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

THE TECHNICAL IMPACT OF INTRODUCING CDMA-PAMR ON THE UIC DMO & GSM-R RADIO SYSTEMS IN THE 900 MHZ BAND

Granada, February 2004

EXECUTIVE SUMMARY

This report considers the technical impact of introducing CDMA-PAMR in the band 870-876/915-921 MHz on the UIC Direct Mode Operation and Railway GSM (UIC DMO & GSM-R) radio system operating in the band 876-880/921-925 MHz.

In this report, UIC DMO refers to 12.5 kHz analogue PMR and UIC GSM-R refers to 200 kHz system as defined in ECC Decision ECC/DEC(02)05, compliant to EN 300 113 and 3GPP TS 45.005 respectively. The report establishes the level of interference that can be expected to affect the UIC DMO & GSM-R radio systems when CDMA-PAMR is deployed adjacent to them.

Monte Carlo simulations have been performed using the CEPT's SEAMCAT (Spectrum Engineering Advanced Monte Carlo Analysis Tool) modelling tool in order to establish the level of interference from CDMA-PAMR to the UIC DMO & GSM-R radio systems. The simulations have considered three scenarios, namely:

- Scenario 1, CDMA-PAMR Mobile Station (MS) into UIC DMO MS (at 876-876.1 MHz)
- Scenario 2, CDMA-PAMR MS into UIC GSM-R Base Station (BS) (at frequencies in the uplink band)
- Scenario 3, CDMA-PAMR BS into UIC GSM-R MS (at frequencies in the downlink band).

The Monte-Carlo modelling has established that, provided that a guard band[1] of 125 kHz is left between the GSM-R and CDMA-PAMR uplink bands, between the GSM-R and CDMA-PAMR downlink bands, and below the frequency for DMO MS receive in the uplink band, the level of interference from CDMA-PAMR into UIC radio systems should generally be sufficiently low to avoid any noticeable interference for the Active Interferer Densities (AIDs) studied. Due to the nature of railway operations, however, where the GSM-R system is being used to support safe operation of the European Train Control System, it may be desired to allow a guard band of 200 kHz in order to reduce the risk of interference further.

MCL calculations of interference from CDMA-PAMR BS into UIC GSM-R MS, when the CDMA-PAMR BS is located within close proximity (i.e. 270 m in the suburban case and 141 m in the urban case) of the railway indicate that co-ordination is required. It should be noted that when implementing this co-ordination, national administrations may have to account for existing co-ordination agreements.

It should be noted that this report did not consider the interference from UIC Radio systems into CDMA-PAMR deployed in adjacent bands, since the effect from the new systems on the already agreed systems is the most important part to deal with.

---

[1] In this report the term guard band is considered to be the minimum frequency separation between the channel edges of the two systems.

INDEX TABLE

The Technical Impact of introducing CDMA-PAMR in the 870-876 / 915-921 MHz band on 12.5 kHz UIC DMO & 200 kHz GSM-R radio systems

1 INTRODUCTION

This report considers technical impact of introducing CDMA-PAMR (as specified in the Lucent SRDoc), on the International Union of Railways (UIC) Direct Mode Operation and Railway GSM (UIC DMO & GSM-R) radio systems, in the bands 876–880/921-925 MHz. In this report, UIC DMO refers to 12.5 kHz analogue PMR and UIC GSM-R radio system refers to 200 kHz as defined in ECC Decision ECC/DEC(02)05.

Parts of the calculations in this report have been performed using the ETSI specification EN 300 113 for the case of 12.5 kHz analogue PMR to cover UIC DMO. UIC DMO is a fall-back mode where five 12.5 kHz channels will be used around 876-876.1 MHz in case the infrastructure fails. In this mode the Mobile Stations (MSs) transmit and receive at the same frequency. This will increase the potential for interference to the UIC MSs because they receive in a band that is designated for uplink.

The report also contains calculations according to 3GPP TS 45.005 to cover the interference from CDMA-PAMR to UIC radio system (GSM-R).

Monte Carlo (MC) modelling has been performed using SEAMCAT (CEPT Spectrum Engineering Advanced Monte Carlo Analysis Tool) in order to investigate the interference to a UIC GSM-R and to UIC DMO caused by the introduction of a CDMA-PAMR network in adjacent spectrum with a guard band between them. The simulations focused on a 1.25 MHz band for CDMA-PAMR because the impact of a second and a third carrier is considered insignificant (see reasoning in Section 3.1.2 Active Interferer Densities). The modelling has investigated the effects of interference from both CDMA-PAMR base stations (BS) and MS to both UIC BS and MS, including DMO.

Minimum Coupling Loss (MCL) calculations have been performed for one scenario to ascertain the direct effect of CDMA-PAMR BS on the UIC GSM-R MS.

It should be noted that this report did not consider the interference from UIC radio systems into CDMA-PAMR deployed in adjacent bands, since the effect from the new systems on the incumbent ones is the most important part to deal with.

2 METHODOLOGY

2.1 Monte Carlo

Monte Carlo modelling using SEAMCAT® was undertaken in the following scenarios (see Figure 1):

- Scenario 1, CDMA-PAMR MS into UIC MS DMO (at 876-876.1 MHz)
- Scenario 2, CDMA-PAMR MS into UIC BS GSM-R (at frequencies in the uplink band)
- Scenario 3, CDMA-PAMR BS into UIC MS GSM-R (at frequencies in the downlink band).

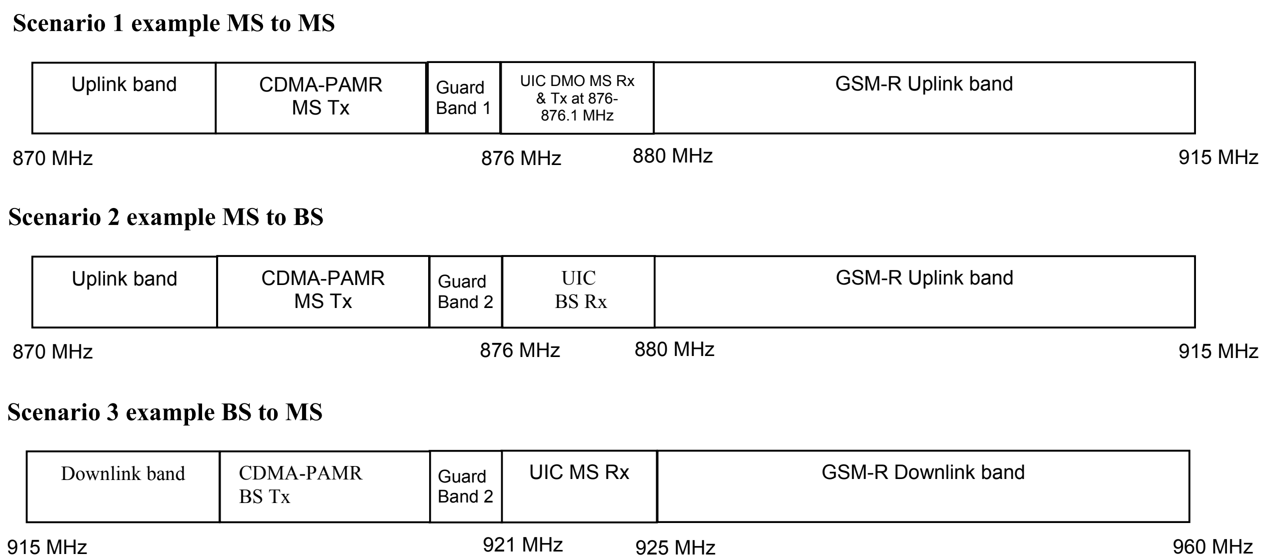

Figure 1: Examples of the different scenarios of UIC and CDMA-PAMR systems in the 870-880 MHz and 915–925 MHz bands

A single CDMA-PAMR channel was modelled in SEAMCAT for Scenario 1 (UIC DMO), that is a CDMA-PAMR single-carrier of 1.25 MHz (1x1250 kHz channel) interfering with a block of 0.1 MHz of UIC DMO (5x12.5 kHz channels), where the geographical position of the systems and the frequency of the UIC system is randomised. In addition a scenario was modelled where the UIC system was operating on a single adjacent channel to provide more precise information about the impact of the guard band, while all other parameters remaining as described above.

Scenarios 2 and 3 were modelled in SEAMCAT for a CDMA-PAMR single-carrier of 1.25 MHz (1x1250 kHz channel) interfering with a block of 3.8 MHz of UIC GSM-R (19x200 kHz channels), where the geographical position of the systems and the frequency of the UIC system was randomised. A one carrier duplex filter was used in the CDMA BS for the purposes of these calculations. The used CDMA spectrum mask including the duplex filter is shown in Annex 1. In addition a scenario was modelled where the UIC system was operating on a single adjacent channel to provide more precise information about the impact of the guard band, while all other parameters remaining as described above.

2.2 Minimum Coupling Loss

Whilst the SEAMCAT® tool has been used for most calculations, as the appropriate one for randomly located MS, one scenario was identified where it was also appropriate to use Minimum Coupling Loss (MCL) calculations. This scenario was the CDMA-PAMR BS located close to the railway where passing trains are fitted with GSM-R MSs to support the European Train Control System (ETCS). In this situation the GSM-R MS is in continuous communication exchanging messages approximately every 2 seconds. Loss of communication for more than 10 s causes the ETCS system to fall back to the less safe control methods causing disruption to the rail traffic. The ETCS system has been mandated under EU directives to be applied initially to high-speed routes and in due course to most European railway routes.
The path loss model used for the MCL calculations was the SE21 version of Hata.

3 INTERFERENCE MODELLING

This section presents results from the interference modelling with SEAMCAT.
The undertaken study investigated the interference that occurs from a CDMA-PAMR transmitter into a UIC receiver. Two mechanisms have been identified that need to be considered when introducing CDMA-PAMR services in the band:

1. Blocking will occur where the incoming power from the CDMA-PAMR transmitters is above the specified UIC blocking level; this will desensitise the UIC receiver, so that the reference sensitivity performance may not be maintained.
2. The Unwanted Emission (Spurious Emission and Wide Band Noise) from the CDMA-PAMR transmitters that is above the receiver noise floor will desensitise the UIC receiver, so that low-level signals may not be received.

All specifications used in the calculations have been derived using standard specification values as these represent the worst case values even though it is recognised that in practice real equipment performance may be better. With respect to the parameters required for the MC method used in this report it was decided to use the requirements of EN 300 113, 3GPP TS 45.005, TIA/EIA 97/98E and the Lucent SRDoc.

3.1 Propagation models and Active Interferer Densities

The propagation models were selected so as to be appropriate for the task.

3.1.1 Monte Carlo models

The ITU-R P.1411 Line-Of-Sight (LOS) propagation model was used for the UIC DMO radio link to cater for the special environment with LOS between MSs. All other Monte Carlo simulations were undertaken using the Extended Hata propagation model as defined by WGPT SE21.

3.1.2 Active Interferer Densities

AID were calculated on the basis that a limited amount of spectrum would be available. This report focused on a 1.25 MHz band for CDMA-PAMR because the impact of a second and third carrier is considered insignificant. This is because of the steep roll-off of the CDMA-PAMR wide band noise through the duplex filter and the carrier separations of 1.25 MHz. Hence, this report is valid for more than one CDMA carrier. The maximum and typical AID figures in Table 1 are quoted per carrier.

Environment	Cell Radius (km)	Cell Area (km^2)	AID (max) per carrier ($1/km^2$)	Number of Users at 0.015 Erlangs	AID (typical) per carrier ($1/km^2$)	Number of Users at 0.015 Erlangs
Urban	4.5	63.6	0.25	1060	0.1	424
Suburban	9	254.5	0.05	848	0.02	339
Rural	25	1963.5	0.01	1309	0.004	524

Table 1: Description of CDMA-PAMR Cell Radii and Active Interferer Density

The maximum urban AID has been assumed to be 0.5 per square km (representing hot spots). Assuming that two carriers are likely to be provided in dense urban areas, an AID of 0.25 per square km per carrier is expected. For suburban and rural environments a single carrier was assumed.

The base station densities were calculated as 1/cell area in km^2.
When the SEAMCAT study was undertaken, the possibility was considered that the interference from the victim system might raise the power control threshold of the CDMA system. This would have resulted in an increase of the interference potential of CDMA-PAMR. Facilities were therefore included in the power control models to simulate this form of interference. It was found that, at the considered AID, a difference of 1 dB was found in no more than 1% of the simulations. It was concluded that this effect was not significant for these simulations.

The effect however, should be considered for systems which have higher AID than considered here.

3.2 Monte Carlo modelling results

MC simulations were performed using the CEPT's SEAMCAT modelling tool in order to establish the level of interference from CDMA-PAMR into UIC 12.5kHz and 200 kHz systems. The simulations considered the three scenarios detailed in section 2.1. The effect of a CDMA-PAMR 1.25 MHz band into PMR/PAMR is considered representative for one or more carriers. This is because of the roll-off of the wide band noise compared to the very wide channel that leads to a second carriers contribution to the wide band noise is 1.25 MHz further away. This allows for simplified SEAMCAT simulations using a single carrier for CDMA-PAMR.
In each results' table, the typical values of interference are highlighted.

3.1.3 Scenario 1 Results: CDMA-PAMR MS to UIC DMO MS

The following tables contain results of SEAMCAT modelling of the interference from CDMA-PAMR MS into UIC DMO MS for a variety of different guard bands. There are three different possible cases depending on the victim MS and the height of its wanted MS:

a) CDMA-PAMR MS into UIC DMO victim MS = 1.5 m and wanted MS = 1.5 m; DMO range is 1000 m. The results are shown in Tables 2.1a and 2.2a.
b) CDMA-PAMR MS into UIC DMO victim MS = 1.5 m and wanted MS = 4 m; DMO range is 1500 m. The results are shown in Tables 2.1b and 2.2b.
c) CDMA-PAMR MS into UIC DMO victim MS = 4 m and wanted MS = 1.5 m; DMO range is 1500 m. The results are shown in Tables 2.1c and 2.2c.

Tables 2.1 a-c cover the case for the DMO MS users being randomly distributed in the 0.1 MHz DMO band and tables 2.2a-c for the case of the DMO MS being in the lowest DMO channel of the band.
A complete summary of the technical parameters used is given in Annex 1.

		Urban		Suburban		Rural	
Guard Band⇩	AID ⇨	0.25	0.1	0.05	0.02	0.01	0.004
125k		0.094%	0.040%	0.014%	0.007%	0.003%	0.001%
200k		0.070%	0.026%	0.014%	0.003%	0.004%	0.001%
260k		0.075%	0.029%	0.011%	0.002%	0.000%	0.000%
500k		0.056%	0.025%	0.007%	0.003%	0.001%	0.001%
1355k		0.010%	0.002%	0.001%	0.000%	0.000%	0.000%
3375k		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

Table 2.1a: Interference probability (%) from a CDMA-PAMR MS Single Channel into UIC DMO MS 0.1 MHz Band (Case a)

		Urban		Suburban		Rural	
Guard Band⇩	AID ⇨	0.25	0.1	0.05	0.02	0.01	0.004
125k		0.085%	0.037%	0.013%	0.004%	0.003%	0.001%
200k		0.058%	0.026%	0.009%	0.003%	0.002%	0.001%
260k		0.066%	0.025%	0.007%	0.002%	0.000%	0.000%
500k		0.051%	0.021%	0.004%	0.003%	0.001%	0.001%
1355k		0.005%	0.002%	0.001%	0.000%	0.000%	0.000%
3375k		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

Table 2.1b: Interference probability (%) from a CDMA-PAMR MS Single Channel into UIC DMO MS 0.1 MHz Band (Case b)

		Urban		Suburban		Rural	
Guard Band⇩	AID ⇨	0.25	0.1	0.05	0.02	0.01	0.004
125k		0.092%	0.038%	0.015%	0.004%	0.006%	0.001%
200k		0.063%	0.027%	0.013%	0.003%	0.007%	0.002%
260k		0.067%	0.026%	0.008%	0.002%	0.003%	0.000%
500k		0.053%	0.021%	0.004%	0.003%	0.001%	0.001%
1355k		0.005%	0.002%	0.001%	0.000%	0.000%	0.000%
3375k		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

Table 2.1c: Interference probability (%) from a CDMA-PAMR MS Single Channel into UIC DMO MS 0.1 MHz Band (Case c)

		Urban		Suburban		Rural	
Guard Band⇩	AID ⇨	0.25	0.1	0.05	0.02	0.01	0.004
125k		0.091%	0.031%	0.008%	0.004%	0.003%	0.001%
200k		0.070%	0.027%	0.012%	0.004%	0.002%	0.002%
260k		0.079%	0.027%	0.012%	0.003%	0.001%	0.000%
500k		0.053%	0.014%	0.005%	0.003%	0.002%	0.000%
1355k		0.008%	0.002%	0.001%	0.001%	0.001%	0.000%
3375k		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

Table 2.2a: Interference probability (%) from a CDMA-PAMR MS Single Channel into UIC DMO MS Single Channel (Case a)

		Urban		Suburban		Rural	
Guard Band⇩	AID ⇨	0.25	0.1	0.05	0.02	0.01	0.004
125k		0.083%	0.031%	0.012%	0.004%	0.002%	0.001%
200k		0.064%	0.024%	0.011%	0.003%	0.002%	0.002%
260k		0.073%	0.026%	0.011%	0.002%	0.001%	0.000%
500k		0.043%	0.011%	0.005%	0.002%	0.001%	0.000%
1355k		0.007%	0.002%	0.001%	0.000%	0.001%	0.000%
3375k		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

Table 2.2b: Interference probability (%) from a CDMA-PAMR MS Single Channel into UIC DMO MS Single Channel (Case b)

		Urban		Suburban		Rural	
Guard Band⇩	AID ⇨	0.25	0.1	0.05	0.02	0.01	0.004
125k		0.087%	0.031%	0.009%	0.004%	0.006%	0.001%
200k		0.068%	0.026%	0.011%	0.003%	0.003%	0.002%
260k		0.074%	0.027%	0.009%	0.003%	0.001%	0.001%
500k		0.044%	0.011%	0.005%	0.002%	0.001%	0.000%
1355k		0.007%	0.002%	0.001%	0.000%	0.001%	0.001%
3375k		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

Table 2.2c: Interference probability (%) from a CDMA-PAMR MS Single Channel into UIC DMO MS Single Channel (Case c)

3.1.4 Scenario 2 Results: CDMA-PAMR MS to UIC GSM-R BS

The following tables contain results of SEAMCAT modelling of interference from CDMA-PAMR MS into UIC GSM-R BS for a variety of different guard bands for the case of the GSM-R BS being randomly distributed across the 19 channels of the 3.8MHz GSM-R band and the case where the GSM-R BS is in the lowest GSM-R channel (i.e.921.2MHz).

		Urban		Suburban		Rural	
Guard Band⇩	AID ⇨	0.25	0.1	0.05	0.02	0.01	0.004
125k		0.220%	0.088%	0.076%	0.027%	0.022%	0.008%
200k		0.184%	0.065%	0.082%	0.035%	0.017%	0.005%
260k		0.166%	0.063%	0.062%	0.027%	0.013%	0.003%
500k		0.108%	0.047%	0.041%	0.011%	0.007%	0.003%
1355k		0.060%	0.020%	0.016%	0.004%	0.003%	0.003%
3375k		0.027%	0.009%	0.014%	0.004%	0.000%	0.000%

Table 3.1: Interference probability (%) from a CDMA-PAMR MS Single Channel into UIC GSM-R BS 3.8 MHz band

		Urban		Suburban		Rural	
Guard Band⇩	AID ⇨	0.25	0.1	0.05	0.02	0.01	0.004
125k		1.262%	0.485%	0.491%	0.167%	0.154%	0.054%
200k		0.950%	0.345%	0.375%	0.131%	0.120%	0.043%
260k		0.825%	0.285%	0.309%	0.116%	0.087%	0.034%
500k		0.504%	0.167%	0.199%	0.071%	0.054%	0.015%
1355k		0.132%	0.047%	0.046%	0.024%	0.011%	0.005%
3375k		0.040%	0.013%	0.004%	0.002%	0.000%	0.000%

Table 3.2: Interference probability (%) from a CDMA-PAMR MS Single Channel into UIC GSM-R BS Single Adjacent Channel

3.1.5 Scenario 3 Results: CDMA-PAMR BS to UIC GSM-R MS

The following tables contain results of SEAMCAT modelling of interference from CDMA-PAMR BS into UIC GSM-R MS for a variety of different guard bands. There are two different possible cases depending on the height of the victim MS:

a. Victim MS is hand held at 1.5 m height. The results are shown in Tables 4.1a and 4.2a.
b. Victim MS is on a carriage of the train at 4 m height. The results are shown in Tables 4.1b and 4.2b.

Both of the above were carried out for the case of the GSM-R MS being randomly distributed across the 19 channels of the 3.8 MHz GSM-R band and the case where the GSM-R MS is in the lowest GSM-R channel (i.e. 870.2 MHz).

		Urban		**Suburban**		**Rural**	
BS AID⇨		**0.0190074**		**0.0047519**		**0.0006158**	
Guard Band⇩	**MS AID ⇨**	**0.25**	**0.10**	**0.05**	**0.02**	**0.01**	**0.004**
125k		0.006%	0.006%	0.003%	0.003%	0.000%	0.000%
200k		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
260k		0.001%	0.001%	0.003%	0.003%	0.000%	0.000%
500k		0.002%	0.002%	0.000%	0.000%	0.000%	0.000%
1355k		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
3375k		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

Table 4.1a: Interference probability (%) from a CDMA-PAMR BS Single Channel into UIC GSM-R MS 3.8 MHz Band (MS = 1.5 m)

		Urban		Suburban		Rural	
BS AID⇨		0.0190074		0.0047519		0.0006158	
Guard Band⇩	MS AID ⇨	0.25	0.10	0.05	0.02	0.01	0.004
125k		0.005%	0.001%	0.003%	0.003%	0.000%	0.000%
200k		0.000%	0.001%	0.000%	0.002%	0.000%	0.000%
260k		0.000%	0.000%	0.001%	0.000%	0.000%	0.000%
500k		0.001%	0.000%	0.000%	0.002%	0.000%	0.000%
1355k		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
3375k		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

Table 4.1b: Interference probability (%) from a CDMA-PAMR BS Single Channel into UIC GSM-R MS 3.8 MHz Band (MS = 4 m)

		Urban		Suburban		Rural	
BS AID⇨		0.0190074		0.0047519		0.0006158	
Guard Band⇩	MS AID ⇨	0.25	0.10	0.05	0.02	0.01	0.004
125k		0.024%	0.022%	0.009%	0.009%	0.003%	0.003%
200k		0.010%	0.007%	0.006%	0.006%	0.001%	0.001%
260k		0.010%	0.010%	0.002%	0.001%	0.002%	0.002%
500k		0.005%	0.005%	0.004%	0.002%	0.001%	0.001%
1355k		0.000%	0.000%	0.001%	0.001%	0.001%	0.001%
3375k		0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

Table 4.2a: Interference probability (%) from a CDMA-PAMR BS Single Channel into UIC GSM-R MS Single Adjacent Channel (MS = 1.5 m)

		Urban		Suburban		Rural	
BS AID⇨		**0.0190074**		**0.0047519**		**0.0006158**	
Guard Band⇩	**MS AID ⇨**	**0.25**	**0.10**	**0.05**	**0.02**	**0.01**	**0.004**
125k		0.020%	0.017%	0.016%	0.008%	0.004%	0.001%
200k		0.007%	0.005%	0.007%	0.004%	0.000%	0.000%
260k		0.004%	0.006%	0.002%	0.000%	0.000%	0.002%
500k		0.003%	0.004%	0.005%	0.002%	0.000%	0.000%
1355k		0.000%	0.000%	0.000%	0.001%	0.000%	0.001%
3375k		0.001%	0.000%	0.000%	0.000%	0.000%	0.000%

Table 4.2b: Interference probability (%) from a CDMA-PAMR BS Single Channel into UIC GSM-R MS Single Adjacent Channel (MS = 4 m)

Whilst the calculations show a very low probability of interference from the CDMA-PAMR BS into UIC GSM-R MS, additional MCL calculations (Annex 2) show that there is a risk of interference in a small number of cases due to blocking when the CDMA-PAMR BS is located within 141 m (urban case) to 270 m (suburban case) of the railway. This is particularly significant where the GSM-R system is supporting the ERTMS/ETCS train control application with the MS in continuous communication as explained in Section 2.2.

4 OBSERVATIONS

From the results of the calculations it is clear that an insignificant level of interference may be expected in the CDMA-PAMR MS to UIC DMO MS case.

In the case of CDMA-PAMR MS into UIC GSM-R BS the interference becomes detectable.
In the single adjacent channel case (Scenario 2, Table 3.2) with a 125 kHz guard band and a typical AID of 0.1 per carrier, the probability of interference is 0.485% and with the maximum AID of 0.25 per carrier, the probability of interference is 1.262%. The relationship with AID appears linear from tables 3.1 and 3.2, Thus if higher AIDs are anticipated these results should be reviewed.

The SEAMCAT calculations for Scenario 3 also show a very low probability of interference from the CDMA-PAMR BS to the UIC GSM-R MS. However the MCL calculations show that there is a risk that blocking can disrupt communication at distances of 141 m (urban) to 270 m (suburban). Co-ordination will be required at these distances.

5 CONCLUSIONS

From the above SEAMCAT calculations, the risk of harmful interference from CDMA-PAMR interfering with UIC DMO (12.5 kHz) and GSM-R (200 kHz) systems in the 900MHz band is low for all of the considered scenarios. In the specific case of CDMA-PAMR MS to UIC DMO MS no noticeable interference is expected.

The modelling has demonstrated that a guard band of 125 kHz between the GSM-R and CDMA-PAMR uplink bands, between the GSM-R and CDMA-PAMR downlink bands, and below the frequency for DMO MS receive in the uplink band, should generally be sufficient to avoid any noticeable interference for the AIDs studied. Due to the nature of railway operations however, particularly where the GSM-R system is being used to support operation of the ETCS train control system (section 2.2), it may be desired to allow a guard band of 200 kHz in order to reduce the risk of interference further.

MCL calculations from CDMA-PAMR BS into UIC-GSM-R MS when the CDMA-PAMR BS is located within close proximity (i.e. 270m in the suburban case and 141m in the urban case) of the railway indicate that coordination is required. It should be noted that when implementing this co-ordination, national administrations may have to take account of existing co-ordination agreements.

It should be noted that this report did not consider the interference from UIC Radio systems into CDMA-PAMR deployed in adjacent bands, since the effect from the new systems on the already agreed systems is the most important part to deal with.

6 REFERENCES

[1] ETSI TR 102 260 v1.1.1: CDMA-PAMR System Reference Document.
[2] CDMA-PAMR SRDoc V0.1.1 (2002-8), Lucent Technologies, "System Reference Document, CDMA-PAMR", SE(02)114.
[3] TIA/EIA/IS-2000.1-C, "Introduction to cdma2000 Standards for Spread Spectrum Systems".
[4] TIA/EIA/IS-2000.2-C, "Physical Layer Standard for cdma2000 Spread Spectrum Systems".
[5] TIA/EIA/IS-2000.3-C, "Medium Access Control (MAC) Standard for cdma2000 Spread Spectrum Systems".
[6] TIA/EIA/IS-2000.4-C, "Signalling Link Access Control (LAC) Standard for cdma2000 Spread Spectrum Systems".
[7] TIA/EIA/IS-2000.5-C, "Upper Layer (Layer 3) Signalling Standard for cdma2000 Spread Spectrum Systems".
[8] TIA/EIA-97-E, "Recommended Minimum Performance Standard for cdma2000 Spread Spectrum Base Stations".
[9] TIA/EIA-98-E, "Recommended Minimum Performance Standards for cdma-2000 Spread Spectrum Mobile Stations".
[10] UIC Project EIRENE, "System Requirements Specification", Version 13.0, Ref MDA029D010-13.0, 15 December 2000, SE37(02)11.
[11] 3GPP TS 45.005, Technical Specification Group GSM/EDGE, Radio Access Network; Radio transmission and reception
[12] ETSI EN 300 113-1 and -2, "Land mobile service; Radio equipment intended for the transmission, of data (and speech) and having an antenna connector"

ANNEX 1: TECHNICAL PARAMETERS USED FOR SEAMCAT® MONTE CARLO MODELLING

Parameter			**CDMA-PAMR**		**FM (DMO)**		**GSM-R**	
			MS	**BS**	**MS**	**BS n/a**	**MS**	**BS**
Channel Spacing		kHz	1250	1250	12.5	12.5	200	200
Cell Radius – Urban		km	4.5		1.0/1.5*		1.6	
– Suburban		km	9		1.0/1.5*		3	
– Rural		km	25		1.0/1.5*		5	
Transmit Power		dBm	23***	44	30		30	44
Receiver Bandwidth		kHz	1250	1250	8		200	200
Antenna Height		m	1.5	30	1.5/4**		1.5/4**	30
Antenna Gain		dB	0	15	0		0	15
Receiver Sensitivity		dBm	-117	-124	-106		-104	-104
Receiver Protection Ratio		dB			12		9	9
Power Control Characteristics	Step	dBm	1	1	N/A	N/A	N/A	N/A
	Range	dBm	60	PC sim.	N/A	N/A	N/A	N/A
	Threshold	dBm	See table below	See table below	N/A	N/A	N/A	N/A

* Calculated using the P1411 propagation model. The cell radius does not exceed 1.0 km for the 1.5 m to 1.5 m MS case and 1.5 km for the 1.5 m to 4 m MS case.
** Antenna height used is 1.5 m for hand held mobiles and 4 m on cab of the train.
*** Although the TIA/EIA-98-E standard specifies values up to 38 dBm for CDMA mobiles' output power, in practice, the maximum output power from existing CDMA-PAMR mobile is 23 dBm in accordance with the ETSI and Lucent SRDocs. This is the value for the maximum output power that is designed into CDMA-PAMR mobiles, and is the same value as the maximum output power for CDMA-1X mobiles (on which CDMA-PANR mobiles are based). The value is suitable for balancing of uplink and downlink link budgets (with CDMA-PAMR base stations having maximum output power of up to 44 dBm). Note that CDMA-PAMR employs fast power control on both the uplink and the downlink, with a particularly large dynamic range on the downlink (typically 60 dB). Hence, both base stations and mobiles in a CDMA-PAMR network will usually be transmitting at output powers that are significantly below the maximum values. For example, the typical output power from a CDMA-PAMR mobile operating on a typical CDMA-PAMR network can be expected to be at least 10-20 dB below the maximum value.

Unwanted Emissions CDMA-PAMR:
The emission levels for frequency offsets between the separations are derived by linear interpolation.

Separation from centre frequency (| Δf |)	Emission limit
750 kHz	-45 dBc / 30kHz
885 kHz	-60 dBc / 30kHz
1.125 to 1.98 MHz	-65 dBc / 30kHz
1.98 to 4.00 MHz	-75 dBc / 30kHz
4.00 to 6.00 MHz	-36 dBm / 100 kHz
> 6.00 MHz	-45 dBm / 100 kHz

a) Base Station limits from the Lucent CDMA-PAMR SRDoc.

Separation from centre frequency (| Δf |)	Emission limit
885 kHz	-47 dBc / 30kHz
1.125 MHz*	-54 dBc / 30kHz
1.98 MHz	-67 dBc / 30kHz
4.00 MHz	-82 dBc / 30kHz
4.00 to 10.0 MHz	-51 dBm / 100kHz

b) Mobile Station limits from the Lucent CDMA-PAMR SRDoc.
*** Note In the TIA/EIA 98E standard the figure given is 1.120 MHz due to a typographical error (Table 4.5.1.3-5, Sub class 1).**

CDMA BS Spectrum Mask Including a One Carrier Duplex Filter

Note 1: this specification for duplex filter performance is proprietary and not included as part of the TIA specifications as referenced in Lucent SRDoc.

	CDMA - PAMR BS Spec.	CDMA - PAMR 44 dBm BS Spec. dBc	CDMA-PAMR BS Normalised to 30 kHz bw		
Offset kHz 1 Channel			1 carrier dBc	Duplex Spec dBc	1 carrier incl Duplexer
-30000	-45.0	-89.0	-94.2	-75.0	-169
-15000	-45.0	-89.0	-94.2	-85.0	-179
-6000	-45.0	-89.0	-94.2	-85.0	-179
-5999	-36.0	-80.0	-85.2	-85.0	-170
-4000	-36.0	-80.0	-85.2	-40.0	-125
-3999	-75.0	-75.0	-75.0	-40.0	-115
-1980	-75.0	-75.0	-75.0	-25.0	-100
-1979	-65.0	-65.0	-65.0	-25.0	-90
-1125	-65.0	-65.0	-65.0	-15.0	-80
-1000	-62.5	-62.5	-62.5	-15.0	-78
-885	-60.0	-60.0	-60.0	-10.0	-70
-750	-45.0	-45.0	-45.0	0.0	-45
-625	0	0.0	-16.2	0.0	-16
625	0	0.0	-16.2	0.0	-16
750	-45.0	-45.0	-45.0	0.0	-45
885	-60.0	-60.0	-60.0	-10.0	-70
1000	-62.5	-62.5	-62.5	-15.0	-78
1125	-65.0	-65.0	-65.0	-15.0	-80
1979	-65.0	-65.0	-65.0	-25.0	-90
1980	-75.0	-75.0	-75.0	-25.0	-100
3999	-75.0	-75.0	-75.0	-40.0	-115
4000	-36.0	-80.0	-85.2	-40.0	-125
5999	-36.0	-80.0	-85.2	-50.0	-135
6000	-45.0	-89.0	-94.2	-50.0	-144
30000	-45.0	-89.0	-94.2	-75.0	-169

FM MS (UIC DMO) Receiver Blocking Characteristics from ETSI EN 300 113

Frequency Offset		FM MS
4 kHz	dBc	0
6.25 kHz	dBc	60
18.75 kHz	dBc	60
18.76 kHz	dBc	70
1000 kHz	dBc	70
1000.01 kHz	dBc	84
20000 kHz	dBc	84

GSM Receiver Blocking Characteristics - extract from 3GPP TS 45.005

Frequency Band	GSM 400, P-, E- and R-GSM 900						DCS 1 800 & PCS 1 900			
	other MS		small MS		BTS		MS		BTS	
	dBμV (emf)	dBm	dBμV (emf)	DBm	dBμV (emf)	dBm	dBμV (emf)	dBm	DBμV (emf)	dBm
in-band										
600 kHz ≤ $\lvert f-f_o \rvert$ < 800 kHz	75	-38	70	-43	87	-26	70	-43	78	-35
800 kHz ≤ $\lvert f-f_o \rvert$ < 1,6 MHz	80	-33	70	-43	97	-16	70	-43	88	-25
1,6 MHz≤ $\lvert f-f_o \rvert$ < 3 MHz	90	-23	80	-33	97	-16	80	-33	88	-25
3 MHz ≤ $\lvert f-f_o \rvert$	90	-23	90	-23	100	-13	87	-26	88	-25
out-of-band #										
(a)	113	0	113	0	121	8	113	0	113	0
(b)	-	-	-	-	-	-	101	-12	-	-
(c)	-	-	-	-	-	-	101	-12	-	-
(d)	113	0	113	0	121	8	113	0	113	0
NOTE: For definition of small MS, see sub clause 1.1.* see below										

Note * Extract from 3GPP TS 45.005
In this ETS some relaxations are introduced for GSM 900 MSs which fulfil the following conditions:
- *pertain to power class 4 or 5 (see subclause 4.1.1);*
- *not designed to be vehicle mounted (see GSM 02.06).*

In this ETS these Mobile Stations are referred to as "small MS".

Note # Definition of out of band frequency ranges from 3GPP TS 45.005.

Frequency Band	*Frequency range (MHz)*			
	GSM 900		*E-GSM 900*	*R-GSM 900*
	MS	*BTS*	*BTS*	*BTS*
in-band	*915 - 980*	*870 - 925*	*860 - 925*	*856 - 921*
out-of-band (a)	*0.1 - < 915*	*0.1 - < 870*	*0.1 - < 860*	*0.1 - < 856*
out-of-band (b)	*N/A*	*N/A*	*N/A*	*N/A*
out-of band (c)	*N/A*	*N/A*	*N/A*	*N/A*
out-of band (d)	*> 980 - 12,750*	*> 925 - 12,750*	*> 925 - 12,750*	*> 921 - 12,750*

Frequency Band	*Frequency range (MHz) DCS 1 800*	
	MS	*BTS*
in-band	*1 785 - 1 920*	*1 690 - 1 805*
out-of-band (a)	*0.1 - 1705*	*0.1 - < 1 690*
out-of-band (b)	*> 1 705 - < 1 785*	*N/A*
out-of band (c)	*> 1 920 - 1 980*	*N/A*
out-of band (d)	*> 1 980 - 12,750*	*> 1 805 - 12,750*

Active Interferer Densities

Environment	**CDMA-PAMR**		
	MS Max. per carrier	**MS Typical per carrier**	**BS per carrier/cell**
Urban	0.25	0.1	0.0190074
Suburban	0.05	0.02	0.0047519
Rural	0.01	0.004	0.0006158

Information in this table is based on assumption of hexagonal cells. The BS densities are calculated as 1/cell area in km^2. Area of regular hexagon = $[(^3/_2 \cdot \sqrt{3}) \cdot R^2]$, where R is the cell radius.

CDMA-PAMR TX power distribution and related Rx threshold values for urban, sub-urban and rural environment cases

Environment	**CDMA-PAMR BS Power distribution (Cumulative probability for SEAMCAT)**					**Related BS Rx threshold values**
	37 dBm	**38 dBm**	**39 dBm**	**40 dBm**	**41 dBm**	**dBm**
Urban max. MS aid 0.25, r = 4.5 km, N =-106.1 dBm	0.03	0.33	0.71	0.94	1	-115.78
Urban typ. MS aid 0.1, r = 4.5 km, N, =-106.1 dBm	0.42	0.86	0.98	1		-116.76
Suburban max. MS aid 0.05, r = 9 km, N, =-111.1 dBm	0.07	0.58	0.93	1		-121.17
Suburban typ. MS aid 0.02, r = 9 km, N, =-111.1 dBm	0.54	0.95	1			-121.95
Rural max. MS aid 0.01, r = 25 km, N, =-113.1 dBm	0.16	0.95	1			-122.23
Rural typ. MS aid 0.004, r = 25 km, N, =-113.1 dBm	0.09	0.96	1			-123.58

Frequencies for the simulation

a) CDMA-PAMR MS into UIC DMO MS (Scenario 1)

CDMA Range (Carrier Centres):

Guard Band (kHz)	125	200	260	500	1355	3375
CDMA Carrier 1	875.25	875.175	875.115	874.875	874.02	872

DMO (FM) Frequency Range: 876.00625 to 876.06875 MHz.
DMO (FM) Most Proximate Carrier: 876.0125 MHz (for single carrier interference).

b) CDMA-PAMR MS into GSM-R BS (Scenario 2)

CDMA Range (Carrier Centres):

Guard Band (kHz)	125	200	260	500	1355	3375
CDMA Carrier 1	875.25	875.175	875.115	874.875	874.02	872

GSM-R Frequency Range: 876.100 to 879.900 MHz.
GSM-R Most Proximate Carrier: 876.200 MHz (for single carrier interference).

c) CDMA-PAMR BS into GSM-R MS (Scenario 3)

CDMA Range (Carrier Centres):

Guard Band (kHz)	125	200	260	500	1355	3375
CDMA Carrier 1	920.25	920.175	920.115	919.875	919.02	917

GSM-R Frequency Range: 921.100 to 924.900 MHz.
GSM-R Most Proximate Carrier: 921.200 MHz (for single carrier interference).

ANNEX 2: MINIMUM COUPLING LOSS CALCULATIONS – CDMA TO UIC GSM-R

The following parameters were used for this calculation:

Modelled Max CDMA Tx Power	51 dBm
Max CDMA Tx Power	55 dBm
CDMA Bandwidth	1.23MHz
CDMA Centre Frequency	920.25 MHz

GSM-R Sensitivity	-104 dBm
GSM-R Bandwidth	200 KHz
GSM-R Centre Frequency	921.2 MHz

At the frequencies shown:

- CDMA Unwanted Emissions will be 60 dBc/30 KHz
- GSM Blocking protection will be -43 dBm.

It is subject to debate concerning whether the mean transmitted power should be applied to the CDMA system or the maximum transmitted power. Whilst on conventional systems the power control process will ensure that distant mobiles result in the use of the maximum power, the modelling of the CDMA system and the results shown in Annex 1 revealed that this did not take place and the power did not exceed 51 dBm. For this MCL calculation the figure of 51 dBm has been used.

Unwanted Emissions

CDMA Tx Power	51 dBm
Bandwidth conversion to 200 KHz	-7.9 dB
Attenuation to adjacent band	-51.7 dB
Sensitivity	-104 dBm
C to I	8 dB
Protected Sensitivity	-112 dBm
Duplex Filter	-13.2dB

Required path loss	90.2 dB

Blocking

CDMA-PAMR Tx Power	51 dBm
Blocking Protection	-43 dBm

Required Path Loss	**94 dB**

The maximum required path loss is 94 dB. The path loss model used at these distances is the SE21 version of Hata.

The urban distance for this path loss is 141 metres. The suburban path loss is 270 metres.