CEPT Report 41

Report from CEPT to the European Commission
in response to Task 2 of the Mandate to CEPT on the 900/1800 MHz bands

"Compatibility between LTE and WiMAX operating within the bands 880-915 MHz / 925-960 MHz and 1710-1785 MHz / 1805-1880 MHz (900/1800 MHz bands) and systems operating in adjacent bands"

Final Report on 12 November 2010 by the

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

0 EXECUTIVE SUMMARY

A Commission Decision of 16 October 2009 (2009/766/EC) and a Directive of the European Parliament and of the Council of 16 September 2009 (2009/114/EC) have been approved as measures to enable the introduction of new technologies into the 900/1800 MHz bands. The annex to the EC Decision contains essential technical parameters for systems for which studies have demonstrated the ability to coexist with GSM. In addition to UMTS, which is already included in this annex, there is confirmation from Industry that other technologies are envisaged for deployment in the 900/1800 MHz bands. Before further technologies can be included in this annex, coexistence analysis would need to be conducted.

The European Commission has issued a mandate to CEPT (see Annex 1) on the technical conditions for allowing LTE and possibly other technologies within the bands 880-915 MHz / 925-960 MHz and 1710-1785 MHz / 1805-1880 MHz (900/1800 MHz bands).

Under Task 1 CEPT has verified that WiMAX technology is another technology besides LTE developing equipment for 900/1800 MHz that would need to be studied within the scope of this mandate.

This CEPT Report deals with the reply to Task 2 of the mandate, in particular the Compatibility between LTE/WiMAX operating within the 900/1800 MHz bands and systems operating in adjacent bands (adjacent band studies). A separate CEPT Report (CEPT Report 40) addresses technical co-existence within the 900/1800 MHz bands (in band studies).

This document is based on ECC Report 096 which was developed for the introduction of UMTS at 900/1800 MHz. Many of the conclusions from ECC Report 096 are considered also applicable to LTE and WiMAX.

The analysis carried out in this Report concludes that introducing LTE and WiMAX into the 900 and 1800 MHz bands should not cause any additional impact on adjacent services. The following summary conclusions can be made:

Section of Report for further details	Band/Scenario (interferer >victim)	Summary Result
4	880 MHz/925 MHz LTE/WiMAX to GSM-R	In general, there is no need of an additional guard band between LTE/WiMAX900 and GSM-R whatever the channelisation or bandwidth considered for LTE/WiMAX 900. ECC Report 096 concludes that a carrier separation of 2.8 MHz or more between the UMTS carrier and the nearest GSM-R carrier is sufficient. For LTE/WiMAX 900, the frequency separation between the nearest GSM-R channel center frequency and LTE/WiMAX channel edge should be at least 300 kHz (at least 200 kHz between channel edges)
4.2	925 MHz - LTE/WiMAX BS to GSM-R MS	For some critical cases (e.g. with high located antenna, open and sparsely populated areas served by high power LTE/WiMAX BS close to the railway tracks, which would lead to assumption of possible direct line of sight coupling) the MCL calculations demonstrate that coordination is needed for a certain range of distances (up to 4 km or more from railway track) when the GSM-R signal is close to the sensitivity level. In order to protect GSM-R operations, LTE/WiMAX operators should take care when deploying LTE/WiMAX in the 900 MHz band, where site engineering measures and/or better filtering capabilities (providing additional coupling loss in order to match the requirements defined for the critical/specific cases) may be needed in order to install LTE/WiMAX sites close to the railway track when the LTE/WiMAX network is using the channel adjacent to the GSM-R band. The deployment criteria of the GSM-R network such as the field strength level at the GSM-R cell edge could be also strengthened in order to improve the immunity of the GSM-R network towards the emissions from other systems.
4.2	880 MHz – GSM-R MS to LTE/WiMAX BS	It is beneficial to activate GSM-R uplink power control, especially for the train mounted MS, otherwise the impact on LTE/WiMAX capacity could be important when the LTE/WiMAX network is using the 10 MHz of spectrum adjacent to the GSM-R band. However, it has to be recognized that this is only applicable in low speed areas as elsewhere the use of uplink control in GSM-R will cause significantly increased call drop out rates. Another solution would be to introduce a higher frequency separation between the GSM-R channel and the 900 MHz allocation by allowing transmission in the extended GSM-R band. However, this solution should be counter-balanced by the potential impact onto the upper part of the 900 MHz allocation. Due to the blocking response profile of LTE, the base station deployed above 890 MHz may also suffer from desensitization due to E-GSM-R BS emissions.

Section of Report for further details	Band/Scenario (interferer >victim)	Summary Result
4.3	915 MHz - LTE/WiMAX MS to E-GSM-R MS (CEPT has recently adopted amendments to ECC Decisions (02)05 on GSM-R and (04)06 on wideband PMR/PAMR. The amended Decisions provide a possibility for GSM-R extension (E-GSM-R) into the bands 873-876 MHz and 918-921 MHz on a national basis under the PMR/PAMR umbrella).	The LTE/WiMAX UE transmitting power is relatively limited, at 23 dBm. In reality, mobile terminals rarely emit a maximum power of 23dBm (in 90% of cases they would emit 14 dBm or less [8]. By considering that the minimum coupling loss between UE and E-GSM-R BS is relatively large (80 dB is used in ECC Report 082 between UE and BS in rural area) compared to the MCL between LTE/WiMAX BS and GSM-R Train Mounted MS, and since the UE is moving, the interference from LTE/WiMAX UE to E-GSM-R MS should not lead to interference. For detailed analysis of interference between LTE/WiMAX UE to E-GSM-R MS, Monte-Carlo simulations should be performed; this is not covered in this Report.
4.3	915 MHz - E-GSM-R BS to LTE/WiMAX BS (CEPT has recently adopted amendments to ECC Decisions (02)05 on GSM-R and (04)06 on wideband PMR/PAMR. The amended Decisions provide a possibility for GSM-R extension (E-GSM-R) into the bands 873-876 MHz and 918-921 MHz on a national basis under the PMR/PAMR umbrella).	The worst interference case is the interference from E-GSM-R BS to LTE/WiMAX BS. The interference from E-GSM-R BS operating at frequencies above 918 MHz may cause receiver desensitization and blocking of LTE/WiMAX900 BS operating below 915 MHz. The specifications of the GSM-R BTS characteristics in the expected extension band are assumed to be the same as those of GSM-R in the primary band. It is assumed the GSM-R BTS for extension band will be designed to protect efficiently the upper part of the uplink 900 MHz band, in particular the spurious emissions will be aligned to the spurious emissions as currently defined to protect the 900 MHz receive band. The main challenge would be to achieve this level in a 3 MHz offset instead of a 6 MHz frequency offset. However, as it would not be sufficient to prevent blocking of LTE/WiMAX base stations, the utilization of interference mitigation techniques should be assessed in order to protect efficiently LTE/WiMAX900 BS
5.2	915 MHz - LTE/WiMAX MS to PMR/PAMR MS	The LTE/WiMAX UE transmitting power is relatively small, at 23 dBm. In reality, mobile terminals rarely emit a maximum power of 23dBm (in 90% of cases they would emit 14 dBm or less [8]. By considering that the minimum coupling loss between UE and PMR/PAMR BS is relatively large (80 dB is used in ECC Report 082 between UE and BS in rural area) compared to the MCL between LTE/WiMAX BS and GSM-R Train Mounted MS, and since the UE is moving, the interference from LTE/WiMAX UE to PMR/PAMR MS should not lead to interference. For detailed analysis of interference between LTE/WiMAX UE and PMR/PAMR MS, Monte-Carlo simulations should be performed; this is not covered in this Report. The worst interference case is the interference from PMR/PAMR BS to LTE/WiMAX BS (see next section).

Section of Report for further details	Band/Scenario (interferer >victim)	Summary Result
5.5	915 MHz - PMR/PAMR BS to LTE/WiMAX BS	The interference from PMR/PAMR (CDMA PAMR, TETRA, TAPS) BS operating at frequencies above 915 MHz will cause receiver desensitization of LTE/WiMAX900 BS operating below 915 MHz. In order to protect LTE/WiMAX900 BS, the utilization of interference mitigation techniques is necessary: 1) Reduced PMR/PAMR BS Tx power; 2) Spatial separation by coordination between operators; 3) External filters applied to the PMR/PAMR BS; 4) Sufficient guard band between the 900 MHz mobile allocation and the first PMR/PAMR channel in use. It is more likely that a combination of these interference mitigation techniques should be used in order to ensure the compatibility of LTE/WiMAX900 operating below 915 MHz and PMR/PAMR (CDMA PAMR, TETRA, TAPS) operating above 915 MHz.

Section of Report for further details	Band/Scenario (interferer >victim)	Summary Result
6	960 MHz - LTE/WiMAX BS to DME/L-DACS	The LTE and WiMAX BS masks for the 900 MHz bands are aligned with the UMTS900 mask for all the LTE/WiMAX channelisation bandwidth available and are expected to have similar characteristics in terms of average power. Similarly, the protection criteria of LTE and WiMAX terminals is aligned with that of UMTS, and hence the conclusions regarding interference between UMTS and DME/L-DACS should be applicable to the scenarios involving LTE/WiMAX on one side and DME/L-DACS on the other side, for the same signal bandwidth. When considering LTE/WiMAX with higher carrier bandwidth (> 5MHz), the compatibility results should be improved. With a large number of interferers with lower bandwidths (<5MHz), the aggregate interference from LTE would increase. However, it is not expected that LTE will be deployed with lower bandwidth. Bandwidth different from 5 MHz for LTE/WiMAX has not been addressed in detail. The results of the studies are as follows: ▪ L-DACS 2 airborne transmitters will not cause any interference to LTE/WIMAX terminals, when the distance between the aircraft and an outdoor LTE/WIMAX terminal is greater than 8.6 km, with a L-DACS 2 transmitting frequency of 960,1 MHz. For a L-DACS 2 transmitting frequency of 962,6 MHz, this distance becomes 6.5 km. The limiting factor is currently the selectivity of the LTE/WIMAX UE. ▪ L-DACS 2 ground stations could cause desensitization to LTE/WIMAX terminals at a distance up to 17.5 km, depending on the propagation characteristics in the area considered and L-DACS 2 ground station antenna height, with a L-DACS 2 transmitting frequency of 960,1 MHz. For a L-DACS 2 transmitting frequency of 962,6 MHz, this distance becomes 14.7 km. The limiting factor is currently the selectivity of the LTE/WIMAX UE. ▪ No interference from LTE/WIMAX base stations to DME airborne receivers is expected above 972 MHz. Below 972 MHz some interference, in the order of 3 to 4 dB, may occur at low altitudes for the mixed-urban case. ▪ L-DACS airborne receivers are no more sensitive to interference than DME. ▪ LTE/WIMAX base station transmissions may cause interference to L-DACS ground stations, if these stations are deployed in the lowest part of the band, and if the L-DACS TDD option is selected, in the order of 17 – 25 dB, depending on the distance from the ground station to the nearest base station. If the FDD (LDACS-1) option is chosen and the associated ground stations receive at frequencies far above 960 MHz, then the interference from LTE/WIMAX base stations to these ground stations would be alleviated. CEPT Report 42 gives results on the compatibility between UMTS and DME/L-DACS-2. Those results have been extended to the compatibility between LTE/WiMAX and DME/L-DACS, based on the similarities between UMTS on one side and LTE/WiMAX on the other side. For additional information, see CEPT Report 42, especially with respect to mitigation techniques.

Section of Report for further details	Band/Scenario (interferer >victim)	Summary Result
7	960 MHz - LTE/WiMAX BS to MIDS MS	To avoid any interference on each MIDS frequency the protection distance between LTE/WiMAX900 base station and MIDS stations should be up to 2 km accordingly when the MIDS receiver is placed in the direction of the LTE/WiMAX base station antenna that corresponds to the worst-case situation. However, the protection should be reduced if the real unwanted emission level of the equipment is better than specified. For the worst case situation (the MIDS receiver is placed in the direction where the LTE/WiMAX base station antenna gain is maximum), to fully protect MIDS without any protection distance, the unwanted emission level should be: • 21 dB better than specified in the 970-1000 MHz band, • 17 dB better than specified in the 1000 - 1206MHz MIDS band (corresponding to the 1-12.75GHz spurious band), • For other azimuths of antenna, the separation distance and the additional filtering requirements decrease. However, a performance degradation of the MIDS can be tolerated: this corresponds to interference on the first 11 MIDS channels (ranging from 969 to 999 MHz). Consequently, if there is an additional isolation of 17 dB above 1 GHz no additional separation distance is required to protect the MIDS receiver for the worst case situation (the MIDS receiver is placed in the direction where the LTE/WiMAX base station antenna gain is maximum). Information put forward by some manufacturers about the performance of a typical LTE/WiMAX900 base station shows that the practical level of unwanted emission provides isolation considerably higher than that required (17dB). Indeed, the interference criteria would be met already at 980 MHz or even lower. It should be noted that the study did not take into account the regulatory status of JTIDS/MIDS, which operates in the band 960-1215 MHz under the conditions of provision 4.4 of the Radio Regulations.

Section of Report for further details	Band/Scenario (interferer >victim)	Summary Result
8	1880 MHz. LTE/WiMAX BS to DECT BS/MS	It can be concluded that the interference created by the LTE/WiMAX1800 system would be similar to the interference created by GSM1800. No guard band is therefore required between LTE/WiMAX1800 and DECT allocations, provided that DECT is able to properly detect interference on closest DECT carriers F9-F7 and escape to more distant carriers F6-F0 within 1880 - 1900 MHz LTE/WiMAX1800 macro-cells can be deployed in the same geographical area in co-existence with DECT which is deployed inside of the buildings, as the interference between DECT RFP and PP and macro-cellular LTE/WiMAX1800 BS and UE is not a problem; When pico-cellular LTE/WiMAX1800 BS is deployed inside of the building in co-existence with DECT RFP and PP deployed in the same building indoor area, some potential interference is likely to exist from indoor pico-cellular LTE/WiMAX1800 BS to DECT if they are placed too close and they are operating in the adjacent channel at 1880 MHz;
9	1710 MHz. LTE/WiMAX MS to METSAT Earth station receivers	The METSAT Earth stations have been adjacent to GSM1800 for many years, and have not experienced interference from GSM MS transmissions. It is believed that the interference from LTE/WiMAX UE to METSAT Earth Stations operating in adjacent frequency band is unlikely to be a problem.
10	1785 MHz. Radio microphone to LTE/WiMAX BS	It can be considered that the proposed guard band of 700 kHz in ERC Report 063 and ERC/REC 70-03 for the protection of GSM1800 is sufficient for protecting LTE/WiMAX 1800 BS receivers. This assumes that the radio microphone maximum transmitting power is limited to 13 dBm (20 mW) for hand held microphones and 17 dBm (50 mW) for body worn microphones, as recommended in ERC Report 63 and ERC/REC 70-03.
11	1710 MHz/1785 MHz/1805 MHz. LTE/WiMAX BS to fixed service	Compatibility between UMTS and Fixed Services operating in co-frequency and adjacent bands was studied and reported in ERC Report 065 [19] and ERC Report 064 [20]. As described in these two ERC Reports, the critical interference scenarios are between UMTS BS and Fixed Service stations. It is thought that these Reports are also applicable to LTE/WiMAX. The Fixed Service frequency range is adjacent to LTE/WiMAX1800 UL at 1710 MHz and 1785 MHz. The potential interference, if any, will be between Fixed Service and LTE/WiMAX1800 BS at 1805 MHz. The interference analysis method used in the two ERC Reports can be used to derive the coordination distance, that is the separation distance between LTE/WiMAX BS and Fixed Service stations as a function of frequency separations between LTE/WiMAX base station and Fixed service station, as an interference prevention solution, as described in ERC Reports 064 and 065.

Table of contents

LIST OF ABBREVIATIONS

Abbreviation	**Explanation**
ACLR	Adjacent Channel power Leakage Ratio
ACS	Adjacent Channel Selectivity
ARNS	Aeronautical Radio Navigation Service
AM(R)S	Aeronautical Mobile (Route) Service
BS	Base Station
CDF	Cumulative Distribution Function
CDMA	Code Division Multiple Access
C/I	Carrier to Interference ratio
DECT	Digital Enhanced Cordless Telecommunications
DME	Distance Measurement Equipment
EPFD	Equivalent Power Flux Density
FRS	Future Radio System
GSM	Global System for Mobile communications
GSM-R	Railway System for Mobile communication
E-GSM-R	Extension for the Railway System for Mobile communication
IST	Institute for Telecommunication Sciences
ITM	Irregular Terrain Model (Longley-Rice)
L-DACS	L-band Digital Aeronautical Communication System
MCL	Minimum Coupling Loss
MS	Mobile Station
MIDS	Multifunctional Information Distribution System
NTIA	National Telecommunications & Information Administration (U.S. Department of Commerce)
PAMR	Public Access Mobile Radio
PMR	Professional Mobile Radio
PSD	Power Spectral Density
RNSS	Radio Navigation Satellite Service
S/N	Signal to Noise ratio
TETRA	Terrestrial Trunked Radio
TS	Technical Specification
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
WCDMA	Wideband CDMA
4-PSK	4-states Phase Shift Keying modulation

Compatibility between LTE and WiMAX operating within the bands 880-915 MHz / 925-960 MHz and 1710-1785 MHz / 1805-1880 MHz (900/1800 MHz bands) and systems operating in adjacent bands

1 INTRODUCTION

A Commission Decision of 16 October 2009 (2009/766/EC) and a Directive of the European Parliament and of the Council of 16 September 2009 (2009/114/EC) have been approved as measures to enable the introduction of new technologies into the 900/1800 MHz bands. The annex to the EC Decision contains essential technical parameters for systems for which studies have demonstrated the ability to coexist with GSM. In addition to UMTS, which is already included in this annex, there is confirmation from Industry that other technologies are envisaged for deployment in the 900/1800 MHz bands. Before further technologies can be included in this annex, coexistence analysis would need to be conducted.

The European Commission has issued a mandate to CEPT (see Annex 1) on the technical conditions for allowing LTE and possibly other technologies within the bands 880-915 MHz / 925-960 MHz and 1710-1785 MHz / 1805-1880 MHz (900/1800 MHz bands).

The mandate comprises the following Tasks:

(1) Verify whether there are other technologies besides LTE developing equipment for 900/1800 MHz that would need to be studied concerning their coexistence with GSM at this stage.

(2) Study the technical conditions under which LTE technology can be deployed in the 900/1800 MHz bands: With the aim of adding LTE and possibly other technologies (identified in Task 1) to the list in the annex of the draft decision on 900/1800 MHz frequency bands (see Footnote 6), technical coexistence parameters should be developed. A Block Edge Mask is not requested at this stage, noting that common and minimal (least restrictive) parameters would be appropriate after strategic decisions concerning the role of GSM as the reference technology for coexistence have been taken.

(3) Investigate compatibility between UMTS and adjacent band systems above 960 MHz: Noting that compatibility with systems outside of the 900/1800 MHz bands will be studied for LTE and any other identified technology at all band edges under Task 2, the aim of this task is to review the risk of interference between UMTS and existing and planned aeronautical systems9 above 960 MHz, in order to enable the development of all systems below and above 960 MHz without taking a risk relating to aeronautical safety.

Under Task 1 CEPT has verified that WiMAX technology is another technology besides LTE developing equipment for 900/1800 MHz that would need to be studied within the scope of this mandate.

This CEPT Report deals with the reply to task 2 of the mandate in particular the Compatibility between LTE and WiMAX operating within the 900/1800 MHz bands and systems operating in adjacent bands (adjacent band studies). A separate CEPT Report (CEPT Report 40) addresses technical co-existence within the 900/1800 MHz bands (in band studies).

2 SYSTEMS OPERATING IN ADJACENT BANDS

2.1 900 MHz

All systems operating in bands adjacent to 800-915 / 925-960 MHz and addressed in this Report are summarized in Table 1 below.

Frequency (MHz)	System	Notes
870-873	PMR/PAMR (UL)	
873-876	PMR/PAMR (UL) E-GSM-R (UL)	GSM-R extension on a national basis
876-880	GSM-R (UL)	
880-915	**GSM900 (UL)** **UMTS900 (UL)** **LTE900 (UL)** **WiMAX (UL)**	• **Including E-GSM and P-GSM**
915-921	PMR/PAMR (DL)	
918-921	PMR/PAMR (DL) E-GSM-R (DL)	GSM-R extension on a national basis
921-925	GSM-R (DL)	
925-960	**GSM900 (DL)** **UMTS (DL)** **LTE900 (DL)** **WiMAX (DL)**	• **Including E-GSM and P-GSM**
960-1164	Aeronautical Radionavigation Aeronautical Mobile (Route) ServiceCommunication systems	• DME/L-DACS • MIDS (Military / NATO)

Table 1: Systems operating in adjacent bands at 900 MHz

CEPT has recently adopted amendments to ECC Decisions (02)05 on GSM-R and (04)06 on wideband PMR/PAMR. The amended Decisions provide a possibility for GSM-R extension (E-GSM-R) under the PMR/PAMR umbrella into the bands 873-876 MHz and 918-921 MHz on a national basis

Based on the list of systems adjacent to the LTE/WiMAX 900 frequency band in Table 2.1, the sharing studies between LTE/WiMAX900 and the following systems are considered in this Report:

1) GSM-R and E-GSM-R
2) PMR/PAMR (e.g. TETRA, TAPS, CDMA)
3) DME/L-DACS
4) MIDS

Aeronautical Radionavigation systems are operating in the frequency band 862-960 MHz in some countries (see 5.323 Radio Regulations). Compatibility studies with these systems were not considered in this Report.

2.2 1800 MHz

All systems operating in bands adjacent to 1710-1785 MHz / 1805-1880 MHz are summarized in Table 2.

Frequency (MHz)	System	Notes
1700-1710	METSAT Fixed - Telemetry	• Weather Satellite • Defence
1710-1785	**GSM1800 (UL)** **UMTS1800 (UL)** **LTE1800 (UL)** **WiMAX (UL)**	
1785-1800	Radio Microphones Fixed & mobile	Guard bands have been defined between radio microphones and GSM1800 Wireless Broadband
1800-1805	Under study in CEPT	Wireless Broadband, Flexible use
1805-1880	**GSM1800 (DL)** **UMTS1800 (DL)** **LTE1800 (DL)** **WiMAX (UL)**	
1880-1900	DECT	

Table 2: Systems operating in adjacent bands at 1800 MHz

Based on the list of systems adjacent to the LTE/WiMAX 1800 frequency band in Table 2, the sharing studies between LTE/WiMAX1800 and the following systems are considered in this Report:

1) DECT
2) METSAT
3) Radio microphone
4) Fixed service

3 COMPARISON OF KEY UMTS, LTE AND WIMAX PARAMETERS

A comparison of the key parameters between UMTS, LTE and WiMAX can be found in CEPT Report 40. Of particular note is the comparison of the UMTS/LTE/WiMAX BS emission spectrum masks which is reproduced below in Figure 1. The figure shows that both LTE and WiMAX masks are identical to the UMTS emission profile. Although not shown by Figure 1, they also remain identical for higher frequency offsets in the frequency band 966-1215MHz. The LTE mask for 1.4 and 3 MHz bandwidth also follow the UMTS mask from 0.2 MHz onward.

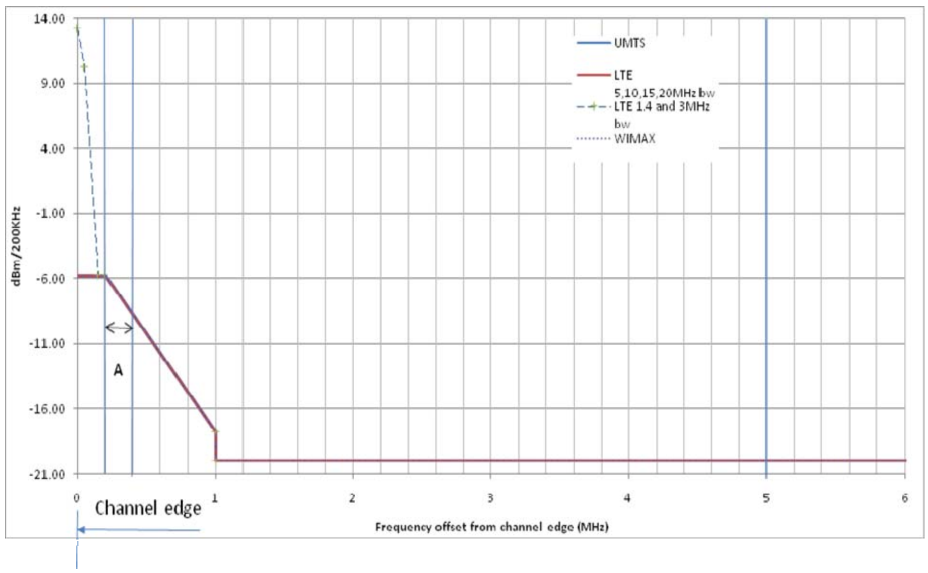

Figure 1: Graphical comparison of Base Station SEMs

4 COMPATIBILITY STUDY BETWEEN LTE/WIMAX 900 AND GSM-R/E-GSM-R

The GSM-R frequency band is arranged as:

- Uplink (MS transmit, BS receive): 876-880 MHz
- Downlink (BS transmit, MS receive): 921-925 MHz
- Carrier separation: 200 kHz

CEPT has recently adopted amendments to ECC Decisions (02)05 on GSM-R and (04)06 on wideband PMR/PAMR. The amended Decisions provide a possibility for GSM-R extension (E-GSM-R) into the bands 873-876 MHz and 918-921 MHz on a national basis under the PMR/PAMR umbrella.

The frequency band plans for GSM-R and LTE/WIMAX are shown in Table 2.

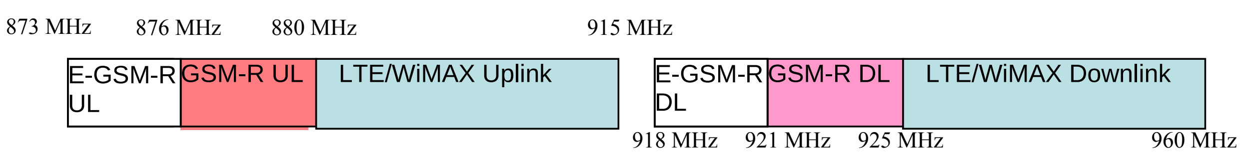

Figure 2: Frequency band plan for GSM-R, E-GSM-R and LTE/WiMAX at 900 MHz

4.1 GSM-R/E-GSM-R system characteristics

Details of the GSM-R/E-GSM-R RF performance and system parameters can be found in 3GPP Technical Specification TS45.005 [11]. See also [12]. The main GSM-R system characteristics are summarized in the following tables:

	GSM-R and E-GSM-R		
Frequency band (UL) (MHz)	876-880 / 873-876		
Frequency band (DL) (MHz)	921-925 / 918-921		
Carrier separation (kHz)	200		
Modulation	GMSK		
Intra network BS-MS MCL (dB)	60 (urban area) 70 (rural area)		
Typical cell range (km)	8		
	BS	**Hand portable MS**	**Train Mounted MS**
Maximum Tx power (W)	30	2	8
Thermal noise (dBm)	-121	-121	-121
Noise figure (dB)	5	9	7
Noise floor (dBm)	-116	-112	-114
Receiver sensitivity (dBm)	-110	-102	-104
Receiver protection ratio (dB)	9	9[1]	9[1]
Antenna height (m)	20 (Urban) 45 (Rural)	1.5	4
Antenna gain (dBi)	18	0	0
Feeder loss (dB)	3	0	3
Spectrum mask and spurious emissions	3GPP TS45.005		3GPP TS45.005

Table 3: Main GSM-R / E-GSM-R system parameters

BS Tx power (dBm)	**100 (kHz)**	**200 (kHz)**	**250 (kHz)**	**400 (kHz)**	**≥ 600** < 1 200 (kHz)	**≥ 1 200** < 1 800 (kHz)	**≥ 1 800** < 6 000 (kHz)	**≥ 6 000** (kHz)
≥ 43	**+0.5**	**-30**	**-33**	**-60***	**-70**	**-73**	**-75**	**-80**
41	+0.5	-30	-33	-60*	-68	-71	-73	-80
39	+0.5	-30	-33	-60*	-66	-69	-71	-80
37	+0.5	-30	-33	-60*	-64	-67	-69	-80
35	+0.5	-30	-33	-60*	-62	-65	-67	-80
≤ 33	+0.5	-30	-33	-60*	-60	-63	-65	-80
NOTE: * For equipment supporting 8-PSK, the requirement for 8-PSK modulation is -56 dB.								

Table 4: Spectrum mask of GSM-R /E-GSM-R BTS*

[1] C/I of 9dB's has been used in the simulations. However, 12dB may be appropriate for critical handover regions

*Note: The values given in this table are the maximum allowed level (dB) relative to a measurement in 30 kHz on the carrier as defined in 3GPP TS45.005 [11].

	BS	MS
General requirement	-36 dBm*	-36 dBm*
Co-siting with GSM900	-89 dBm/100 kHz	

Table 5: Spurious emission of GSM-R /E-GSM-R MS

* measurement band depends on the carrier separation, which is defined in 3GPP TS45.005 [11].

Frequency band	GSM-R					
	other MS		small MS		BTS	
	emf (dBµV)	(dBm)	emf (dBµV)	(dBm)	emf (dBµV)	(dBm)
In-band						
600 kHz ≤ $\|f-f_o\|$ < 800 kHz	75	-38	70	-43	87	-26
800 kHz ≤ $\|f-f_o\|$ < 1,6 MHz	80	-33	70	-43	97	-16
1.6 MHz ≤ $\|f-f_o\|$ < 3 MHz	90	-23	80	-33	97	-16
3 MHz ≤ $\|f-f_o\|$	90	-23	90	-23	100	-13
out-of-band						
(a)	113	0	113	0	121	8
(b)	-	-	-	-	-	-
(c)	-	-	-	-	-	-
(d)	113	0	113	0	121	8

Table 6: Blocking characteristics of GSM-R /E-GSM-R

The cases (a), (b), (c), (d) are defined in 3GPP TS45.005 [11]. This table is based on the blocking behaviour in laboratory conditions where wanted signal is static and interfering signal is un-modulated.

4.2 Coexistence of LTE/WiMAX with GSM-R

4.2.1 Scenario LTE/WiMAX DL into GSM-R DL

The LTE and WiMAX base station masks for the 900 MHz bands are aligned with the UMTS900 mask for all the LTE/WiMAX channelisation bandwidth available. Hence the conclusions relating to LTE/WiMAX BS to GSM-R MS coexistence within ECC Report 096 have been extended within this Report based on the mask alignment. It is important to note that these simulations did not consider dynamic behaviour of GSM-R (eg. For the case of deployment of high speed trains) and UMTS 900 systems. Additional studies for those cases maybe needed on a national basis, based on practical experience.
The analysis developed in ECC Report 096 do not take into account the work under development in ETSI TC RT and 3GPP GERAN that is intending to improve the GSM-R terminal capabilities by changing the GSM-R specifications in order to alleviate the potential blocking effects and intermodulation effects. The immunity of the GSM-R network towards the unwanted emissions coming from the 900 MHz band could be also much improved by increasing the signal level received at the GSM-R terminal. Currently, the minimal field strength level for GSM-R is defined between -98 and -92 dBm/200 kHz with a probability of 95 % at an antenna height of 4 m depending on the speed of the railway line. As the sensitivity level in the downlink direction is -104 dBm, the margin to counter surrounding radio interference is very limited. Therefore, a higher field strength level could be deeply assessed for future GSM-R deployments. .Moreover, the mobile networks such as GSM/UMTS/LTE networks are designed in order to achieve indoor coverage as well as ubiquitous communication services. Therefore, they are usually designed with higher field strength levels than the ones given before. Since the 3GPP specifications have been developed assuming the 900 MHz mobile and GSM-R network have similar typologies, this explains that a significant difference in terms of deployment may exceed the nominal functioning as defined and may generate some limitations. GSM-R is mainly line-oriented even though it is based on a cellular network

4.2.2 .Scenario GSM-R UL onto LTE UL

The impact of GSM-R UL onto LTE BS is assessed in this section. In this case, the LTE BS is placed close to the railway track in order to simulate a worst case, as shown in Figure 3 below. The LTE BS interference criteria is based on the desensitization created by the GSM-R train mounted MS emissions. The GSM-R MS is moved in the LTE BS main lobe in order to evaluate the maximal desensitization that the LTE BS could suffer from.

Usually, a I/N ratio of -10 dB which leads to a desensitization of about 0.5 dB is considered as acceptable for IMT base stations.

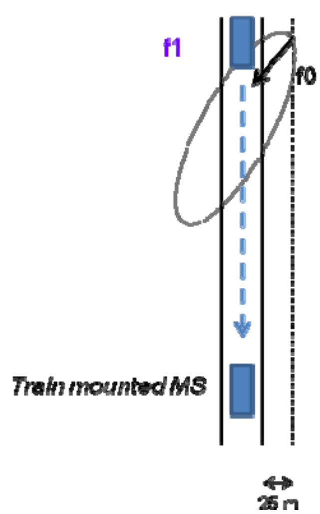

Figure 3: Configuration for assessing the interference from GSM-R UL onto LTE BS

The selectivity profile of LTE radio system is consistent with the figures in the CEPT Report 40.

BS	Frequency offset (kHz)	ACS test	Rejection (dB)	Interfering signal
LTE(1.4 MHz)	252.5	-49 dBm	54.9	LTE 1 RB
LTE(3 MHz)	247.5	-49 dBm	50.9	LTE 1 RB
LTE(5 MHz)	342.5	-49 dBm	48.7	LTE 1 RB
LTE(10 MHz)	347.5	-49 dBm	48.7	LTE 1 RB

Table 7: BS receiver rejection derived from narrow band blocking

Note 1: the values of BS receiver rejection are calculated on the basis of the following formula:

ACS_relative = ACS_test – Noise_floor – $10*\log_{10}(10^{M/10}-1)$

Table 8 gives the desensitization for both environments under consideration for a LTE channel deployed in the E-GSM sub-band.

Rural environment GSM-R carrier (879.8 MHz and below)				
Bandwidth (MHz)	1.4	3	5	10
Maximal LTE BS Desensitization	23.6 dB	24.1 dB	21.9 dB	21.9 dB
Urban environment GSM-R carrier (879.8 MHz and below)				
Bandwidth (MHz)	1.4	3	5	10
Maximal LTE BS Desensitization	15.7 dB	14.8 dB	14.0 dB	14.0 dB

Table 8: Maximal desensitization of LTE BS when interfered by a train mounted GSM-R MS

The LTE network can suffer from harmful interference caused by GSM-R terminal emissions when it is deployed nearby. Interferences are generated over the whole E-GSM band. The P-GSM band may also suffer from desensitization according to the blocking profile defined in the 3GPP specifications.

Summary and Analysis

In case where GSM-R uplink power control is not used, the simulation results indicate the LTE network can suffer from desensitization, especially for the cells located near the railway track. Due to the blocking profile, the interferences may even impact in a certain extent the P-GSM sub-band.

4.2.3 Conclusions for GSM-R

The LTE and WiMAX base station masks for the 900 MHz bands are aligned with the UMTS900 mask for all the LTE/WiMAX channelisation bandwidth available. Hence the conclusions relating to LTE/WiMAX BS to GSM-R MS coexistence within ECC Report 096 have been extended within this Report based on the mask alignment. It is importanct to note that these simulations did not consider dynamic behavior of GSM-R (eg. For the case of deployment of high speed trains) and UMTS 900 systems. Additional studies for those cases maybe needed on a national basis, based on practical experience.

Based on the studies within ECC Report 096 the following conclusions can be made:

LTE/WiMAX900 can be deployed in the same geographical area in co-existence with GSM-R when respecting the following points:

1) In general there is no need of an additional guard band between LTE/WiMAX900 and P-GSM-R whatever the channelisation or bandwidth considered for LTE/WiMAX 900. ECC Report 096 concludes that a carrier separation of 2.8 MHz or more between the UMTS carrier and the nearest GSM-R carrier is sufficient. For LTE/WiMAX 900,

the frequency separation between the nearest GSM-R channel center frequency and LTE/WiMAX channel edge should be at least 300 kHz (at least 200 kHz between channel edges).

2) However for some critical cases (e.g. with high located antenna, open and sparsely populated areas served by high power LTE/WiMAX BS close to the railway tracks, which would lead to assumption of possible direct line of sight coupling) the MCL calculations demonstrate that coordination is needed for a certain range of distances (up to 4 km or more from railway track) when the GSM-R signal is close to the sensitivity level

3) It is beneficial to activate GSM-R uplink power control, especially for the train mounted MS, otherwise the impact on LTE/WiMAX capacity could be important when the LTE/WiMAX network is using the 10 MHz of spectrum adjacent to the GSM-R band. However, it has to be recognized that this is only applicable in low speed areas as elsewhere the use of uplink control in GSM-R will cause significantly increased call drop out rates. Another solution would be to introduce a higher frequency separation between the GSM-R channel and the 900 MHz allocation by allowing transmission in the extended GSM-R band. However, this solution should be counter-balanced by the potential impact onto the upper part of the 900 MHz allocation. Due to the blocking response profile of LTE/WiMAX, the base station deployed above 890 MHz may also suffer from desensitization due to GSM-R BS emissions.

4) In order to protect GSM-R operations, LTE/WiMAX operators should take care when deploying LTE/WiMAX in the 900 MHz band, where site engineering measures and/or better filtering capabilities (providing additional coupling loss in order to match the requirements defined for the critical/specific cases) may be needed in order to install LTE/WiMAX sites close to the railway track when the LTE/WiMAX network is using the channel adjacent to the GSM-R band. The deployment criteria of the GSM-R network such as the field strength level at the GSM-R cell edge could be also strengthened in order to improve the immunity of the GSM-R network towards the emissions from other systems.

It has to be noted that this study did not address tunnel coverage. Site sharing, which is expected to improve the coexistence, has not been studied either.

4.3 GSM-R extension for the bands 873-876 MHz / 918-921 MHz

4.3.1 Impact of the EGSM-R Downlink onto LTE uplink (880-915 MHz)

This section assesses the impact of extending the GSM-R allocation in the band 873-876 / 918-921 MHz towards the 900 MHz band. The most critical scenario is the GSM-R BS onto LTE BS due to the minimal coupling loss between base stations.

Unwanted emissions from GSM-R BTS

The GSM specifications will be updated in order to incorporate the extended GSM-R band. An optional requirement on the spurious emissions of the GSM base station for co-siting is given in Table 9 ,the power being measured with a filter and video bandwidth of 100 kHz [11].

	GSM 900 & GSM 850 & MXM 850 & GSM 700 (dBm)	DCS 1800 & PCS 1900 & MXM 1900 (dBm)
Normal BTS	-98	-98
Micro BTS M1	-91	-96
Micro BTS M2	-86	-91
Micro BTS M3	-81	-86
Pico BTS P1	-70	-80
GSM-R 900 BTS	-89	

Table 9: Limits for spurious emissions of the GSM base stations

These values assume a 30 dB coupling loss between transmitter and receiver.

If the extended GSM-R BTS can fulfil the spurious emission levels defined in the Table 9 for protecting the upper part of the uplink 900 MHz band by emitting no more than -89 dBm in 100 kHz BW, the protection of LTE BS receive frequencies due to E-GSM-R BS OOB emissions should be at an acceptable level.

Blocking response of LTE BS

Moreover, mitigation techniques may be necessary to alleviate some blocking phenomenon on the LTE BS. CEPT Report 40 assesses the ACS figures for LTE towards the emissions of a 200 kHz channel bandwidth. With ACS figures between 48.7 and 54.9 dB, it can be concluded the Minimum Coupling Loss between GSM-R BTS and LTE BS should be at least 126.8 dB in order to achieve a I/N ratio of -10 dB when assuming a 58 dBm GSM-R BTS EIRP and the worst case situation where the main lobes of both BS are aligned. Thus, to alleviate the interferences, the implementation of mitigation techniques is necessary.

4.3.2 Conclusions for GSM-R extension for the bands 873-876 MHz / 918-921 MHz

CEPT has recently adopted amendments to ECC/DEC/(02)05 on GSM-R and ECC/DEC/(04)06 on wideband PMR/PAMR. The amended Decisions provide a possibility for GSM-R extension (E-GSM-R) into the bands 873-876 MHz and 918-921 MHz on a national basis under the PMR/PAMR umbrella.

The extension of GSM-R within these bands was not studied previously within ECC Report 096 when UMTS was introduced into the 900/1800 MHz bands. However PMR/PAMR was studied for this band and some of the conclusions are applicable here. It can be seen that the LTE/WIMAX900 UL frequency block (880-915 MHz) is close to the E-GSM-R DL frequency block (918-921 MHz). The worst interference case is the interference from E-GSM-R BS to LTE/WiMAX BS.

The investigations and assumptions made in this report show that there may be interference from E-GSM-R BS to LTEWiMAX BS. It is assumed, that the worst interference case is the interference between E-GSM-R BS to LTE/WiMAX BS. Mitigation techniques and coordination may be needed to resolve interference.

LTE/WiMAX UE to E-GSM-R MS at 915 MHz

The LTE/WiMAX UE transmitting power is relatively small, at 23 dBm. In reality, mobile terminals rarely emit a maximum power of 23dBm (in 90% of cases they would emit 14 dBm or less [8]. By considering that the minimum coupling loss between UE and E-GSM-R BS is relatively large (80 dB is used in ECC Report 082 between UE and BS in rural area) compared to the MCL between LTE/WiMAX BS and GSM-R Train Mounted MS, and since the UE is moving, the interference from LTE/WiMAX UE to E-GSM-R MS should not be a problem. For detailed analysis of interference between LTE/WiMAX UE to E-GSM-R MS, Monte-Carlo simulations should be performed; this is not covered in this Report.

The worst interference case is the interference from E-GSM-R BS to LTE/WiMAX BS (see next section).

E-GSM-R BS to LTE/WiMAX900 BS at 915 MHz

The interference from E-GSM-R BS operating at frequencies above 918 MHz may cause receiver desensitization and blocking of LTE/WiMAX900 BS operating below 915 MHz. The specifications of the GSM-R BTS characteristics in the expected extension band are assumed to be the same as those of GSM-R in the primary band. It is assumed the GSM-R BTS for extension band will be designed to protect efficiently the upper part of the uplink 900 MHz band, in particular the spurious emissions will be aligned to the spurious emissions as currently defined to protect the 900 MHz receive band. The main challenge would be to achieve this level in a 3 MHz offset instead of a 6 MHz frequency offset. However, as it would not be sufficient to prevent blocking of LTE/WiMAX base stations, the utilization of interference mitigation techniques should be assessed in order to protect efficiently LTE/WiMAX900 BS.

5 COMPATIBILITY CONSIDERATION BETWEEN LTE/WIMAX 900 AND PMR/PAMR

5.1 Characteristics of PMR/PAMR systems

Several radio systems will potentially use the PMR/PAMR frequency band, such as TETRA, CDMA PAMR, TAPS, etc.

5.1.1 CDMA PAMR system characteristics

The system description of CDMA PAMR can be found in ETSI harmonized standard EN 301 449 for CDMA PAMR [13]. The main CDMA PAMR system characteristics are summarized in Table 10 to Table 15

	CDMA PAMR	
Frequency band (UL) (MHz)	870-876	
Frequency band (DL) (MHz)	915-921	
Carrier separation (MHz)	1.25	
Modulation	QPSK/BPSK	
BS-MS MCL (dB)	70 (Urban area) 80 (Rural area)	
	BS	**MS**
Maximum Tx power (dBm)	43	23
Thermal noise (dBm)	-113	-113
Noise figure (dB)	5	9
Noise floor (dBm)	-108	-104
Receiver sensitivity (dBm)	-119	-114
Antenna height (m)	30 (Urban) 40 (Rural)	1.5
Antenna gain (dBi)	17	0
Feeder loss (dB)	2	0
ACS (dB)	55	68

Table 10: Main CDMA PAMR system parameters

For |Δf| within the Range	**Applicability**	**Emission Limit**
750 to 885 KHz	Single Carrier	-45-15(|Δf|-750)/135 dBc in 30 kHz
885 to 1125 KHz	Single Carrier	-60-5(|Δf|-885)/240 dBc in 30 kHz
1.125 to 1.98 MHz	Single Carrier	-65 dBc / 30kHz
1.98 to 4.00 MHz	Single Carrier	-75 dBc / 30kHz
4.00 to 6.00 MHz	Single and Multiple Carrier	-36 dBm / 100kHz
6.00 to 45.00 MHz	Single and Multiple Carrier	-45 dBm / 100kHz
> 45.00 MHz	Single and Multiple Carrier	-36 dBm / 1 kHz; 9 kHz < f < 150 kHz -36 dBm / 10 kHz; 150 kHz < f < 30 MHz -36 dBm / 100 kHz 30 MHz < f < 1 GHz -30 dBm / 1 MHz; 1 GHz < f < 12.5 GHz

Table 11: CDMA PAMR BS spectrum mask (Transmitter unwanted emission limits for Band Class 12)

For f within the range |Δf| within the Range	Applicability	Emission Limit
1.98 to 4.00 MHz	Single Carrier	-100 dBc / 30kHz
4.00 to 6.00 MHz	Single and Multiple Carrier	-61 dBm / 100kHz
>6.00 MHz	Single and Multiple Carrier	-61 dBm / 100kHz

Table 12: Additional BS Transmitter unwanted emission limits for Band Class 12 within the frequency range 876-915 MHz

For |Δf| within the Range	Emission Limit	
885 kHz to 1.125 MHz	-47 – 7 × (|Δf| – 885) / 235 dBc in 30 kHz	
1.125 MHz to 1.98 MHz	-54 – 13 × (|Δf| – 1120) / 860 dBc in 30 kHz	
1.98 MHz to 4.00 MHz	-67 – 15 × (|Δf| – 1980) / 2020 dBc in 30 kHz	
4.00 MHz to 10.0 MHz	-51 dBm in 100 kHz	
>10.0 MHz	-36 dBm/1 kHz; -36 dBm/10 kHz;-36 dBm/100 kHz;-30 dBm/1 MHz;	9 kHz < f < 150 kHz150 kHz < f < 30 MHz30 MHz < f < 1 GHz1 GHz < f < 12,75 GHz

Table 13: CDMA PAMR MS Spectrum mask (Unwanted emission limits for mobile stations)

Frequency	Maximum E.R.P/ reference bandwidth
30 MHz ≤ f < 1 000 MHz	-36 dBm/100 kHz
1 GHz ≤ f < 12,75 GHz	-30 dBm/1 MHz
Fc1 – 4 MHz < f < Fc2 + 4 MHz	No requirement
NOTE 1: Centre frequency of first carrier frequency (Fc1) used by the base station. NOTE 2: Centre frequency of last carrier frequency (Fc2) used by the base station. NOTE 3: Note 1 and Note 2 assume contiguous frequencies otherwise multiple exclusion bands will apply.	

Table 14: BS Spurious emission (Radiated unwanted emissions requirements)

Frequency	Limit (E.R.P)/ reference bandwidth idle mode	Limit (E.R.P)/ reference bandwidth traffic mode
30 MHz ≤ f < 1 000 MHz	-57 dBm/100 kHz	-36 dBm/100 kHz
1 GHz ≤ f < 12,75 GHz	-47 dBm/1 MHz	-30 dBm/1 MHz
Fc – 4 MHz < f < fc + 4 MHz	No requirement	No requirement
NOTE: fc is the nominal MS transmit centre frequency.		

Table 15: MS Radiated unwanted emissions requirements

5.1.2 TETRA system characteristics

The main TETRA system characteristics are summarized in the following tables:

	TETRA	
Frequency band (UL) (MHz)	870-876	
Frequency band (DL) (MHz)	915-921	
Carrier separation (MHz)	25 kHz	
BS-MS MCL (dB)	70 (Urban area) 80 (Rural area)	
	BS	**MS**
Maximum Tx power (dBm)	43	30
Receiver bandwidth (kHz)	18	18
Thermal noise (dBm)	-131	-131
Noise figure (dB)	5	9
Noise floor (dBm)	-128	-124
Receiver sensitivity (dBm)	-106	-103
Antenna height (m)	30 (Urban) 40 (Rural)	1.5
Antenna gain (dBi)	14	0
Feeder loss (dB)	2	0
Receiver protection ratio (dB)	19	19

Table 16: Main TETRA system parameters

Frequency Offset	**30 dBm Mobile Station**	**44 dBm Base Station**
25 kHz	- 30 dBm	- 16 dBm
50 kHz	-40 dBm	- 26 dBm
75 kHz	-40 dBm	- 26 dBm
100 – 250 kHz	-45 dBm	- 36 dBm
250 – 500 kHz	-50 dBm	- 41 dBm
500 kHz - f_{rb}	- 50 dBm	- 46 dBm
> f_{rb}	- 70 dBm	- 56 dBm

Table 17: TETRA Spectrum Mask*

*measured in an 18 kHz bandwidth.

*f_{rb} is the edge of the receive band belonging to the TETRA MS/BS. The minimum unwanted emissions requirement is - 36 dBm for frequency offsets of 25, 50 and 75 kHz and - 70 dBm for higher offsets.

Frequency Offset	**MS**	**BS**
50 - 100 kHz	- 40 dBm	-40 dBm
100 – 200 kHz	- 35 dBm	- 35 dBm
200 – 500 kHz	- 30 dBm	- 30 dBm
> 500 kHz	- 25 dBm	- 25 dBm

Table 18: TETRA Receiver Blocking

5.2 Interference analysis considerations

It can be seen that the LTE/WIMAX900 UL frequency block (880-915 MHz) is adjacent to the PMR/PAMR system (CDMA PAMR or TETRA) DL frequency block (915-921 MHz) at the frequency 915 MHz.

LTE/WiMAX UE to PMR/PAMR UE at 915 MHz

Regarding LTE/WiMAX UE to PMR/PAMR UE the LTE/WiMAX UE transmitting power is relatively small, at 23 dBm. In reality, mobile terminals rarely emit a maximum power of 23dBm (in 90% of cases they would emit 14 dBm or less [8]. By considering that the minimum coupling loss between UE and PMR/PAMR BS is relatively large (80 dB is used in ECC Report 082 between UE and BS in rural area) compared to the MCL between LTE/WiMAX BS and GSM-R Train Mounted MS, and since the UE is moving, the interference from LTE/WiMAX UE to PMR/PAMR MS should not be a problem. For detailed analysis of interference between LTE/WiMAX UE and PMR/PAMR MS, Monte-Carlo simulations should be performed; this is not covered in this Report.

The worst interference case is the interference from PMR/PAMR BS to LTE/WiMAX BS, as shown in Figure 4

5.3 Potential interference between LTE/WiMAX900 and CDMA PAMR at 915 MHz

Interference from CDMA PAMR BS operating between 917-921 MHz to GSM900 BS operating below 915 MHz with a frequency separation of 2.15 MHz was analyzed in ECC Report 041 [14].

As described in ECC Report 041 [14], a frequency separation of 2.15 MHz between GSM900 operating below 915 MHz and CDMA PAMR operating above 917 MHz is not sufficient for the protection of GSM900 BS receiver; coordination between GSM900 and CDMA PAMR is recommended in ECC Report 041 [14].

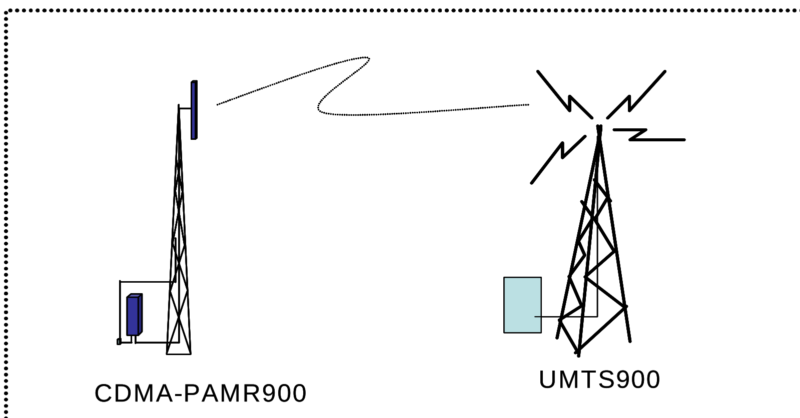

Figure 4: Worst Interference scenario between CDMA PAMR downlink and LTE/WiMAX900 uplink

As shown in Figure 4, the potential interference from CDMA-PAMR BS can desensitize LTE/WiMAX900 BS receiver if the protection is not sufficient.

5.4 Potential interference between LTE/WiMAX900 and TETRA at 915 MHz

The adjacent compatibility study between GSM900 and TETRA or TAPS at 915 MHz was described in ECC Report 005 [15] showing that without any guard band or other interference mitigation techniques, interference from TETRA/TAPS BS will desensitize GSM900 BS receivers. In order to protect the GSM900 BS receiver operating below 915 MHz, several interference mitigation techniques were recommended in ECC Report 005 for the protection of GSM900 BS receivers, such as guard band, filters, and/or coordination between operators.

The interference analysis method described in ECC Report 005 can be re-used for the interference analysis between LTE/WiMAX900 and TETRA systems operating below and above 915 MHz respectively, by considering that LTE/WiMAX900 BS is more sensitive to interference than GSM900. By applying the interference analysis method described in ECC Report 005, similar conclusions can be made that without interference mitigation techniques there will be serious interference from a TETRA/TAPS BS transmitter to LTE/WiMAX900 BS. Thus LTE/WiMAX900 BS receivers will be desensitized due to strong interference from TETRA/TAPS. The following interference mitigation techniques can be used to reduce the interference from TETRA/TAPS to LTE/WiMAX900 BS:

i) Guard band;

ii) External filters;

iii) Spatial separation by coordination between LTE/WiMAX900 and TETRA/TAPS operators;

iv) Reduced transmitting power of TETRA/TAPS BS.

5.5 Conclusions for PMR/PAMR

The LTE and WiMAX BS masks for the 900 MHz bands are aligned with the UMTS900 mask for all the LTE/WiMAX channelisation bandwidth available. The conclusions relating to PMR/PAMR within ECC Report 096 are considered applicable here:

LTE/WiMAX MS to PMR/PAMR MS at 915 MHz

The LTE/WiMAX UE transmitting power is relatively small, at 23 dBm. In reality, mobile terminals rarely emit a maximum power of 23dBm (in 90% of cases they would emit 14 dBm or less [8]. By considering that the minimum coupling loss between UE and E-GSM-R BS is relatively large (80 dB is used in ECC Report 082 between UE and BS in rural area) compared to the MCL between LTE/WiMAX BS and GSM-R Train Mounted MS, and since the UE is moving, the interference from LTE/WiMAX UE to E-GSM-R MS should not be a problem. For detailed analysis of interference between LTE/WiMAX UE to E-GSM-R MS, Monte-Carlo simulations should be performed; this is not covered in this Report.

The worst interference case is the interference from PMR/PAMR BS to LTE/WiMAX BS

PMR/PAMR BS to LTE/WiMAX900 BS at 915 MHz

The interference from PMR/PAMR (CDMA PAMR, TETRA, TAPS) BS operating at frequencies above 915 MHz will cause receiver desensitization of LTE/WiMAX900 BS operating below 915 MHz. In order to protect LTE/WiMAX900 BS, the utilization of interference mitigation techniques is necessary:

1) Reduced PMR/PAMR BS Tx power;

2) Spatial separation by coordination between operators;

3) External filters applied to the PMR/PAMR BS;

4) Sufficient guard band between the 900 MHz mobile allocation and the first PMR/PAMR channel in use.

It is more likely that a combination of these interference mitigation techniques should be used in order to ensure the compatibility between LTE/WiMAX900 operating below 915 MHz and PMR/PAMR (CDMA PAMR, TETRA, TAPS) operating above 915 MHz.

6 COMPATIBILITY STUDY BETWEEN LTE/WIMAX900 AND DME/L-DACS

The LTE and WiMAX BS masks for the 900 MHz bands are aligned with the UMTS900 mask for all the LTE/WiMAX channelisation bandwidth available and are expected to have similar characteristics in terms of average power. Similarly, the protection criteria of LTE and WiMAX terminals is aligned with that of UMTS, and hence the conclusions regarding interference between UMTS and DME/L-DACS should be applicable to the scenarios involving LTE/WiMAX on one side and DME/L-DACS on the other side, for the same signal bandwidth.

When considering LTE/WiMAX with higher carrier bandwidth (> 5MHz), the compatibility results should be improved. With a large number of interferers with lower bandwidths (<5MHz), the aggregate interference from LTE would increase. However, it is not expected that LTE will be deployed with lower bandwidth. Bandwidth different from 5 MHz for LTE/WiMAX has not been addressed in detail.

For the reasons explained above, the results of the studies between LTE/WiMAX and DME/L-DACS have been derived from those involving UMTS and DME/L-DACS (CEPT Report 42), as follows:

- L-DACS 2 airborne transmitters will not cause any interference to LTE/WIMAX terminals, when the distance between the aircraft and an outdoor LTE/WIMAX terminal is greater than 8.6 km, with a L-DACS 2 transmitting frequency of 960,1 MHz. For a L-DACS 2 transmitting frequency of 962,6 MHz, this distance becomes 6.5 km. The limiting factor is currently the selectivity of the LTE/WIMAX UE.
- L-DACS 2 ground stations could cause desensitization to LTE/WIMAX terminals at a distance up to 17.5 km, depending on the propagation characteristics in the area considered and L-DACS 2 ground station antenna height, with a L-DACS 2 transmitting frequency of 960,1 MHz. For a L-DACS 2 transmitting frequency of 962,6 MHz, this distance becomes 14.7 km. The limiting factor is currently the selectivity of the LTE/WIMAX UE.
- No interference from LTE/WIMAX base stations to DME airborne receivers is expected above 972 MHz. Below 972 MHz some interference, in the order of 3 to 4 dB, may occur at low altitudes for the mixed-urban case.
- L-DACS airborne receivers are no more sensitive to interference than DME.
- LTE/WIMAX base station transmissions may cause interference to L-DACS ground stations, if these stations are deployed in the lowest part of the band, and if the L-DACS TDD option is selected, in the order of 17 – 25 dB, depending on the distance from the ground station to the nearest base station. If the FDD (LDACS-1) option is chosen and the associated ground stations receive at frequencies far above 960 MHz, then the interference from LTE/WIMAX base stations to these ground stations would be alleviated.

For additional information, see CEPT Report 42, especially with respect to mitigation techniques.

7 COMPATIBILITY STUDY BETWEEN LTE/WIMAX900 AND MIDS

7.1 System parameters and co-existence scenario

Frequency band plan

The frequency band plans for MIDS and LTE/WiMAX900 are shown in Figure 5 below:

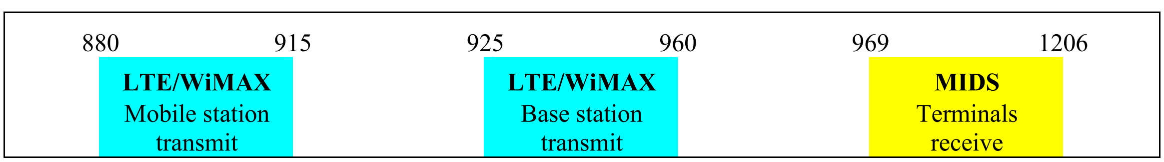

Figure 5: Frequency band plans for MIDS and LTE/WiMAX900

900 frequency band is arranged as follows:

- Uplink (UE transmit, BS receive) : 880-915 MHz
- Downlink (BS transmit, UE receive) : 925-960 MHz
- Carrier separation: 5 MHz

MIDS frequency band is arranged as follows:

MIDS operates in the 960 to 1215 MHz band, with MIDS frequencies occurring every 3 MHz between 969 to 1206 MHz. Two sub-bands centered on 1030 MHz and 1090 MHz are excluded because they are used by IFF.

LTE/WiMAX System parameters

LTE/WiMAX900 parameters can be found in CEPT Report 40

MIDS parameters

MIDS (Multifunctional Information Distribution System) is a tactical military system. The MIDS receiver to consider is the MIDS terminal, integrated in a shelter. The antenna is mounted on a 16 metres mast. The terminal mode to consider is the frequency hopping mode (51 frequencies). The lowest frequency is 969 MHz.

Receiver	**MIDS terminal**
Bandwith	5 MHz
Feeder loss	5 dB
Antenna gain	9 dBi
Antenna height	16 metres
Equivalent downtilt	+ 3°
3 dB beam width in the vertical plane	16°
Horizontal plan	Omni

Table 19: MIDS terminal parameters

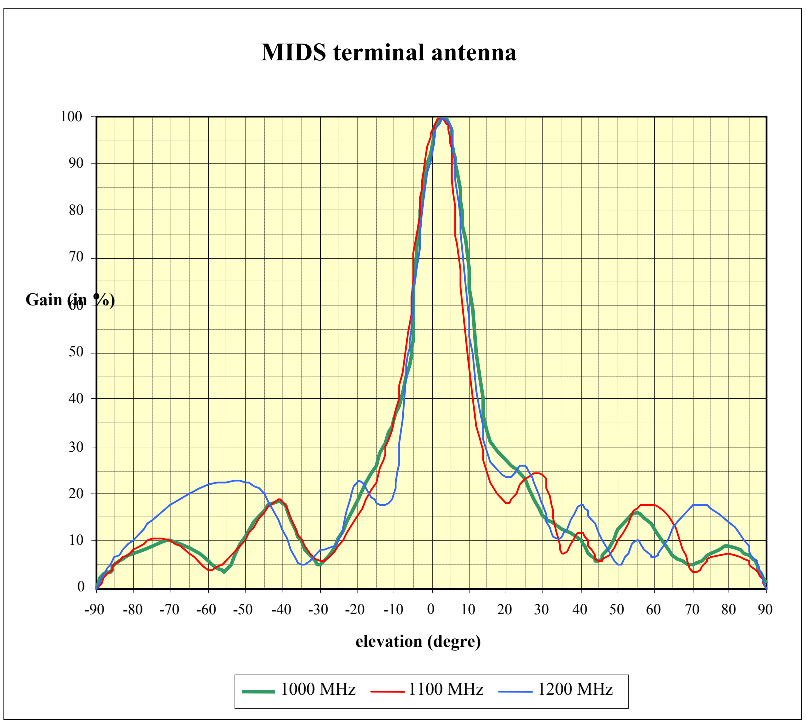

Figure 6: MIDS terminal elevation antenna diagram

Other assumptions taken in the study:

- The frequency used in the simulation is 970 MHz;
- The hopping frequencies are as follows:

N°	Frequency (MHz)	N°	Frequency (MHz)	N°	Frequency (MHz)
0	969	17	1062	34	1158
1	972	18	1065	35	1161
2	975	19	1113	36	1164
3	978	20	1116	37	1167
4	981	21	1119	38	1170
5	984	22	1122	39	1173
6	987	23	1125	40	1176
7	990	24	1128	41	1179
8	993	25	1131	42	1182
9	996	26	1134	43	1185
10	999	27	1137	44	1188
11	1002	28	1140	45	1191
12	1005	29	1143	46	1194
13	1008	30	1146	47	1197
14	1053	31	1149	48	1200
15	1056	32	1152	49	1203
16	1059	33	1155	50	1206

Table 20

- Protection from the unwanted emissions of an interfering system: criterion n°1

Measurements have been performed in a French DoD laboratory to assess the protection criteria of MIDS receiver. The curves of the permissible level of a signal which is out of the MIDS band, have been picked out: for a transmission at 960 MHz, there is no degradation of the MIDS terminal performances as long as the power of the transmitter remains below -10 dBm (the reference is a CW signal).

- Noise level permissible in the MIDS channel: criterion n°2

On the same line as in the previous paragraph, measurements on MIDS receiver give a permissible noise level equal to -103dBm, for one of the 51 channels, i.e. -104 dBm/5 MHz, taking into account 1dB margin

This tolerated value allows an acceptable MIDS sensitivity referred to MIDS SSS (System Segment Specification) to be obtained.

- Interference threshold expressed as an interfered frequencies rate

The MIDS receiver can tolerate a certain number of interfered channels amongst the 51 channels used, without any performance degradation. This threshold is classified and is not given in this document. This interference threshold, without being communicated in the Report for security reason, is covered by the criterion n°2, when assessing the number of frequencies for which the permissible noise floor is exceeded.

7.1.1 Conclusions for MIDS

The LTE and WiMAX masks for the 900 MHz bands are aligned with the UMTS900 mask for all the LTE channelization bandwidth available. Hence the conclusions relating to MIDS within ECC Report 096 are applicable here.

Based on the studies within ECC Report 096 the following conclusions can be made:

This adjacent band compatibility study between LTE900 (operating below 960 MHz) and the MIDS (operating above 969 MHz) considers the impact of the unwanted emissions (above 960 MHz) for the worst case situation, where the MIDS receiver is placed in the direction of the LTE base station antenna. It shall be noted than the assessment of interferences from MIDS on the LTE terminals has not been taken into account in this compatibility study, since the 900 mobile allocation is separated by a considerable distance in the frequency domain from MIDS transmissions. In this context, it should be noted that this study does not take into account the regulatory status of JTIDS/MIDS, which operates in the band 960-1215 MHz under the conditions of provision 4.4 of the Radio Regulations. It is additionally noted that MIDS is part of the navigation systems listed in the ERC Report 025 (ECA) operating above 960 MHz. To avoid any interference on each MIDS frequency the protection distance between LTE/WiMAX900 base station and MIDS stations should be up to 2 km accordingly when the MIDS receiver is placed in the direction of the LTE/WiMAX base station antenna that corresponds to the worst-case situation.

However, the protection should be reduced if the real unwanted emission level of the equipment is better than specified.. For the worst case situation (the MIDS receiver is placed in the direction where the LTE/WiMAX base station antenna gain is maximum), to fully protect MIDS without any protection distance, the unwanted emission level should be:

- 21 dB better than specified in the 970-1000 MHz band,
- 17 dB better than specified in the 1000-1206 MHz MIDS band (corresponding to the 1-12.75 GHz spurious band),
- For other azimuths of antenna, the separation distance and the additional filtering requirements decrease.

However, a performance degradation of the MIDS can be tolerated: this corresponds to interference on the first 11 MIDS channels (ranging from 969 to 999 MHz). Consequently, if there is an additional isolation of 17 dB above 1 GHz no additional separation distance is required to protect the MIDS receiver for the worst case situation (the MIDS receiver is placed in the direction where the LTE/WiMAX base station antenna gain is maximum).

Information put forward by some manufacturers about the performance of a typical LTE/WiMAX900 base station shows that the practical level of unwanted emission provides isolation considerably higher than that required (17dB). Indeed, the interference criteria would be met already at 980 MHz or even lower.

8 COMPATIBILITY STUDY BETWEEN LTE/WIMAX1800 AND DECT

8.1 DECT system characteristics

Main DECT system characteristics are summarized in Table 21 to Table 25 and Figure 7 below.

	DECT	
Frequency band (UL & DL) (MHz)	1880-1900	
Carrier separation (MHz)	1.728	
Modulation	GMSK	
	BS	**MS**
Maximum Tx power (dBm)	24 dBm (250 mW)	24 dBm (250 mW)
Receiver bandwidth (MHz)	1.152	1.152
Thermal noise (dBm)	-113	-113
Noise figure (dB)	10	10
Noise floor (dBm)	-103	-103
Receiver sensitivity (dBm)	-93	-93
Antenna height (m)	0.8	1.5
Antenna gain (dBi)	0	0
Feeder loss (dB)	0	0

Table 21: Main DECT system parameters

Emissions on RF channel "Y"	Maximum power level	Maximum power level	Frequency Offset
1. Y=M±1	160 µW	-8 dBm	ΔF=+/ -1.728 MHz
2. Y=M±2	1 µW	-30 dBm	ΔF=+/ -3.456 MHz
3. Y=M±3	80 nW	-41 dBm	ΔF=+/ -5.184 MHz
4. Y>M±3	40 nW	-44 dBm	any other channel

Table 22: Spectrum mask

Note: "M" is the Equipment Under Test (EUT) transmitting channel (carrier) and "Y" is a legal DECT channel other than the EUT transmit channel.

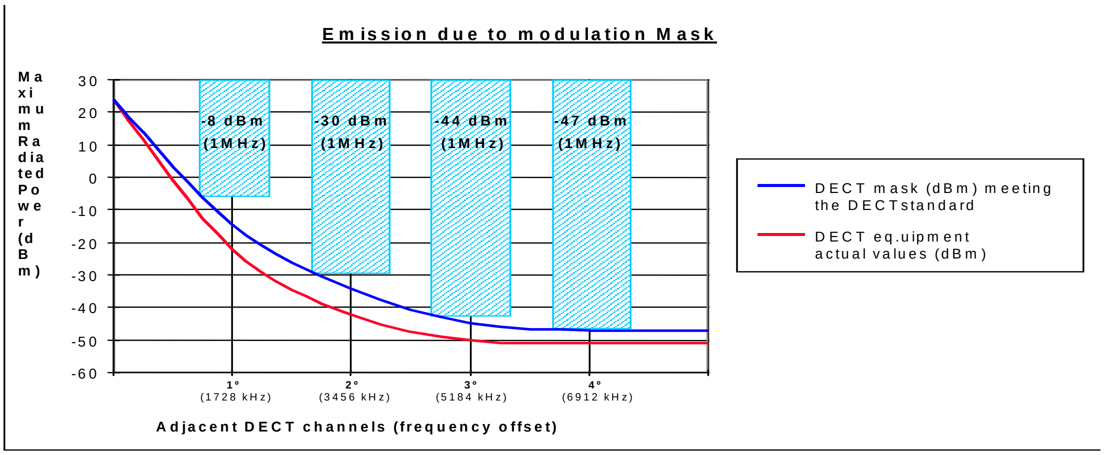

Figure 7: DECT emission mask

The spurious emissions shall not be greater than -36 dBm (250 nW) at frequencies below 1 GHz and -30 dBm (1 µW) at frequencies above 1 GHz. The measurement bandwidth is given in Table 8.3.

Frequency offset from edge of band	Resolution bandwidth
0-2 MHz	30 kHz
2-5 MHz	30 kHz
5-10 MHz	100 kHz
10-20 MHz	300 kHz

Table 23: Spurious emission measurement filter bandwidth

The C/I requirements are set with respect to the ability of DECT equipment to continue receiving in the presence of an interfering signal on the same or different DECT RF channel. Wanted signal level: -73dBm

Interferer on RF channel	Interfering signal strength	C/I	Frequency range (MHz)	Frequency at GSM band edge (MHz)
Y=M=F_0	-84 dBm	11 dB	ΔF= 0	1881.792
Y=M +/- 1	-60 dBm	-13 dB	ΔF =+/- 1.728	1880.064
Y=M +/- 2	-39 dBm	-34 dB	ΔF =+/- 3.456	1878.336
Y=M +/- 3	-33 dBm	-40 dB	ΔF =+/- 5.184	1876.606

Table 24: C/I requirement

The RF carriers "Y" shall include the three nominal DECT RF carrier positions immediately outside each edge of the DECT band.

Frequency (f)	Continuous wave interferer level	Comments
25 MHz ≤ f ≤ 1780 MHz	-23 dBm	GSM MS transmitter band
1780 ≤ f ≤ **1875 MHz**	-33 dBm	GSM BTS transmitter band
$|f-F_C|$ > 6 MHz	-43 dBm	GSM BTS transmitter band
1905 MHz < f ≤ 2000 MHz	-33 dBm	not relevant
2000 MHz <f ≤ 12.75 GHz	-23 dBm	not relevant

Table 25: Receiver blocking

*F_C is DECT RF channel (carrier) for wanted signal: c = 0, 1, ... ,9.

8.2 LTE/WiMAX1800 system characteristics

LTE/WiMAX1800 system parameters can be found in [7] and in CEPT Report 40.

8.3 Interference analysis between LTE/WiMAX 1800 and DECT

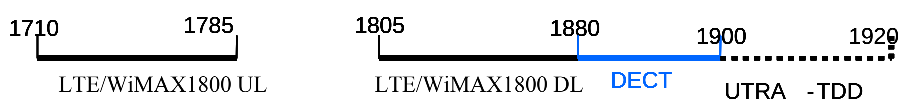

Figure 8: DECT frequency band is adjacent to 1800 DL

As shown in Figure 8, the DECT frequency band 1880-1900 MHz is adjacent to the LTE/WiMAX1800 downlink block 1805-1880 MHz band. It is also adjacent to the UTRA-TDD band 1900-1920 MHz. The adjacent band compatibility study between DECT and UTRA-TDD has been described in ERC Report 065 [19]. The adjacent band compatibility study between DECT and DCS1800 was described in ERC Report 031 [3] and ERC Report 100 [4].

<u>The configuration considered to assess the interference from LTE1800 onto DECT allocation:</u>

The interference from mobile system onto DECT was intensively studied through the Reports [3], [4] and [5].
In order to evaluate the interference from the mobile system onto the DECT system, it is assumed 5 MHz LTE channel; the upper LTE carrier centered onto 1877.5 MHz and the lowest DECT channels are considered, since this configuration represents the worst case in terms of coexistence, in line with the previous simulations.

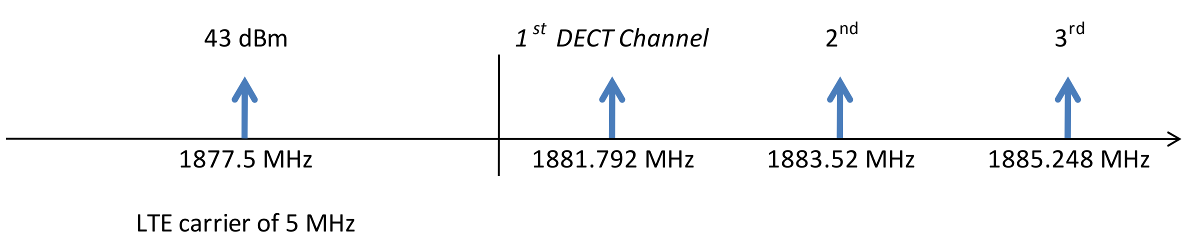

Figure 9: Channels under consideration

<u>The interference is evaluated by calculating ACS and ACLR figures</u>

Moreover, it is necessary to differentiate the unwanted emissions from mobile system within the DECT band from the blocking response from DECT when having an interfering signal in the adjacent allocation.

In the following, the evaluation of the DECT blocking response and the LTE1800 unwanted emissions will be assessed through respectively the ACS and ACLR figures.

<u>ACS figures for DECT derived from [6].</u>

The C/I requirements are set with respect to the ability of DECT equipment to continue receiving in the presence of an interfering signal on the same or different DECT RF channel (with a wanted signal level: of-73dBm).

Interferer on RF channel "Y"	Interferer signal strength (dBµV/m)	Interferer signal strength (dBm)
Y = M	59	-84
Y = M ± 1	83	-60
Y = M ± 2	104	-39
Y = any other DECT channel	110	-33
NOTE: The RF carriers "Y" shall include the three nominal DECT RF carrier positions immediately outside each edge of the DECT band.		

Table 26: C/I requirements for DECT

It should be noted that the RF carriers "Y" shall include the three nominal DECT RF carrier positions immediately outside each edge of the DECT band.

For a higher frequency offset, Table 8.7 should be considered (with a wanted signal level: of-80 dBm):

Frequency (f)	Continuous wave interferer level	
	For radiated measurements dB µV/m	For conducted measurements dBm
25 MHz ≤ f < F_L - 100 MHz	120	-23
F_L - 100 MHz ≤ f < F_L - 5 MHz	110	-33
$\lvert f - F_C \rvert$ > 6 MHz	100	-43
F_U + 5 MHz < f ≤ F_U + 100 MHz	110	-33
F_U + 100 MHz < f ≤ 12,75 GHz	120	-23

For the basic DECT frequency band allocation F_L is 1 880 MHz and F_U is 1 900 MHz. Receivers may support additional carriers, e.g. up to F_U = 1 920 MHz.

Table 27: Blocking requirements for DECT

Based on a C/I ratio of 11 dB, we obtained from Table 26 the three first ACS figures for DECT in Table 28 below. ACS_4 etc are derived from the blocking requirements Table 27. For F_L = 1880 MHz the blocking level -33 dBm applies for the frequency range 1780 MHz <= f < 1875 MHz. The blocking figure -33 dBm can be translated into an ACS figure:

ACS (1875 MHz) = Blocking level – Wanted signal level + C/I = -33 + 80 + 11 = 58 dB.

Related to the DECT carrier F9, 1875 MHz falls at the 4^{th} adjacent channel carrier, but at 1875 MHz, just 5MHz outside of the DECT band, the main attenuation comes from the IF-filter, and very little from the RF-filter, and thus the -58 dB is supposed to be relevant for all DECT carriers F0 to F9. See F9 etc notations in Figure 9.

Interferer on RF channel	**ACS figures (dB)**
Y=M +/- 1	ACS_1 = 24
Y=M +/- 2	ACS_2 = 45
Y=M +/- 3	ACS_3 = 51
Y=M +/- 4 etc	ACS_4 = 58

Table 28: DECT ACS figures

The above ACS figures relate to a DECT-like interferer. Based on these ACS figures, approximate ACS figures have been derived for a 5 MHz LTE interferer at 1877,5 MHz. The DECT adjacent channel closest to the LTE block is at 1880,064 MHz. The first DECT adjacent channel within the LTE block is at 1878,236 MHz. See Figure 9. This adjacent channel is used to derive the ACS figures in Table 29:

DECT carrier	ACS figures (dB) related to 5 MHz LTE at 1877.5 MHz
F9	45
F8	51
F7 – F0	58

Table 29: DECT ACS figures related to an LTE interferer

ACLR figures for LTE derived from [7].
The ACLR figures for LTE related to a 1 MHz wide DECT receiver are shown in Table 30

DECT carrier	Out of band/block interference level	LTE ACLR figures (dB) related to a 1 MHz DECT receiver and LTE Tx power 43 dBm
F9 –F5	-13 dBm/MHz	56
F4 (1890.432 MHz)	-30 dBm/MHz	73
F3-F0	-30 dBm/MHz	73

Table 30: LTE ACLR related to a DECT 1 MHz receiver

For LTE BS 5 MHz option the ACLRs for F9-F5 is derived from [7], *Table 6.6.3.2.2-6: "Regional operating band unwanted emission limits in band 3 and 8 for 5, 10, 15 and 20 MHz channel bandwidth for Category"*, Figure 1 above could also have been used. For F4-F0 where the OOBE and ACLR are derived from [7], *Table 6.6.4.1.2.1-1:" BS Spurious emissions limits, Category B*".

WiMAX BS 5 MHz option will have the same ACLR figures as LTE in Table 30.

Comparing ACS and ACLR figures
The table below compares ACS and ACLR:

DECT carrier	ACS (dB)	ACLR (dB)
F9	45	56
F8	51	56
F7-F5	58	56
F4-F0	58	73

Table 31: Comparing ACLR and ACS

For LTE/WiMAX interferers, blocking of DECT dominates except for three DECT carriers F7-F5, where the unwanted interference (iRSS unwanted) created by the out-of-band emissions is somewhat (2 dB) higher than the blocking response (iRSS blocking).

In previous studies [4] and [5], blocking of DECT has been the dominating interference mechanism. In these Reports it has also been assumed that DECT by its DCS provision is able to detect possible harmful interference on carriers close to the band edge and escape to a less interfered carrier.

Since for LTE/WiMAX only 3 out of 10 carriers are interfered somewhat more than given by the blocking response, and since DECT provides DCS, we could conclude that the LTE/WiMAX case will be very similar to a case where the blocking mechanism dominates on all carries.

Therefore relevant results from previous coexistence Reports apply. See below section 8.4 Conclusions for DECT.

8.4 Conclusions for DECT

The LTE and WiMAX Base Station masks for the 1800 MHz bands are aligned with the UMTS1800 mask for all the LTE channelisation bandwidth available. In previous studies [4] and [5], blocking of DECT has been the dominating interference mechanism. In these Reports it has also been assumed that DECT by its DCS provision is able to detect possible harmful interference on carriers close to the band edge and escape to a less interfered carrier. For LTE/WiMAX interferers, blocking of DECT also dominates except for three DECT carriers F7-F5, where the unwanted interference (iRSS unwanted) created by the out-of-band emissions is somewhat (2 dB) higher than the blocking response (iRSS blocking). Since only 3 out of 10 carriers are interfered somewhat more than given by the blocking response, and since DECT provides DCS, the LTE/WiMAX case will be very similar to a case where the blocking mechanism dominates on all carries. Therefore results from previous coexistence Reports can be applied as follows:

- The conclusion is the same as for the previous studies [4] and [5], that no guard band is required between LTE1800 and DECT allocations, provided that DECT is able to properly detect GSM interference on closest DECT carriers F9-F7 and escape to more distant carriers F6-F0. How to detect GSM interference is described in ETSI EN 300 175-3, clause 11.4.5, “Handover criteria due to Interference”.

- Therefore, LTE/WiMAX1800 macro-cells can be deployed in the same geographical area in co-existence with DECT which is deployed inside of the buildings, as the interference between DECT RFP and PP and macro-cellular LTE/WiMAX1800 BS and UE is not a problem;

- When pico-cellular LTE/WiMAX1800 BS is deployed inside of the building in co-existence with DECT RFP and PP deployed in the same building indoor area, some potential interference is likely to exist from indoor pico-cellular LTE/WiMAX1800 BS to DECT if they are placed too close and they are operating in the adjacent channel at 1880 MHz;

- The following interference mitigation techniques could be used to address the potential interference from indoor pico-cellular LTE/WiMAX1800 to indoor DECT RFP and PP when they are operating at the adjacent frequency point of 1880 MHz (ECC Report 096):

  a) Space separation between indoor pico-cell LTE/WiMAX1800 BS and DECT RFP or PP of 65 m or more;

  b) External filter on indoor pico-cellular LTE/WiMAX1800 BS;

  c) Avoiding the adjacent frequencies of 1880 MHz for indoor pico-cellular LTE/WiMAX1800 BS and DECT or operate with reduced transmitting power if necessary.

In term of interference analysis, the DECT system has the DCA (Dynamic Channel Allocation) mechanism which allows it to avoid efficiently an interfered channel, except if both systems are deployed indoors.

9 COMPATIBILITY CONSIDERATION BETWEEN LTE/WIMAX 1800 AND METSAT

9.1 Main characteristics of METSAT

Meteorological satellite service (Space to earth) system characteristics are described in ITU-R Recommendation SA.1158 [16]. The main system parameters of the meteorological satellite system operating in the frequency range 1698-1710 MHz are summarized in Table 32.

Meteorological satellite Earth Stations are normally receiving data at elevation angles above typically 5° but have to support occasional satellite passes with lower elevation angles.

Satellite	Orbit height (km)	Inclination (degrees)	Lower frequency (MHz)	Upper frequency (MHz)
FY-1	870 870	98.7 98.7	1 698 1 705.5	1 703 1 710
METOP	827 827	98.7 98.7	1 698.75 1 704.75	1 703.25 1 709.25
SPOT	822	98.7	1 703	1 705
METEOR	1 020 1 020	99.6 99.6	1 698.5 1 703.5	1 701.5 1 706.5
NOAA	850 850	98.7 98.7	1 698.75 1 704.75	1 703.25 1 709.25
ADMIN1-A	840	98.7	1 698	1 702
ADMIN1-B	840	98.7	1 702	1 706
ADMIN2-A	840	98.7	1 702	1 706
ADMIN2-B	840	98.7	1 706	1 710
ADMIN3	840	98.7	1 706	1 710

Table 32: Meteorological satellite data used for the simulation

9.2 Interference analysis considerations

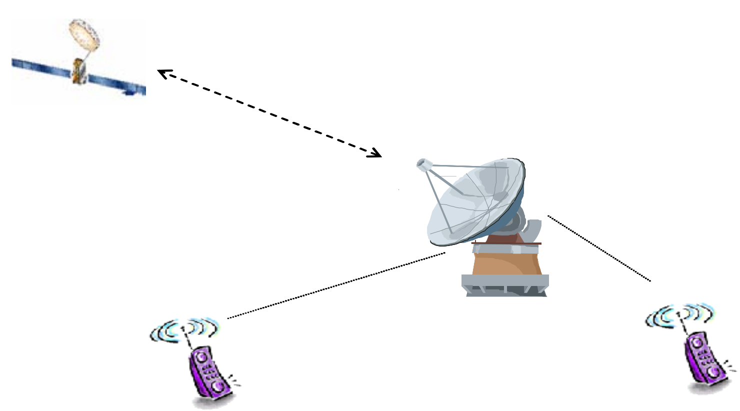

Figure 10: Interference scenario between LTE/WiMAX (GSM) UL and METSAT DL

The compatibility between meteorological satellite and MSS (Mobile Satellite System) has been studied and described in ITU-R Recommendation SA.1158 [16]. The compatibility between meteorological satellite Earth Stations operating in the frequency range 1700-1710 MHz and GSM1800 has not been studied. GSM1800 has been deployed and in extensive use over many years, and there has been no interference problem between GSM1800 and METSAT. As shown in Figure 10 the interference scenario between LTE/WiMAX/GSM mobile station and METSAT Earth Station takes into account that the METSAT Earth Station antenna radiation pattern has very small back lobes or side lobe, and that the possible interference signal, if any, from ground mobile station is in principle strongly attenuated.

As shown in Table 32, the METSAT operating frequency range of 1700-1710 MHz is adjacent to the LTE/WiMAX1800 uplink frequency block at 1710-1785 MHz. The ACLR of GSM1800 mobile stations is given ECC Report 082 (same as for GSM 900, see Table 7), and the unwanted emissions of LTE/WiMAX1800 UE are given in CEPT Report 40).

GSM1800 MS adjacent channel leakage power ratio at 5 MHz is ACLR=43.8 dB/3.84 MHz. GSM1800 MS maximum Tx power is 30 dBm without uplink power control. The leakage power of GSM1800 MS measured over the first adjacent UMTS channel is thus 30 – 43.8 = -13.8 dBm. Power control may also be used, which may decrease the GSM UE power to 5 dBm, with leakage power 5 – 43.8 = -38.8 dBm.

For LTE/WiMAX1800 UE the unwanted emissions vary with bandwidth and offset. For an offset from the channel of 1 MHz or more, the unwanted emissions will be -10 dBm/MHz or less. The lowest possible power for LTE UEs is -40 dBm. To summarize, the LTE (and WiMAX) UE has a power range that is very similar to that of GSM UEs.

The potential interference from METSAT DL to LTE/WiMAX1800 UE is not covered in this Report; this issue is left for future further study if it appears necessary.

9.3 Conclusions

From the frequency arrangement between METSAT and LTE/WiMAX1800, the possible interference scenario is the interference from LTE/WiMAX UE into METSAT Earth Station receivers. The METSAT Earth stations have been adjacent to GSM1800 for many years, and have not experienced interference from GSM MS transmissions. A comparison of adjacent leakage power between GSM MS and LTE/WiMAX UE indicates that the effective LTE/WiMAX UE adjacent channel leakage power is in the same range as GSM adjacent channel leakage power, so it is believed that the interference from LTE/WiMAX UE to METSAT Earth Stations operating in adjacent frequency band is unlikely to be a problem.

10 COMPATIBILITY CONSIDERATION BETWEEN LTE/WIMAX1800 AND RADIO MICROPHONES

10.1 Main characteristics of Radio Microphones

Radio microphone system characteristics are described in ERC Report 063 [17], ERC/REC 70-03 [18], ETSI standard EN 300 422 [21]. They are summarized in Table 33.

Parameter	Value
Transmitter output power hand held	13 dBm (20 mW)
Transmitter output power body worn	17 dBm (50 mW)
Transmitter spectrum mask	as set out in ETSI EN 300 422, shown in Figure 1
Bandwidth (-60 dB)	analogue as set out in ETSI EN300 422 (max. 200 kHz) digital approx. 300 kHz (which is not in compliance with ETSI EN 300 422)
Body effect loss hand held	6 dB
Body effect loss body worn	14 dB
Receiver input power	Analogue : - 68 dBm/74 dB(μV/m); Digital: - 85 dBm/57 dB(μV/m)
C/I ratio	Analogue: 25 dB Digital: 18 dB
Max. interfering field strength	Analogue: 49 dB(μV/m) Digital: 39 dB(μV/m)
Receiver spectrum mask	Shown in Figure 12
Operating modes	indoor and outdoor
Channel selection	no dynamic channel selection, frequency tuning possible throughout the frequency range.

Table 33: Main characteristics of radio microphone

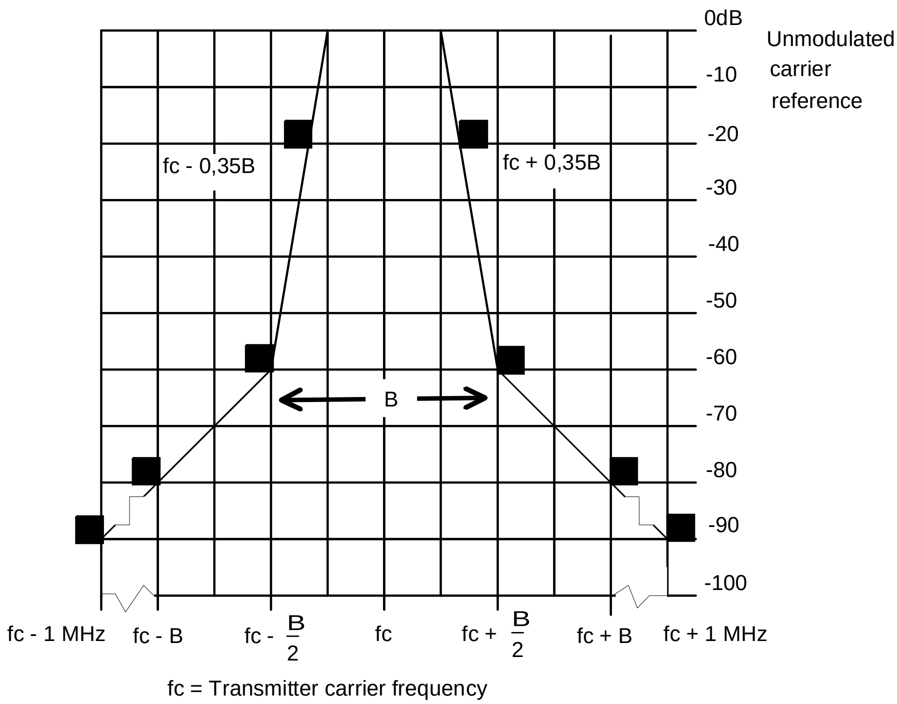

Figure 11: Microphone transmitter spectrum mask (normalized to channel bandwidth B)

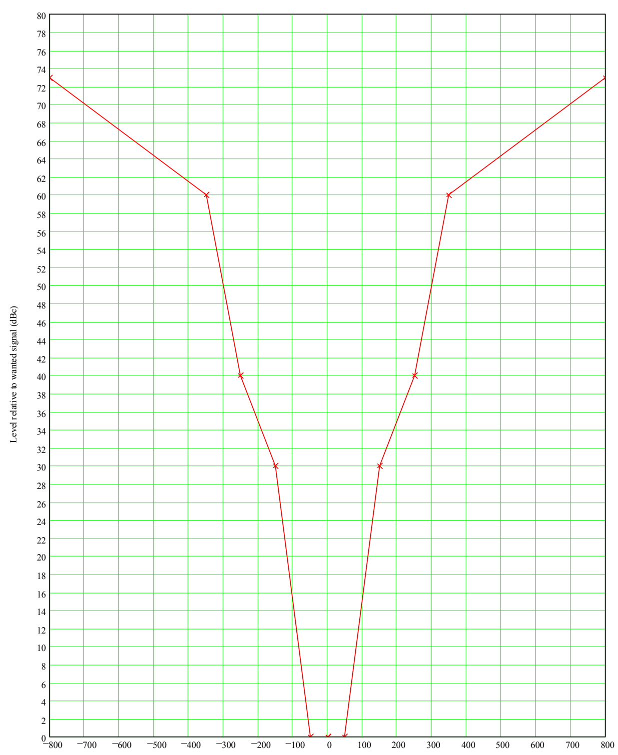

Figure 12: Microphone receiver mask

10.2 Interference analysis

Interference analysis between GSM1800 and Radio Microphones operating in adjacent frequency bands was described in ERC Report 063 [17]. The same interference analysis method can be used for the interference analysis between LTE/WiMAX1800 and Radio Microphones operating in adjacent bands. The conclusion of the interference analysis between GSM1800 and Radio Microphones was that a guard band of 700 kHz (1785-1785.7 MHz) was recommended for avoiding potential interference problems between radio microphones and GSM1800.

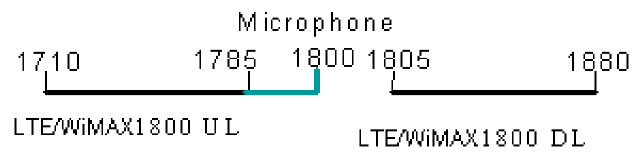

Figure 13: Radio Microphone frequency band is adjacent to LTE/WiMAX1800 UL

For the compatibility between radio microphones and LTE/WiMAX1800, there is a need to verify through interference analysis whether the recommended guard band of 700 kHz in ERC Report 063 [17] is sufficient for ensuring compatibility between LTE/WiMAX1800 and radio microphones operating in the adjacent band.

LTE1800 BS receiver narrow band blocking as defined in 3GPP TS 36.104 [7] and for WiMAX can be found in CEPT Report 40. The narrow band blocking was defined to ensure that GSM1800 MS with maximum power of 30dBm (1 W) should be able to co-exist with LTE/WiMAX with a smaller frequency separation than 700 kHz, and by considering that radio microphones transmit at a maximum power of 13 dBm, the interference from radio microphones to LTE/WiMAX BS should not be a problem with a guard band of 700 kHz.

10.3 Conclusions for Radio Microphones

It can be considered that the proposed guard band of 700 kHz in ERC Report 063 and ERC/REC 70-03 for the protection of GSM1800 is sufficient for protecting LTE/WiMAX 1800 BS receivers. This assumes that the radio microphone maximum transmitting power is limited to 13 dBm (20 mW) for hand held microphones and 17 dBm (50 mW) for body worn microphones, as recommended in ERC Report 063 and ERC/REC 70-03.

11 COMPATIBILITY STUDY BETWEEN LTE/WIMAX1800 AND FIXED SERVICES

The LTE and WiMAX masks for the 1800 MHz bands are aligned with the UMTS1800 mask for all the LTE channelisation bandwidth available. The conclusions relating to Fixed services within ECC Report 096 are considered applicable to LTE/WiMAX.

Compatibility between UMTS and Fixed Services operating in co-frequency and adjacent bands was studied and reported in ERC Report 065 [19] and ERC Report 064 [20]. As described in these two ERC Reports, the critical interference scenarios are between UMTS BS and Fixed Service stations. The interference between UMTS UE and Fixed Services was not considered. It is thought that these Reports are also applicable to LTE/WiMAX.

The Fixed Service frequency range is adjacent to LTE/WiMAX1800 UL at 1710 MHz and 1785 MHz. The potential interference, if any, will be between Fixed Service and LTE/WiMAX1800 BS at 1805 MHz. The interference analysis method used in the two ERC Reports can be used to derive the coordination distance, that is the separation distance between LTE/WiMAX BS and Fixed Service stations as a function of frequency separations between LTE/WiMAX base station and Fixed service station, as an interference prevention solution, as described in ERC Reports 064 and 065.

12 CONCLUSIONS

This document is based on ECC Report 096 which was developed for the introduction of UMTS at 900/1800 MHz. Many of the conclusions from ECC Report 096 are considered also applicable to LTE and WiMAX.
For aeronautical systems, CEPT Report 42 gives results on the compatibility between UMTS and DME/L-DACS-2. Those results have been extended to the compatibility between LTE/WiMAX and DME/L-DACS, based on the similarities between UMTS on one side and LTE/WiMAX on the other side.

Introducing LTE and WiMAX into the 900 and 1800 MHz bands should not cause any additional impact on adjacent services.

Detailed conclusions on each boundary can be found in the relevant sections of this Report and within the Executive Summary.

ANNEX 1: EC MANDATE TO CEPT

EUROPEAN COMMISSION
Information Society and Media Directorate-General

Electronic Communications Policy
Radio Spectrum Policy

Brussels, 15 June 2009
DG INFSO/B4

ADOPTED

Mandate to CEPT on the 900/1800 MHz bands

PURPOSE

The purpose of this Mandate is to contribute to putting into practice the concept of flexibility as advocated in the Opinion of the RSPG on Wireless Access Policy for Electronic Communications Services (WAPECS), by developing least restrictive technical conditions which are sufficient to avoid harmful interference in the frequency bands that have been tentatively identified by the RSC for the implementation of the WAPECS approach.

The technical conditions specific to each frequency band expected in response to this mandate will be considered for the introduction or amendment of harmonised technical conditions within the Community in order to achieve internal market objectives and facilitate cross-border coordination.

JUSTIFICATION

Pursuant to Article 4 of the Radio Spectrum Decision[2], the Commission may issue mandates to the CEPT for the development of technical implementing measures with a view to ensuring harmonised conditions for the availability and efficient use of radio spectrum. Such mandates shall set the task to be performed and the timetable therefore.

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[2] Decision 676/2002/EC of the European Parliament and of the Council of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community, OJ L 108 of 24.4.2002.

Flexibility and facilitating market entry are key requirements for ensuring that information and communication technologies help to deliver growth and jobs, in line with the renewed Lisbon Strategy. The issue of flexible spectrum use has been identified as an important aspect by the Commission[3] as well as Member States[4] and the success of this approach will now depend on an optimal implementation on the basis of concrete measures at the level of specific frequency bands. In this context it is necessary to look into the technical conditions attached to the rights of use of spectrum with the aim of implementing the defined policy approach. Reviewing the results of the CEPT Mandate on WAPECS[5] as well as recent developments in the market place, it seems necessary to continue the process towards an environment with a similar and minimal set of conditions for electronic communications services across all the relevant frequency bands and all Member States, while taking into account the experience of Member States so far.

In December 2008 the European Council adopted conclusions[6] regarding the economic recovery plan, which inter alia include support for regulatory incentives to develop broadband internet, including in areas that are poorly served. Ensuring that state-of-the-art wireless broadband technologies have access to a number of spectrum bands so that both capacity and coverage can be achieved is an important aspect that will stimulate broadband deployment.

Concerning the bands 880-915 MHz / 925-960 MHz and 1710-1785 MHz / 1805-1880 MHz (900/1800 MHz bands) a draft Decision[7] has been approved by the RSC as a mechanism that will gradually introduce new technologies (i.e. technology neutrality) into the GSM bands and it will come into force when Council and Parliament agree on the amendment of the GSM Directive[8]. The annex to this draft Decision contains essential technical parameters for systems that have demonstrated the ability to coexist with GSM. In addition to UMTS, which is already in the list, there are signs that other technologies, such as LTE[9], are envisaged for deployment in the 900/1800 MHz bands by incumbent operators. In order to ensure that LTE is recognised through insertion into the annex of the decision on 900/1800 MHz as a technology that should be taken into account when conducting in band and adjacent band interference studies, there is a need for CEPT to study the technical implications in order to ensure coexistence as well as flexible spectrum use.

TASK ORDER AND SCHEDULE

CEPT is mandated to study the following issues:

Verify whether there are other technologies besides LTE developing equipment for 900/1800 MHz that would need to be studied concerning their coexistence with GSM at this stage.

Study the technical conditions under which LTE technology can be deployed in the 900/1800 MHz bands: With the aim of adding LTE and possibly other technologies (identified in Task 1) to the list in the annex of the draft decision on 900/1800 MHz frequency bands (see Footnote 6), technical coexistence parameters should be developed. A Block Edge Mask is not requested at this stage, noting that common and minimal (least restrictive) parameters would be appropriate after strategic decisions concerning the role of GSM as the reference technology for coexistence have been taken.

Investigate compatibility between UMTS and adjacent band systems above 960MHz: Noting that compatibility with systems outside of the 900/1800 MHz bands will be studied for LTE and any other identified technology at all band edges under Task 2, the aim of this task is to review the risk of interference between UMTS and existing and planned aeronautical systems[10] above 960 MHz, in order to enable the development of all systems below and above 960 MHz without taking a risk relating to aeronautical safety.

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3 Communication on "Rapid access to spectrum through more flexibility", COM(2007)50

4 RSPG Opinion on Wireless Access Policy for Electronic Communications Services (WAPECS)

5 http://ec.europa.eu/information_society/policy/ecomm/radio_spectrum/_document_storage/mandates/ec_to_cept_wapecs_06_06.pdf

6 *Presidency Conclusions*, Council of the European Union, Brussels, 12 December 2008 17271/08

7 http://ec.europa.eu/information_society/policy/ecomm/radio_spectrum/_document_storage/rsc/rsc20_public_docs/07_04%20final_900_1800.pdf

8 On 19.11.2008 the Commission issued a proposal for an amendment of the GSM Directive (see COM(2008) 762final), which is currently in co-decision procedure.

9 Long Term Evolution (LTE) is the next major step of technological development in the GSM and UMTS product line. It is currently being standardised by 3GPP.

10 The review of planned systems should be based on the latest available information on the new aeronautical communication system being developed above 960 MHz in the context of the Single European Sky ATM Research (SESAR) programme.

The main deliverable for this Mandate will be a report, subject to the following delivery dates:

Delivery date	**Deliverable**
18 Sept. 2009	For the RSC#29: First progress report
27 Nov. 2009	For RSC#30: Second progress report including a final report on Task 1
10 March 2010	For RSC#31: Draft final report[11]
24 June 2010	For RSC#32: Final report

In implementing this mandate, the CEPT shall, where relevant, take the utmost account of Community law applicable and support the principles of technological neutrality, non-discrimination and proportionality insofar as technically possible.

[11] Public consultation should take place based on this version of the text.

ANNEX 2: LIST OF REFERENCES

[1] ECC Report 096 “Compatibility between UMTS 900/1800 and systems operating in adjacent bands”, March 2007.

[2] ECC Report 128 “Compatibility of pseudolites in 1164-1215, 1215-1300 and 1559-1610 MHz”, February 2009.

[3] ERC Report 031 “Compatibility between DECT and DCS1800”, June 1994.

[4] ERC Report 100 “Compatibility between certain radiocommunications systems operating in adjacent bands: evaluation of DECT / GSM1800 compatibility” February 2000.

[5] ECC Report 146 “Compatibility between GSM MCBTS and adjacent systems”, June 2010.

[6] ETSI EN 300 175-2 V2.0.1 (2007-03) “Digital Enhanced Cordless Telecommunications (DECT);Common Interface (CI); Part 2: Physical Layer (PHL)”.

[7] 3GPP TS 36.104 V9.1.0 (2009-09) “Technical Specification Group Radio Access Network; E-UTRA; Base Station (BS) radio transmission and reception (Release 9)”.

[8] Annex 14 to Document ITU-R JTG 5-6/88-E “Sharing studies conducted in Regions 1 and 3 between the mobile service and other primary services”, 3 June 2009.

[9] CEPT Report 40 “Compatibility study for LTE and WiMAX operating within the bands 880-915 MHz / 925-960 MHz and 1710-1785 MHz / 1805-1880 MHz (900/1800 MHz bands)” in response Task 2 of the EC Mandate to CEPT on the 900/1800 MHz band.

[10] CEPT Report 42 “Compatibility between UMTS and existing and planned aeronautical systems above 960MHz” in response to Task 3 of the EC Mandate to CEPT on the 900/1800 MHz band.

[11] 3GPP TS45.005 (Release 5) “GSM/EDGE Radio Access Network, Radio Transmission and Reception”.

[12] Interoperability Directives: Council Directive 96/48/EC of 23 July 2006, Directive 2001/16/EC of the European Parliament and of the Council of 19 March 2001, Directive 2004/50/EC of the European Parliament and of the Council of 29 April 2004.

[13] ETSI EN 301 449 V1.1.1 (2005) “Electromagnetic compatibility and Radio spectrum Matters (ERM);Harmonized EN for CDMA spread spectrum base stations operating in the 450 MHz cellular band (CDMA 450) and 410, 450 and 870 MHz PAMR bands (CDMA-PAMR) covering essential requirements of article 3.2 of the R&TTE Directive”.

[14] ECC Report 041 “Adjacent band compatibility between GSM and CDMA-PAMR at 915 MHz, February 2004.

[15] ECC Report 005 “Adjacent band compatibility between GSM and TETRA Mobile Services at 915 MHz”, June 2002.

[16] ITU-R Recommendation SA1158-3 “Feasibility of frequency sharing in the 1670-1710 MHz band between the meteorological-satellite service (space-to-Earth) and the mobile-satellite service (Earth-to-space)”, 2003.

[17] ERC Report 063 “Introduction of radio microphone applications in the frequency range 1785-1800 MHz”, May 1998.

[18] ERC/REC 70-03 “Relating to the use of short range devices (SRD)”, Annex 10 “Radio microphones and Assistive Listening Devices”.

[19] ERC Report 065 “Adjacent band compatibility between UMTS and other services in the 2 GHz band”, November. 1999.

[20] ERC Report 064 “Frequency sharing between UMTS and existing fixed services”, May 1999.

[21] ETSI EN 300 422-1, V1.2.2 (2000-08) “Electromagnetic compatibility and Radio spectrum Matters (ERM); Wireless microphones in the 25 MHz to 3 GHz frequency range; Part 1: Technical characteristics and test methods”.