx power in GSM channel} = \text{Indoor UE Tx power} - ACIR(\Delta f) \quad \text{in dB} \qquad (3)$$

where Δf denotes the centre frequency spacing between UMTS and GSM carriers. When the UMTS UEs interfere with GSM picocell, the ACIR is 31.3 dB for 2.8 MHz centre frequency separation and 43.3 dB for 4.8 MHz centre frequency separation. Table 30 shows the UE Tx power in GSM channel for various UE Tx power percentiles and centre frequency separations.

Table 30: UMTS UE Tx Power in GSM channel

Cumulative Distribution Function (CDF)	90%		50%	
Indoor UE Tx power (dBm)	-4.5		-15.7	
Δf (MHz)	2.8	4.8	2.8	4.8
UMTS UE Tx power in GSM channel (dBm/200kHz)	-35.8	-47.8	-47.0	-59.0

c) UMTS UE interference level received by GSM picocell

It is assumed that the distance (D) between the interfering UMTS UE and affected GSM picocell could be 3 m and 15 m. The associated UE to picocell propagation losses based on the COST231 indoor model are 51.3 dB and 72.3 dB, respectively. The GSM picocell received interference power (I_{ext}) from UMTS UE can be expressed as:

$$I_{ext} = \text{UMTS UE Tx power in GSM channel} - PL(D) \quad \text{in dB} \qquad (4)$$

where PL is the path loss (including the propagation loss and antenna gains) from UMTS UE to GSM picocell. Table 31 shows the UMTS UE interference power received by GSM picocell for various UE Tx power percentiles, centre frequency separations and UE-to-picocell distances.

Table 31: UMTS UE interference power received by GSM picocell

CDF	90%				50%			
Indoor UE Tx power (dBm)	-4.5				-15.7			
Δf (MHz)	2.8		4.8		2.8		4.8	
UMTS UE Tx power in GSM channel (dBm/200kHz)	-35.8		-47.8		-47.0		-59.0	
UE-to-picocell Distance (m)	3	15	3	15	3	15	3	15
Iext (dBm/200kHz)	-87.1	-108.1	-99.1	-120.1	-98.3	-119.3	-110.3	-131.3

d) Impact of UMTS UE interference on GSM picocell uplink

When the GSM uplink power control is activated and the UMTS UE interference is present, GSM mobile needs to transmit more power to maintain the uplink SINR target (*SINR*) in the GSM picocell receiver as long as the required mobile transit power does not exceed the maximum power (33 dBm). Without UMTS UE interference, the required Tx power of a GSM mobile at the picocell edge can be determined by:

$$GSM\_mobile\_Tx\_required = N_t + SINR + PL(D=50\ m) + M \quad \text{in dB} \qquad (5)$$

where Nt denotes the GSM picocell receiver noise floor (-94 dBm/200 kHz), PL(D=50 m) denotes the path loss (88.0 dB) for a 50 m distance between the GSM picocell and the GSM mobile at the picocell edge, and M denotes the lognormal fading and interference margin (10 dB). Consequently, in the absence of UMTS UE interference, the GSM mobile power requirement is 10 dBm.

In the presence of UMTS UE interference, the required Tx power of a GSM mobile at the picocell edge can be expressed as:

$$GSM\_mobile\_Tx\_required = (N_t + I_{ext}) + SINR + PL(D{=}50\ m) + M \quad \text{in dB} \qquad (6)$$

where (Nt + Iext) in dBm is the linear sum of the GSM picocell noise floor and the UMTS UE interference. Table 32 shows the required GSM mobile Tx power with UMTS UE interference for various UE power percentiles, centre frequency separations and UE-to-picocell distances.

Table 32: Required GSM mobile transmit power in the presence of UMTS UE interference

CDF	90%				50%			
Indoor UE Tx power (dBm)	-4.5				-15.7			
Δf (MHz)	2.8		4.8		2.8		4.8	
UMTS UE Tx power in GSM channel (dBm/200kHz)	-35.8		-47.8		-47.0		-59.0	
UE-to-picocell Distance (m)	3	15	3	15	3	15	3	15
I_{ext} (dBm/200kHz)	-87.1	-108.1	-99.1	-120.1	-98.3	-119.3	-110.3	-131.3
N_t+I_{ext} (dBm/200kHz)	-86.3	-93.8	-92.8	-94.0	-92.6	-94.0	-93.9	-94.0
GSM_mobile_Rx_power (dBm)	-70.3	-77.8	-76.8	-78.0	-76.6	-78.0	-77.9	-78.0
GSM_mobile_Tx_power (dBm)	**17.7**	**10.2**	**11.2**	**10.0**	**11.4**	**10.0**	**10.1**	**10.0**

3.5.5.4 Conclusions

The interference from UMTS UE to GSM picocell BS has been analyzed with the simulated outdoor UE Tx powers and indoor UE Tx power. Based on the analysis results for the co-existence scenario 6 between UMTS macrocell and GSM picocell, the following conclusions can be made:

1) When UMTS UE is located at 15 m distance from GSM pico-BTS, the interference from UMTS UE to GSM pico-BTS is lower than the GSM pico-BTS noise floor, hence the transmitting power of GSM MS located at cell edge is not affected.
2) When UMTS UE is located at 3 m distance from GSM pico-BTS and the carrier separation between UMTS and GSM is 2.8 MHz, the transmitting power of GSM MS at cell edge (50 m from pico-BTS) will increase by 0 - 7.7 dB, depending on the interference caused by the UMTS UE transmitter. However, the required GSM MS transmitting power stays still below the maximum power and therefore it is considered that there is no call dropping in GSM system caused by the interference from UMTS UE.
3) When UMTS UE is located at 3 m distance from GSM pico-BTS and the carrier separation between UMTS and GSM is 4.8 MHz, the transmitting power of GSM MS at cell edge (50 m from pico-BTS) will increase by 0 - 1.2 dB, depending on the interference caused by the UMTS UE transmitter. As the interference is small and GSM transmitters have more than enough power margin to compete against it, therefore it is considered that there is no call dropping in GSM system caused by the interference from UMTS UE.
4) UMTS UE spectrum mask allow a good co-existence between UMTS macrocell and GSM picocell for the defined co-existence scenario hence there is no need to harden the UMTS UE spectrum mask.
5) For ensuring a good co-existence between UMTS macrocells and GSM picocell, it is recommended to have maximum separation between UMTS carrier and GSM picocell carrier in order to minimize the possible interference from UMTS UE to GSM picocellular BS.

4 SHARING STUDY FOR UMTS OPERATING IN THE 1800 MHZ BAND

4.1 1800 MHz band plan

2 x 75 MHz of the 1800 MHz frequency band are totally or partially allocated to and used by GSM (DCS), see figure 40:

- Uplink: 1 710 MHz to 1 785 MHz: mobile transmit, base receive;
- Downlink: 1 805 MHz to 1 880 MHz: base transmit, mobile receive.

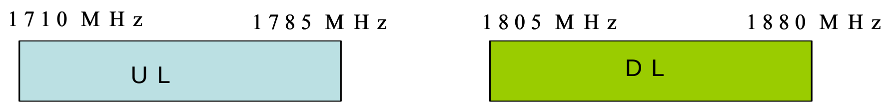

Figure 40: 1800 MHz frequency band plan

4.2 UMTS1800 system characteristics

UMTS1800 system characteristics are derived from the UMTS1800 technical specifications TS25.104 and TS25.101. Radio site parameters are proposed based on the 3GPP technical report TR25.885 [7], they are summarized in table 33.

Table 33: UMTS1800 system characteristics

	UMTS1800	
Downlink band (MHz)	1805-1880	
Uplink band (MHz)	1710-1785	
Carrier separation (MHz)	5	
Channel raster (kHz)	200	
	BS	**UE**
Tx Power (Maximum) (dBm)	43	21
Antenna gain (dBi)	18	0
Feeder loss (dB)	3	0
Antenna height (m)	45 (Rural) 30 (Urban)	1.5
Antenna tilt (°)	3 (Urban)	-
BS_UE MCL (dB)	80 (Rural) 70 (Urban)	-
Spectrum mask	TS25.104	TS25.101
ACLR (±5MHz) (dB)	45	33
ACLR (±10 MHz) (dB)	50	43
Spurious emissions	TS25.104	TS25.101
Receiver Bandwidth (MHz)	3.84	3.84
Receiver Temperature (KBT) (dBm)	–108	–108

Receiver noise figure (dB)	5	12
Receiver Thermal Noise Level (dBm)	–103	-96
Receiver reference sensitivity*	-121	-114
Receiver ACS (dB)	46	33
Receiver in-band blocking	TS25.104	TS25.101
Receiver out-of-band blocking	TS25.104	TS25.101
Receiver Narrow band blocking at 2.8 MHz (dBm)	-47 (useful signal at -115 dBm)	-56 (useful signal at RefSens+10)
**Receiver reference sensitivity was defined for speech 12.2 kbps in TS25.104 and TS25.101.*		

4.3 UMTS1800 deployment scenarios

By considering that the propagation characteristics of 1800 MHz band are similar to those of the 2 GHz band, the deployment of UMTS in the 1800 MHz band is similar to the UMTS deployment in the 2 GHz band, except the co-existence of UMTS and GSM in the 1800 MHz band. Therefore UMTS1800 deployment scenarios defined for these sharing studies are mainly focusing on the co-existence between UMTS and GSM in the 1800 MHz band, three scenarios were defined and studied during the development of UMTS1800 technical specifications:

1) Sharing studies for deployment scenario_1 (10 MHz “Sandwich” mixed GSM and WCDMA coordinated operation);
2) Sharing study for deployment scenario_2 (5 MHz uncoordinated operation);
3) 2 x 10 MHz deployed with 2 WCDMA carriers.

4.4 Co-existence between UMTS networks in the 1800 MHz band

Co-existence between UMTS networks in the 1800 MHz band was not specifically studied in this report since it was believed that the sharing study results for the co-existence between UMTS networks in the 2GHz band [5] were applicable to UMTS1800.

The simulation results for the co-existence between UMTS networks operating in the 2 GHz band were described in detail in 3GPP TR25.942 [5], they show that UMTS can be deployed in urban, sub-urban and rural areas with carrier separation of 5 MHz, or less, even in the worst case, where the base stations of network B are located at the cell edge of network A, the capacity loss due to interference is below 5% at carrier separation of 5 MHz or less. For detailed information, please refer to the 3GPP report TR25.942 [5].

4.5 Co-existence between UMTS and GSM in the 1800 MHz band

4.5.1 Co-existence between UMTS and GSM with 10 MHz “Sandwich” mixed coordinated operation

4.5.1.1 Scenario description

In this scenario one WCDMA carrier is placed in 2 x 10 MHz with geographically coordinated WCDMA and GSM base stations in the same 2 x 10 MHz band. The WCDMA Uplink and Downlink carriers are surrounded by GSM carriers, noted as a "sandwich" concept (GSM/WCDMA/GSM), see figure 40(a).

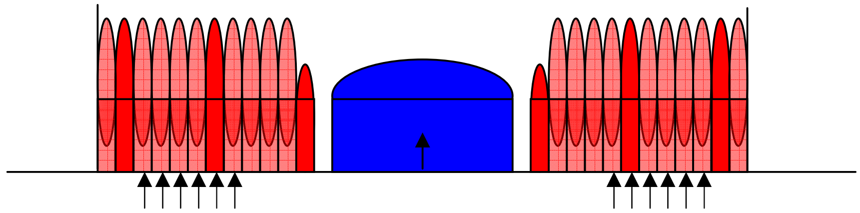

Figure 40(a): 10 MHz “Sandwich” mixed GSM and WCDMA coordinated operation

4.5.1.2 Interference analysis method

Coordinated case with co-sited UMTS and GSM base stations means that both systems are deployed into the same site in order to diminish the near-far effects.

Considering that the GSM BS receiver is protected over the whole receiving band against the spurious emissions from the GSM transmitter, in the same way, the UMTS BS receiver is protected over the whole receiving band against the spurious emissions from the UMTS transmitter. GSM and UMTS BS can be co-located with the interference level below the acceptable threshold.

The interference between UMTS and GSM was studied by Monte-Carlo simulations. The objectives of Monte-Carlo simulations are to evaluate the UMTS DL/UL capacity losses due to interferences from GSM DL/UL, and also to evaluate the difference between GSM DL/UL SIR distributions due to interference from UMTS DL/UL.

ACIR values for both UMTS DL/UL as victim and for both GSM DL/UL as victim are given in section 3.5.1.2. They are applicable to UMTS and GSM operating in the 1800 MHz band.

4.5.1.3 Simulation result and analysis

a) Impact on UMTS DL due to interference from GSM BS

For the case of GSM BS and UMTS BS co-located, it was supposed that regardless of the location of the UMTS UE, the path losses from either the UMTS BS or the GSM BS are assumed to be nearly equal to within the fading margins.

The simulated UMTS DL capacity loss due to interference from GSM BS is given in figure 41. The simulation condition is that the cell radius is 2.4 km and the GSM BS carriers are of full power at 2.6 MHz offset from the UMTS carrier frequency.

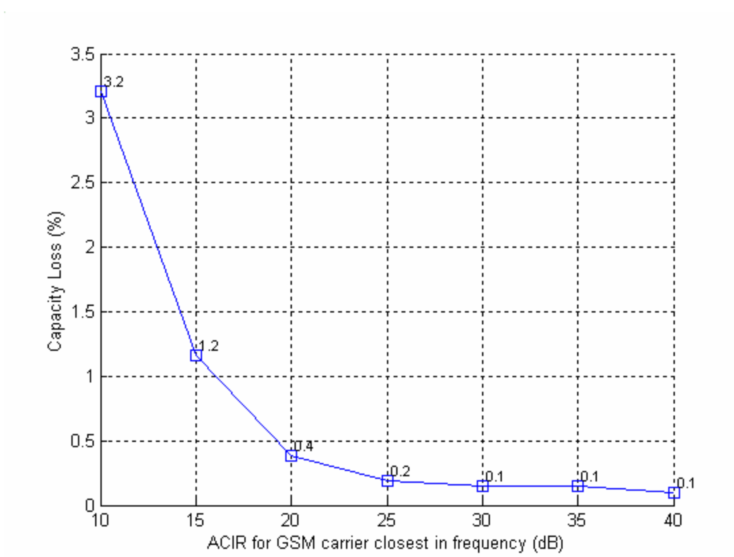

Figure 41 : Simulated UMTS DL capacity loss

It can be seen that at ACIR of 30.5 dB which corresponds to the carrier separation between UMTS carrier and the nearest GSM carrier of 2.8 MHz, the UMTS DL capacity loss is 0.1%.

b) Impact on UMTS UL due to interference from GSM MS

The simulation results on the impact of interference from GSM MS on UMTS uplink are given in figure 42 and 43 with and without GSM MS power control respectively. The simulation conditions were that:

i) The frequency separation between nearest UMTS and GSM carriers is 2.6 MHz;

ii) GSM MS are randomly distributed.

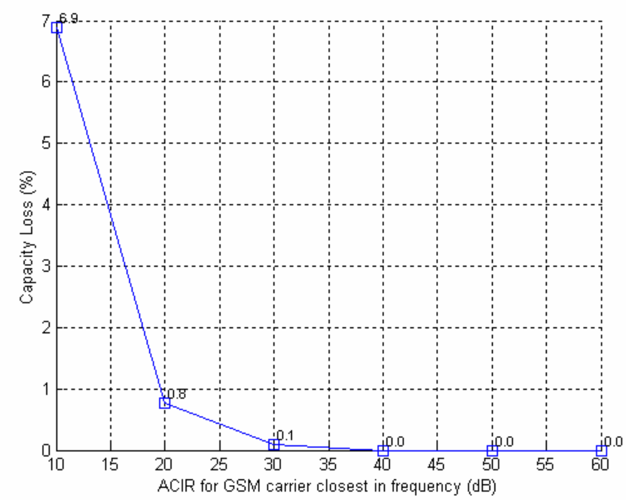

Figure 42: UMTS UL capacity loss with GSM UL power control ON

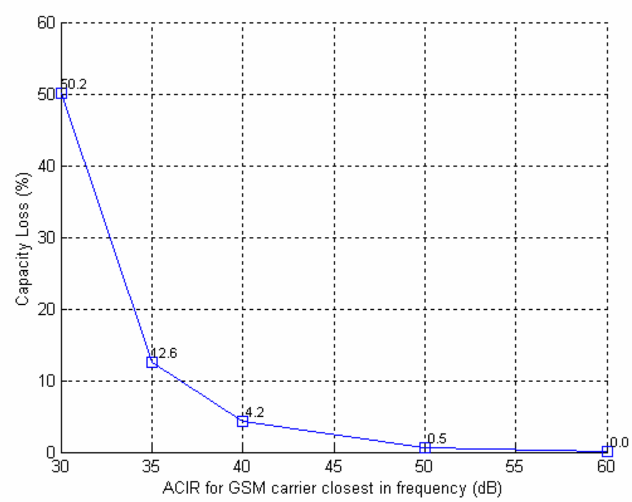

Figure 43: UMTS UL capacity loss with GSM UL power control OFF

It can be seen that at ACIR of 43.1 dB, when GSM uplink power control is on, the UMTS UL capacity loss is almost 0. When GSM UL power control is off, the UMTS UL capacity loss due to interference from GSM uplink is about 3.5%.

c) Impact on GSM DL due to interference from UMTS BS

The impact on GSM downlink due to interference from UMTS base station was evaluated by the comparison of GSM downlink SIR(Signal to Interference Ratio) distributions with and without UMTS BS emissions.

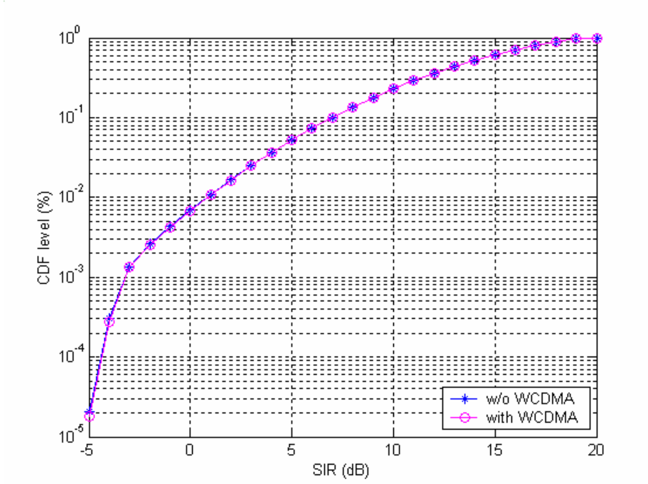

Figure 44: Simulated GSM DL SIR for cases with & without UMTS

The following simulation conditions were assumed:

i) cell range of 2.4 km;

ii) frequency separation between UMTS and GSM nearest carriers of 2.6 MHz;

iii) GSM MS are randomly distributed

The simulated GSM DL SIR (Signal to Interference Ratio) is given in figure 44.

The results show that for the cases with and without interferences from UMTS, the SIR curves are overlapped, that means there is no change of GSM DL SIR.

d) Impact on GSM UL due to interference from UMTS UE

GSM UL SIR simulation curves are given in the figure 45, under the simulation conditions:

i) cell range of 2.4 km;

ii) frequency separation between UMTS and GSM nearest carriers of 2.6 MHz;

iii) randomly distributed UMTS UE;

iv) UMTS network load of 75% with 6 dB noise rise.

These two SIR curves are also totally overlapped, which means there is no significant impact on GSM UL SIR with the presence of UMTS.

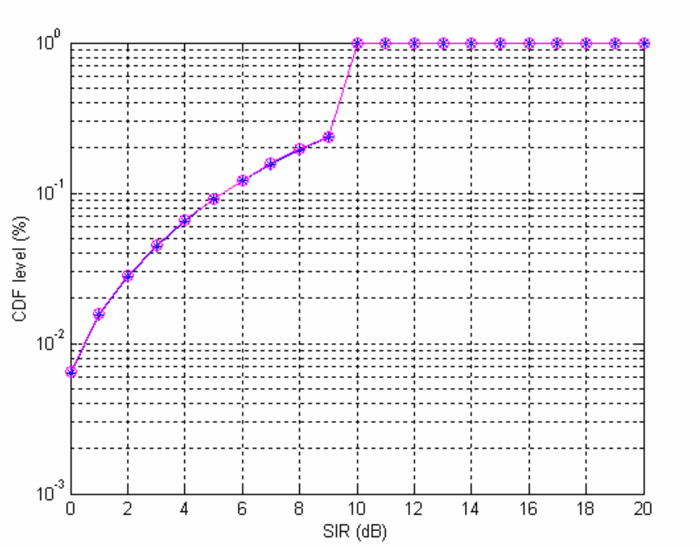

Figure 45: Simulated GSM UL SIR for cases with & without UMTS

4.5.1.4 Conclusion

Based on the analysis of the simulation results for the co-existence scenario 1 between UMTS1800(macro)-GSM1800(macro) in urban and sub-urban area with 10 MHz "Sandwich" mixed GSM and WCDMA coordinated operation at cell range of 2400 m, the following conclusion can be made:

- UMTS and GSM can co-exist with a carrier separation of 2.6 MHz or more between the UMTS carrier and the nearest GSM carrier.

4.5.2 Co-existence between UMTS and GSM with 5 MHz uncoordinated operation

4.5.2.1 Scenario description

This scenario considers deployment with one WCDMA carrier in a 2 x 5 MHz band with geographically uncoordinated deployment at both band edges, see figure 46.

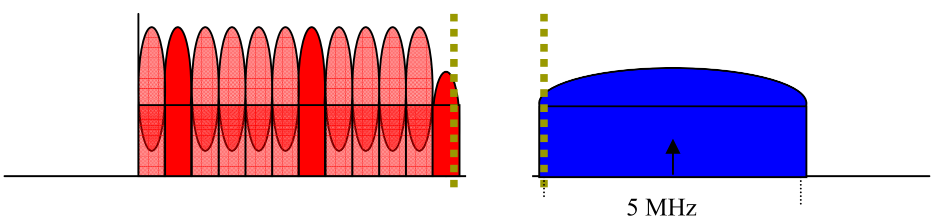

Figure 46 : 5 MHz uncoordinated operation

4.5.2.2 Interference analysis method

Interference between UMTS and GSM in co-existence with 5 MHz uncoordinated operation was studied by Monte-Carlo simulations.

For the uncoordinated operation between UMTS and GSM, the worst case scenario was used as simulation assumption, as the cell layout shown in figure 47.

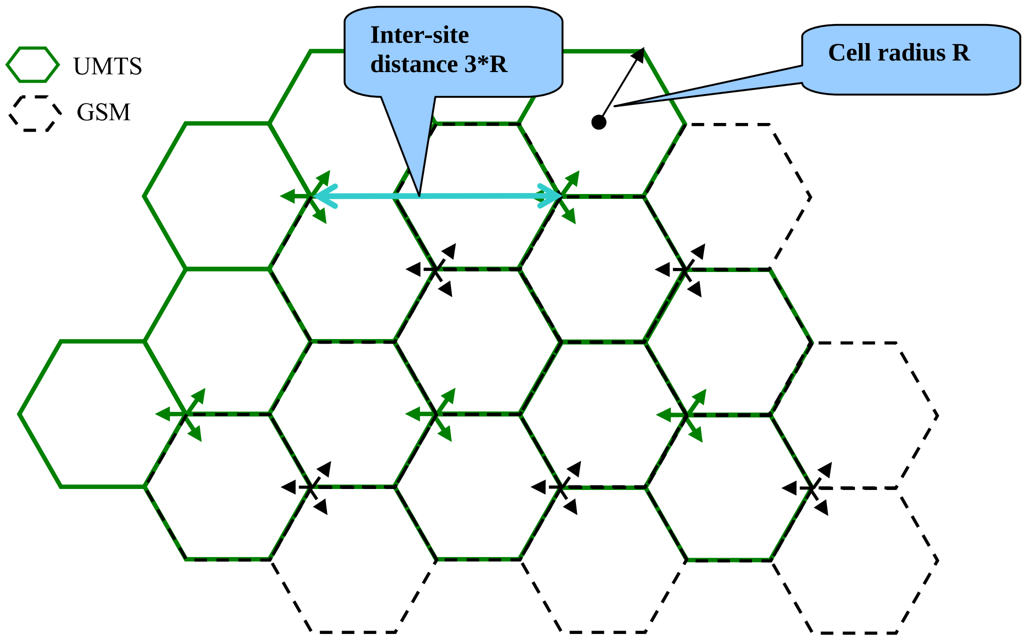

Figure 47: Uncoordinated operation cell layout

Worst-case simulation assumptions can be summarized as:

- The interfering system base stations are placed at the edge of the victim cells, this cell layout causes the most possible interference to terminals when they are receiving the weakest level of desired signal.
- When the closest interfering signal is from a base station, it is assumed to be at maximum power and transmitting continuously. For the case of a GSM BS, the signal represents a BCCH carrier. This is certainly possible but not a very likely design practice in real networks, where the target is to protect the signalling carriers from uncoordinated interference as much as possible.
- Capacity losses are referred to the maximum load of the system or a fixed outage criterion. At this operating point, the system is most vulnerable to the external interference and small amounts of interference are more easily detected.

The major parameters used in the simulations are summarized in the table 34.

Table 34: Parameters used in the simulations

Parameter	Value	Unit
WCDMA MCL micro	53	dB
WCDMA MCL macro	70	dB
MCL UE – UE (between systems)	40	dB
GSM BS sensitivity	-104	dBm
GSM BS TX power	43	dBm
WCDMA BS noise floor	-103	dBm
WCDMA BS TX power	43	dBm
GSM UE maximum TX power	30	dBm
GSM UE ACIR @ 2.7 MHz	50	dB
WCDMA UE maximum TX power	21	dBm

4.5.2.3 Simulation results and analysis

a) Impact on UMTS DL due to interference from GSM BS

Simulation results on UMTS downlink capacity losses due to interference from GSM base stations for cell range of 577 m and 2400 m are respectively given in figures 48 and 49.

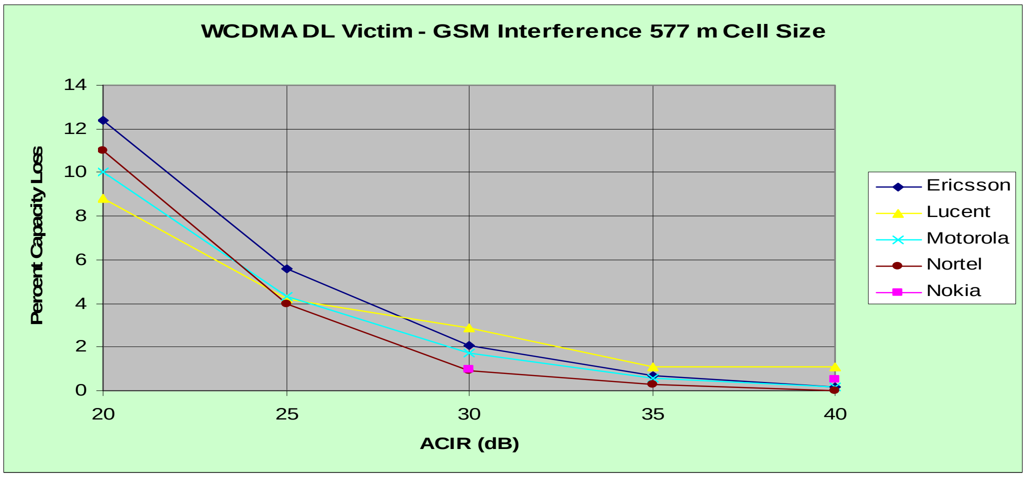

Figure 48: UMTS DL capacity loss for cell range of 577 m

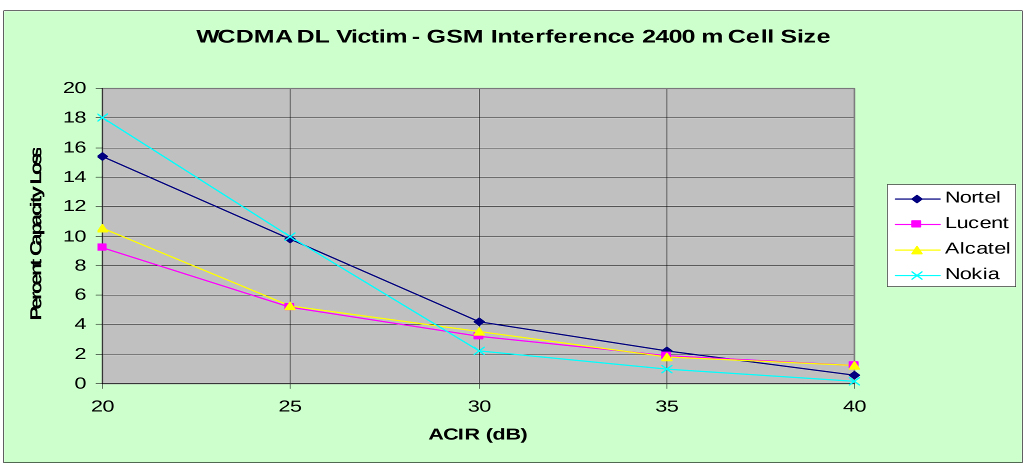

Figure 49: UMTS DL capacity loss for cell range of 2400 m

It can be seen that at ACIR of 30.5 dB, UMTS DL capacity loss for cell ranges of 577 m are below 2.8% and for 2400 m are below 4%.

b) Impact on UMTS UL due to interference from GSM MS

The simulated UMTS uplink capacity losses as function of ACIR for cell range=577m and cell range=2400 m are given respectively in figures 50 and 51.

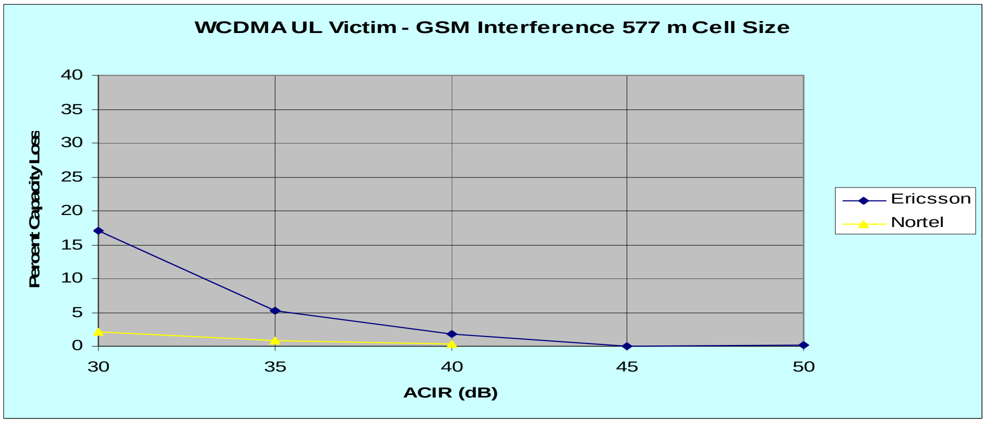

Figure 50: UMTS UL capacity loss for cell range of 577 m

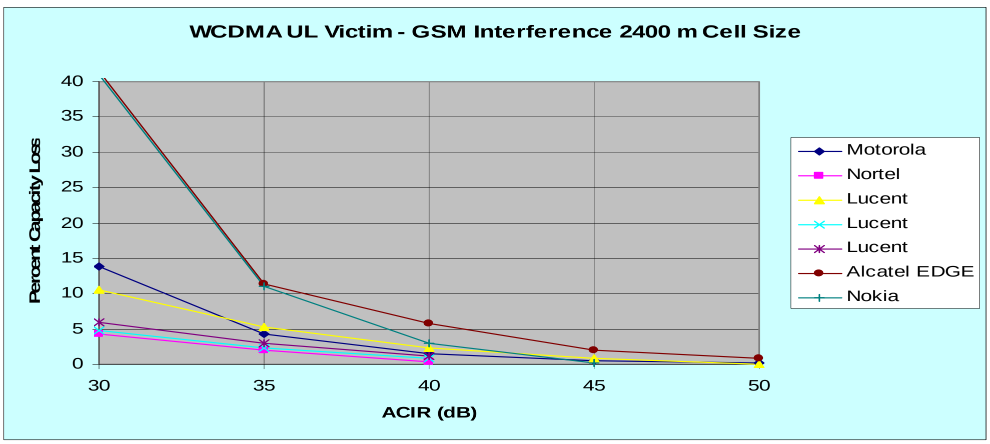

Figure 51: UMTS UL capacity loss for cell range of 2400 m

The simulation results given in figures 50 and 51 show that UMTS UL capacity losses due to interferences from GSM UL at ACIR=43.1 dB for cell ranges of 577 m are below 0.5% and for 2400 m below 3.5%.

c) Impact on GSM DL due to interference from UMTS BS

The simulation methodology for the evaluation of impact on GSM downlink due to UMTS downlink interference was designed so that the simulation was first performed without the WCDMA interfering system operating in order to establish a baseline performance. For this set of simulations, a CDF (cumulative distribution function) of number of users versus SINR is obtained. Then the interfering system is turned on and the simulations run again, obtaining a new CDF versus SINR with the UMTS downlink interference present. The change in CDF (%) is then indicative of the impact of the WCDMA system on the GSM downlink. Results are shown in table 35.

Table 35: GSM DL SINR CDF change due to interference from UMTS BS

Company Reference	Antenna type	Cell size (m)	DownlinkMode	ACIR (dB)	Nearest carrier (MHz)	**Delta CDF (%)**
Ericsson	Omni	577	GSM	48.8	2.7	**0.05**
Ericsson	Omni	577	GSM	48.8	2.7	**0 ***
Nokia	Tri-sector	2400	GSM	48.8	2.7	**0**
Nokia	Tri-sector	2400	EDGE	48.8	2.7	**0.7**
Motorola	Omni	577	GSM	48.8	2.7	**0.3**
Nortel	Tri-sector	577	GSM	48.8	2.7	**0.2**
Lucent	Tri-sector	2400	GSM	48.8	2.7	**0.3**
Alcatel	Tri-sector	large	EDGE	50	2.8	**0**

Note(*): No power control

The GSM downlink SINR CDF change for the cell range of 2400 m is bigger than that for small cell range of 577 m. The SINR CDF change is about 0.5%. That means interference from UMTS downlink to GSM downlink may exist, but the impact is small, from statistical point of view, the impact is not very critical.

d) Impact on GSM UL due to interference from UMTS MS

The simulation methodology for the evaluation of impact on GSM uplink due to interference from UMTS uplink is that the simulation is again done with first simulation performed without the WCDMA interfering system operating in order to establish a baseline performance. For this set of simulations, a CDF of number of users versus SINR is obtained. Then the interfering system is turned on and the simulations run again, obtaining a new CDF versus SINR with the interference present. The change in CDF (%) is then indicative of the impact of the WCDMA system on the GSM Uplink. Results are shown in table 36.

Table 36: GSM UL SINR CDF change due to interference from UMTS UE

Company reference	Antenna type	Cell Size (m)	Nearest Carrier (MHz)	ACIR (dB)	**Delta CDF (%)**
Ericsson	Omni	577	2.7	29.8	**0**
Nokia	Tri-sector	2550			**(4% outage)***
Motorola	Omni	577	2.7	29.8	**0.1**
Lucent	Tri-sector	3100	2.7	29.8	**0**

Note(*): results were given in terms of increased outage (4%). When the change of outage was recorded, the GSM system was fully loaded, i.e. all timeslots used. Adjacent WCDMA system was as well fully loaded (57/users per cell). Due to WCDMA interference outage probability was increased from 5 to 9 %.

From the simulation results given in table 36, it can be concluded that the GSM Uplink might suffer slightly from an adjacent WCDMA carrier with a given frequency offset. However the statistical probability is very low, even in the worst case where the interfering WCDMA BS is located at the GSM cell edge.

4.5.2.4 Conclusion

Based on the analysis of the simulation results for the co-existence scenario between UMTS1800 (macro)-GSM1800 (macro) in urban and sub-urban area with 5 MHz uncoordinated operation, at carrier separation of 2.8 MHz between UMTS carrier and the nearest GSM carrier, GSM DL and UL may suffer some interferences from UMTS for the worst case where GSM sites are located at the cell edge of UMTS cell, especially for large cell range of 2400 m.

4.5.3 Co-existence between UMTS and GSM with two coordinated UMTS carriers

This is another possible deployment scenario for a 10 MHz frequency spectrum block. It consists of 2 coordinated WCDMA carriers, with approximately equal cell sizes, see figure 52.

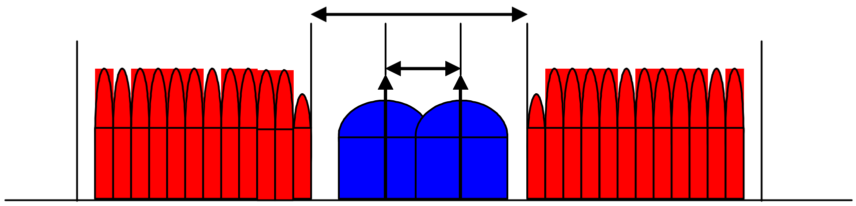

Figure 52: 2 x 10 MHz coordinated operation

However the interference between UMTS1800 and GSM1800 for this co-existence scenario is identical to the previously considered scenario, which was covered by the simulation results and analysis described in section 4.5.1.

5 CONCLUSIONS OF THE REPORT

Based on the sharing study results and the analysis presented in this report, it can be concluded that UMTS900/1800 can be deployed in urban, sub-urban and rural areas in co-existence with UMTS and/or GSM under the following conditions:

1) UMTS900/1800 networks can co-exist with other UMTS900/1800 networks in the same geographical area with a carrier separation of 5 MHz. The recommended carrier separation between two uncoordinated UMTS networks is 5 MHz or more. The recommended carrier separation in coordinated operation, for example, multiple carriers over the same UMTS network, is 5 MHz or less, in the same way as for the core band.

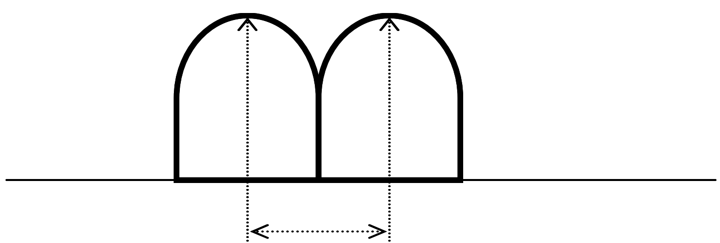

Figure 53: Carrier separation between two UMTS carriers

2) UMTS900/1800 can be deployed in urban, sub-urban and rural areas in co-existence with GSM900/1800 macrocells in coordinated operation and/or in uncoordinated operation. When UMTS900/1800 networks and GSM900/1800 networks are in uncoordinated operation, the recommended carrier separation between UMTS carrier frequency and the nearest GSM carrier frequency is 2.8 MHz or more. When UMTS900/1800 networks and GSM900/1800 networks are in coordinated operation (co-located sites), the recommended carrier separation between UMTS carrier frequency and the nearest GSM carrier frequency is 2.6 MHz or more.

3)

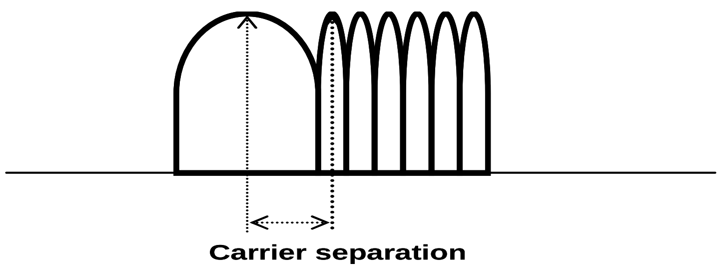

Figure 54: Carrier separation between UMTS carrier and GSM carriers

4) UMTS900/1800 can be deployed in urban, sub-urban areas in co-existence with GSM900/1800 microcell and/or picocell in uncoordinated (non-located sites between different networks) operation. The recommended carrier separation between the UMTS carrier frequency and the nearest GSM microcell and/or picocell carrier frequency is 2.8 MHz or more. It is suggested that the UMTS carrier should be placed as far as possible from GSM microcell and/or picocell carrier frequencies.

   One possible solution is for the operator to separate their UMTS carriers and their GSM microcell and/or picocell carrier frequency sub-band by the GSM macrocell carrier frequency sub-band.

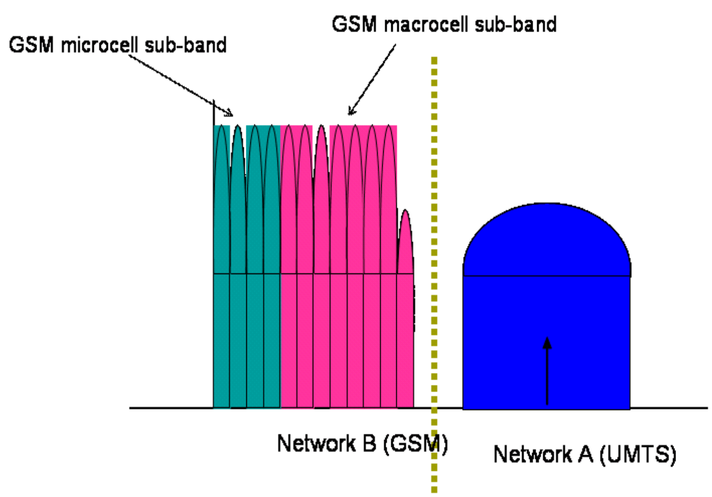

Figure 55: Suggested frequency arrangement between an UMTS carrier and GSM carriers

5) In order to avoid or minimise the interference between two operators, it is suggested for the operator who plans to deploy UMTS and GSM in the same band that it is better to use the so called "Sandwich" frequency arrangement as shown below.

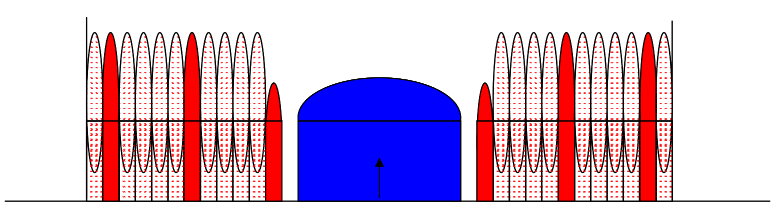

Figure 56a: Suggested frequency arrangement for an operator deploying one UMTS carrier

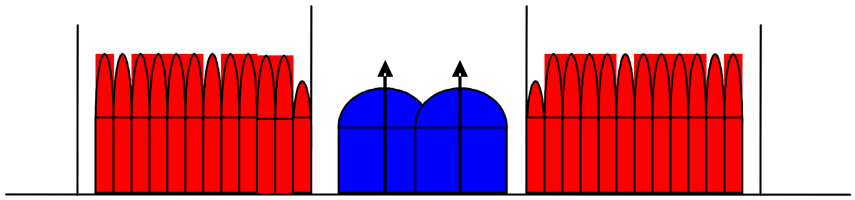

Figure 56b: Suggested frequency arrangement for an operator deploying two or more UMTS carriers

6 REFERENCES

[1] 3GPP Technical Specification TS25.104 (Release 7), Base Station (BS) radio transmission and reception (FDD), 2005-12

[2] 3GPP Technical Specification TS25.101 (Release 7), User Equipment (UE) radio transmission and reception (FDD), 2005-12

[3] ECC Doc. PT1(05)157, LS from 3GPP TSG RAN WG4 on Preliminary UMTS900 simulation results, document available from ERO document server at http://www.ero.dk/download

[4] 3GPP RP-050760, LS from 3GPP TSG RAN WG4 on UMTS900 simulation results, Source : Chairman of ECC PT1

[5] 3GPP TR25.942, Radio Frequency (RF) system scenarios

[6] 3GPP TS45.005 (Rel-5): GSM/EDGE Radio Access Network, Radio Transmission and Reception

[7] 3GPP TR25.885 V1.2.0 (Rel-5): UMTS1800/1900 Work Items Technical Report