European Radiocommunications Committee (ERC)
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NARROWBAND RETURN PATH TWO WAY PAGING COMPATIBILITY STUDIES IN THE 406.1 - 410 MHz, 440 - 470 MHz AND 862 - 871 MHz BANDS

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EXECUTIVE SUMMARY

This report is the final report of CEPT Project Team SE33 concerning compatibility studies on the allocation of spectrum for return path Two Way Paging (TWP) narrow band channels.

SE33 was requested to perform analysis on the frequency bands listed below:

i. 406.1 – 410 MHz

ii. 440 – 470 MHz

iii 862 – 871 MHz

To perform co-existence and compatibility studies SE33 used two techniques to develop conclusions on identifying a suitable spectrum allocation. These are a methodology developed in SE33 which is described in detail in the report, and a Monte Carlo analysis based on the Monte Carlo analysis tool developed in WGSE.

In order to gain a greater degree of confidence in its findings SE33 has also performed where appropriate, additional adjacent band analysis of operational services with TWP.

Conclusions

SE33 makes the following conclusions regarding the allocation of spectrum for Narrowband TWP channels:

1. 406.1 – 410 MHz

SE33 concludes that sharing between TWP and Radioastronomy services in the 406.1 – 410 MHz band will be subject to very large co-ordination distances.

2. 440 – 470 MHz

a) 440 – 450 MHz

The results in this report are presented as separation distances which are comparable to those in the 450 - 470 MHz band but coordination would be subject to smaller distances. However due to the fact the methodology used is based on worst case assumptions, the actual separation distances are expected to be lower than those calculated. These distances could be reduced by the use of planning and/or site engineering.

b) 450 - 470 MHz

The results in this report are presented as separation distances which can be considered large. However due to the fact the methodology used is based on worst case assumptions, the actual separation distances are expected to be lower than those calculated. These distances could be reduced by the use of planning and/or site engineering.

3. 862 – 871 MHz

Based on the results of these studies and the diminishing usage of CT2 the band 867.6 - 868.0 MHz is considered feasible for TWP. However, it should be noted that for countries who deploy Tactical Radio Relay systems based on the parameters in the Report, sharing is not considered feasible. It is not desirable to use two-way paging in the 867.6 - 868.0 MHz band if channel 69 television transmissions are to be used. The uncertainty of use of channel 69 is discussed in section 3.4.1.

Narrow band Return Path Two Way Paging Compatibility Studies
in the 406.1 - 410 MHz, 440 - 470 MHz and 862-871 MHz bands

INDEX TABLE

1 INTRODUCTION

This report is the final report of CEPT Project Team SE33 concerning compatibility studies on the allocation of spectrum for return path Two Way Paging (TWP) narrow band channels (the ToR of SE33 is attached in **Annex 1**).

The report describes in detail the methodology and processes used to determine which spectrum could be suitable for TWP and the sharing criteria required in order to provide a commercial TWP service.

The report is not intended to provide detail of all the compatibility studies performed in SE33 but highlights the important work used to formulate the conclusions of SE33. The reader is referenced to two main reports produced in SE33; CEPT SE33/FM35(99)36rev1' Sharing studies to identify suitable Return Path frequencies for the ETSI TWP Narrow Band Standard' and CEPT SE33/FM35(98)35' A Compatibility Study of ReFLEX Sharing with CT2 in the Band 864.1 – 868.1 MHz and TETRA in the Bands 870 - 876 MHz and 915 - 921 MHz adjacent to GSM, GSM-R, SRD and CAD Bands' where further details can found regarding technical analysis.

2 SCOPE OF ACTIVITIES

SE33 was requested to perform analysis on the frequency bands listed below with general usage listed as described in the ECA Table, though is noted that national usage can be significantly different across the CEPT:

2.1 406.1 – 410 MHz

Radio Astronomy
Land Mobile – single frequency

2.2 440 – 470 MHz

440 – 450 MHz
Land Mobile – analogue & digital PMR/Radio Location/On-site paging

450 – 470 MHz
Mobile – analogue & digital PMR/existing cellular networks

2.3 862 – 871 MHz

863 – 865 MHz	: -	Cordless Audio Devices
864.1 – 868.1 MHz	: -	CT2 telephony
868 – 870 MHz	: -	Non-specific Short Range Devices
870 – 871 MHz	: -	Mobile/Defense systems

In order to gain a greater degree of confidence SE33 has also performed adjacent band analysis of operational services with TWP.

3 SHARING STUDIES

This section provides a description of the sharing studies performed in SE33. In each of the three bands listed in Section 2 an analysis of the study results is presented and conclusions are drawn regarding the suitability of providing a spectrum allocation to TWP.

3.1 406.1 – 410 MHz Band

The use of this band is dominated by Radio Astronomy particularly in the major populated countries of Europe, which are the key two-way paging markets.

3.1.1 Sharing with radio astronomy in 406.1 – 410 MHz

Radio Astronomy sites have very sensitive receivers (not too dissimilar to the return channel base station paging receivers) and a very tight level specification for protection from harmful interference is defined. As a result sharers of this band, for example Short Range Devices, civil radio location systems, and land mobile radio (single frequency operation) are limited on a geographical basis.

From Rec. ITU-R RA. 769-1 "Protection criteria used for radioastronomical measurements" and CEPT SE33/FM35(98)31 "French Services in the three bands proposed, Parameters for the compatibility analysis" , threshold levels of interference detrimental to radio astronomy continuum observations are given.

Centre frequency	**Assumed bandwidth**	Harmful interference levels **Input power (integration time)**	
		2000 seconds	**1second**
408.05 MHz	**3.9 MHz**	**-173dBm**	**-156dBm**

Table 1. Levels of interference detrimental to radio astronomy observations

If we use the Minimum Coupling Loss method described in WG-SE(99) TEMP 37 to identify the sharing opportunities, then the unwanted emissions analysis equation is :-

Isolation = $P_{INT} + dB_{BW} + MC_{INT} + G_{VICT} + G_{INT} - (S_{VICT} - C/I_{VICT}) + f(dBc_{INT}, P_{INT})$

The relevant radio parameters required by the analysis are provided in **Table 2**.

Parameter	Value
Interferer Transmit Power including ant. gain (Typical)	17.78 dBm (60mW)
Interferer Transmit Power including ant. gain (Max)	27.00 dBm (500mW)
Bandwidth Conversion Factor	0 dB
Multiple Carrier Margin	0 dB
Base Antenna Gain (assumed)	9 dBi
Victim Sensitivity including Protection ratio	-173dBm / - 156 dBm

Table 2. Radio System Parameters (Taken from Table 1, and CEPT SE33 (98)23 "Return Channel Parameters for Spectrum Engineering Analysis") for Unwanted Emissions MCL Analysis

The isolation requirement in dB is given by -
Isolation = 199.78 dB (60 mW and 2000 second integration time)
= 209.0 dB (500 mW and 2000 second integration time)
= 182.78 dB (60 mW and 1 second integration time)
= 192.0dB (500 mW and 1 second integration time).

These isolations can be achieved through physical separation. The path loss model or a suburban area specified by WG SE in the Monte Carlo specification[1] has been used for this study. Distances above 20 km are only considered so the modified Hata propagation model is assumed.

For the following operational conditions:-

Frequency = 408 MHz
Mobile station antenna height = 1.5 m
Base station antenna height = 30 m
Distance between systems "d" = > 20km

The propagation model from [1] (Sub-annex B.a.1) is :-

[1] CEPT ERC SE Monte Carlo Radio Compatibility Tool, Doc. SE(97)30, http://www.ero.dk/eroweb/monte/SE973001.pdf

Suburban;
Median path loss L = -15.8 + 41.77 log d dB
(where d is in meters)

From applying the isolations required to the above path loss equation **Table 3** can be obtained.

Operational conditions	Required protection distance
Typical ERP and 1 second integration	57 km
Maximum ERP and 1 second integration	94 km
Typical ERP and 2000 second integration	145 km
Maximum ERP and 2000 second integration	240 km

Table 3. Protection distances required between a Two-way pager operating in the 406.1 - 410 MHz Band and a Radio Astronomy site.

The figures in **Table 3** are basically in line with the paper submitted by the UK CEPT SE33/FM35(98)3 "United Kingdom services in the band 406 – 410 MHz" In the UK there are eight Radio Astronomy user sites and there is a 100 km co-ordination zone around each.

3.1.2 Additional information on the protection of the lower adjacent band 406 - 406.1 MHz

In addition, care must be taken for future systems in the band 406.1 - 410 MHz in order not to cause harmful degradation to the Cospas-Sarsat system in the band 406 - 406.1 MHz. This band is dedicated to search and rescue and it is clearly stated that « any emission capable of causing harmful interference to the authorised uses of the band 406-406.1 MHz is prohibited ».
Following ITU-R Resolution 219, a DNR (Draft New Recommandation) has been adopted at the ITU-R WP-8D meeting (April 1999) giving the relevant figures to be considered to protect the 406 - 406.1 MHz band.
However, due to the large co-ordination distances needed to protect the Radioastronomy services in the 406.1 – 410 MHz band (see section 3.1.1 above), it has been considered that it was not useful to study further this frequency band. Therefore, the impact of TWP on the 406-406.1 MHz band has not been analysed in this report.

3.1.3 Conclusion of Sharing in the 406.1 – 410 MHz band

SE33 concludes that sharing between TWP and Radioastronomy services in the 406.1 – 410 MHz band will be subject to very large co-ordination distances.

3.2 440 – 470 MHz BAND

3.2.1 450 – 470 MHz

From the papers submitted to the SE33 it can be concluded that the major users of this band are Private Mobile Radio both analogue and digital, and analogue cellular radio telephone services.

Both PMR and cellular sites have portions of the band for transmission and portions for reception. The effective radiated power from the base station transmitters and the mobile transmitter is approximately the same so the interference is a function of the proximity probability . Sharers of the band include on-site paging with callout and answer back and wide area one way paging using high power transmitters.

This band is characterised by an uncertainty resulting from a change from old analogue systems to new digital systems both in the field of PMR and cellular. Also the introduction of these new systems is being used to correct inconsistencies between different European countries. For example the UK will be changing the base station receive frequencies to base station transmit frequencies over a phased eight year program.
The band will over a period be brought into line with Recommendation T/R 25-08, T/R 22-01 & T/R 22-05.

An important aspect of evaluating this band for a Two-way paging return channel use is assessing the level of radio frequency interference that the return channel base station receiver is going to be exposed to. In order to do this it is necessary to have a specification for the out of band emissions generated by the other users of the band, e.g. PMR, both analogue and digital and analogue cellular.

The older PMR analogue transmitters, both mobile and fixed, did not have an approval specification that identified out of band power beyond the adjacent channel.

An evaluation based on **Tables 10, 11** & **12** would yield similar results in this band as for the 440 – 450 MHz band if this band were not subject to the major changes planned.

3.2.1.1 Sharing with TETRA

The sharing possibilities of this band were analysed by using information from CEPT SE7(98)66r " Adjacent Band Compatibility of 400 MHz TETRA and Analogue FM PMR" and models from SE(99)TEMP 387 "Evaluation of Minimum Frequency Separation".

The use of the MCL Minimum Coupling Loss method was considered appropriate because the major interference was from the TETRA Base station transmitters into the Two-way paging base station receivers. The result being to black out areas of Two-way Return Channel coverage.

The data used in the analysis is shown in **Tables 4** to **7**.
TETRA : -

Parameter	Mobile Station	Base Station
Channel Spacing	25 kHz	25 kHz
Transmit Power	30 dBm, 35 dBm, 40 dBm	44 dBm
Receiver Bandwidth	18 kHz	18 kHz
Antenna Height	1.5 m	30 m
Antenna Gain	0 dBi	9 dBi (12 dBi - 3 dB)
Active Interferer Density Range	Variable	Variable
Receiver Sensitivity	- 103 dBm	- 106 dBm
Receiver Protection Ratio	19 dB	19 dB
TDMA Users / carrier	4	4
Power Control Characteristic	5 dB steps to a minimum of 15 dBm. Threshold = - 86 dBm	Not used

Table 4. Parameters used to model the TETRA System

Frequency Offset	30 dBm Mobile Station	35 dBm Mobile Station	40 dBm Mobile Station	44 dBm Base Station
25 kHz	- 60 dBc	- 60 dBc	- 60 dBc	- 60 dBc
50 kHz	- 66 dBc	- 70 dBc	- 70 dBc	- 70 dBc
75 kHz	- 66 dBc	- 70 dBc	- 70 dBc	- 70 dBc
100 – 250 kHz	- 75 dBc	- 78 dBc	- 80 dBc	- 80 dBc
250 – 500 kHz	- 80 dBc	- 82 dBc	- 85 dBc	- 85 dBc
500 kHz – 1 MHz	- 80 dBc	- 85 dBc	- 90 dBc	- 90 dBc
> 1 MHz	- 90 dBc	- 100 dBc	- 100 dBc	- 100 dBc

Table 5. Unwanted Emissions relative to carrier for the bandwidth of 18 kHz)
TETRA System (measurement)

ETSI Two-way Paging System Narrow Band - 12.5 kHz / 25 kHz : -

Parameter	Mobile Station (Transmit)	Base Station (Receive)
Channel Spacing	12.5 kHz / 25 kHz	12.5 kHz / 25 kHz
Transmit Power	30 dBm	-
Receiver Bandwidth	-	10.5 kHz / 18 kHz
Antenna Height	1.5 m	30 m
Antenna Gain	-12 dBi	6 dBi
Active Interferer Density Range	-	Variable & Fixed
Receiver Sensitivity (dynamic)	-	- 115 dBm
Receiver Protection Ratio	-	19 / 17 dB
Power Control Characteristic	not used	Not used

Table 6- Parameters Assumed for 12.5 kHz / 25 kHz ETSI Two-way Narrow Band Return Channel System

TETRA - Base station Tx. Interfering with Two-way Base station Rx

The relevant radio parameters required by the analysis are provided in **Table 7**.

Parameter	Value
Interferer Transmit Power	44 dBm (25watts)
Bandwidth Conversion Factor	-2.3/0dB
Multiple Carrier Margin	6 dB
Base Antenna Gains	9 / 6 dBi
Victim Sensitivity	- 115 dBm
Victim Protection Ratio	19 / 17 dB

Table 7. Radio System Parameters for Unwanted Emissions MCL Analysis

The isolation requirement in dB is given by -

Isolation $= P_{INT} + dB_{BW} + MC_{INT} + G_{VICT} + G_{INT} - (S_{VICT} - C/I_{VICT}) + f(dBc_{INT,}, P_{INT})$

$= 44 - 2.3 + 6 + 6 + 9 - (-115 - 19) + f(dBc_{INT,}, P_{INT})$ (12.5 kHz Ret. Ch.)

$= 44 + 0 + 6 + 6 + 9 - (-115 - 17) + f(dBc_{INT,}, P_{INT})$ (25 kHz Ret. Ch.)

$= 196.7 + f(dBc_{INT,}, P_{INT})$ (12.5 kHz Ret. Ch.)

$= 197 + f(dBc_{INT,}, P_{INT})$ (25 kHz Ret. Ch.)

Physical separations

The required isolations can be achieved through physical separation and standard site engineering. In the first case assuming that no site engineering is used, the only isolation comes from physical separation.

The path loss model for an urban area specified by WG SE in the Monte Carlo specification[2] was used in the study. Distances above 100 m are only considered so the modified Hata propagation model is assumed.

For the following operational conditions:-

Frequency	= 460 MHz
Paging Base station antenna height	= 30 m
TETRA Base station antenna height	= 30 m
Distance between systems "d"	= 100 m < d < 20km

The propagation models from [1] (Sub-annex B.a.1) are :-

Urban;

Median path loss L = 90.472 + 35.22 log d dB

Suburban;

Median path loss L = 82.117 + 35.22 log d dB

(where d is in km)

The selection of the appropriate propagation model will depend on the siting of the base station antenna systems and the topography. These propagation models were used together to obtain the physical separations shown in Tables. This is done in **Tables 8** and **9** assuming that no site engineering is used.

Urban model TETRA : -

Frequency Offset	Physical Separation assuming **Urban model** 12.5 kHz Return Ch.	25 kHz Return Ch.
25 kHz	21.5 km	20.9 km
50 kHz	11.2 km	10.9 km
75 kHz	11.2 km	10.9 km
100 kHz – 250 kHz	5.8km	5.7 km
250 kHz – 500 kHz	4.2 km	4.1 km
500 kHz – 1 MHz	3.0 km	2.9 km
> 1 MHz	1.6 km	1.5 km

Table 8. The Variation in Physical Separation for System B (TETRA) to System A (Paging Return Channel) Base Stations at different Frequency Offsets (BS to BS)

[2] CEPT ERC SE Monte Carlo Radio Compatibility Tool, Doc. SE(97)30, http://www.ero.dk/eroweb/monte/SE973001.pdf

Suburban model TETRA : -

Frequency Offset	Physical Separation assuming **Suburban model** 12.5 kHz Return Ch.	25 kHz Return Ch.
25 kHz	37.1 km	36.1 km
50 kHz	19.3 km	18.8 km
75 kHz	19.3 km	18.8 km
100 kHz – 250 kHz	10.0 km	9.8 km
250 kHz - 500 kHz	7.2 km	7.0 km
500 kHz – 1 MHz	5.2 km	5.1 km
> 1 MHz	2.7 km	2.6 km

Table 9. The Variation in Physical Separation for System B (TETRA) to System A (Paging Return Channel) Base Stations at different Frequency Offsets (BS to BS)

3.2.1.2 Conclusions of sharing in the 450 – 470 MHz band

The results of the SE33 study show that the separation of the Two-way paging base station and the TETRA base station transmitter is very important if this frequency band is to be considered for use. As many of these systems share common base station sites this expected be a serious issue.

SE33 observed significant differences between the papers CEPT SE33/FM35(98)4, "CEPT SE33/FM35(98)4, and CEPT SE33/FM35(98)4, "UK Services in the band 440 – 470 MHz", "Co-ordination & Coexistence issues from ECA Frequency Table" and "French Services in the three bands proposed, Parameters for the compatibility analysis". As a result it was concluded that it would be very difficult indeed to find a portion of spectrum in this band that will not result in a Two-way paging Return Channel base station receiver being subject to unacceptable levels of interference .
This is supported by the UK reporting major changes in this band to be phased over an eight year period.

In practice it is thought to be extremely difficult to find base station sites for Two-way paging Return Channel receivers that are in all cases going to be always one kilometre or more from a PMR or cellular base station operating in this band.
Also the increased use of PMR / TETRA mobiles with continuous transmission (a number of minutes) within a few kilometres of a Two-way paging return channel base station receiver will have significant effect on the two-way paging service and result in the need for many more base stations and thus significant cost increase.

The results in this report are presented as separation distances which can be considered large. However due to the fact the methodology used is based on worst case assumptions, the actual separation distances are expected to be lower than those calculated. These distances could be reduced by the use of planning and/or site engineering.

3.2.2 440 – 450 MHz

SE33 paid special attention to this band as two administrations France and Finland reported that they preferred this band because they had great difficulty in obtaining access to the 863 – 870 MHz band. It was noted that an input paper from the UK administration CEPT SE33 (99) 22 "Wind Profile Systems in the UK 440 –450 MHz Band" meant that this band was eliminated from use in the UK. These radar transmitters, used across this band at all the airports in the UK, have a peak EIRP of 85 dBW, a mean EIRP of 50 dBW and a bandwidth of 2 MHz.

The sharing possibilities of this band were analyzed by using information from CEPT SE7(98)66r " Adjacent Band Compatibility of 400 MHz TETRA and Analogue FM PMR" and models from SE(99)TEMP 37 "Evaluation of Minimum Frequency Separation".
The use of the MCL Minimum Coupling Loss method was considered appropriate because the major interference was from the PMR / TETRA Base station transmitters into the Two-way paging base station receivers. The result being to black out areas of Two-way Return Channel coverage.

The data used in the analysis is shown in **Tables 10** to **14**.

Analogue PMR - 25 kHz FM : -

Parameter	Mobile Station	Base Station
Channel Spacing	25 kHz	25 kHz
Transmit Power	37 dBm	44 dBm
Receiver Bandwidth	15 kHz	15 kHz
Antenna Height	1.5 m	30 m
Antenna Gain	0 dBi	9 dBi
Active Interferer Density Range	Variable	Variable
Receiver Sensitivity	- 107 dBm	- 110 dBm
Receiver Protection Ratio	17 dB	17 dB
Power Control Characteristic	not used	Not used

Table 10. Parameters Assumed for 25 kHz FM Systems

Frequency Offset	Mobile Station	Base Station
25 kHz	- 70 dBc	- 66 dBc
100 – 250 kHz	- 90 dBc	- 86 dBc
250 – 500 kHz	- 97 dBc	- 93 dBc
500 kHz – 1 MHz	- 101 dBc	- 97 dBc
1 MHz - 10 MHz	- 106 dBc	- 102 dBc
> 10 MHz	- 108 dBc	- 104 dBc

Table 11. Unwanted Emissions relative to carrier for 25 kHz FM Systems (measurement bandwidth of 18 kHz)

Analogue PMR -12.5 kHz FM : -

Parameter	Mobile Station	Base Station
Channel Spacing	12.5 kHz	12.5 kHz
Transmit Power	37 dBm	44 dBm
Receiver Bandwidth	8 kHz	8 kHz
Antenna Height	1.5 m	30 m
Antenna Gain	0 dBi	9 dBi
Active Interferer Density Range	Variable	Variable
Receiver Sensitivity	- 107 dBm	- 110 dBm
Receiver Protection Ratio	21 dB	21 dB
Power Control Characteristic	not used	Not used

Table 12. Parameters Assumed for 12.5 kHz FM Systems

Frequency Offset	Mobile Station	Base Station
12.5 kHz	- 60 dBc	- 56 dBc
100 – 250 kHz	- 80 dBc	- 76 dBc
250 – 500 kHz	- 97 dBc	- 93 dBc
500 kHz – 1 MHz	- 101 dBc	- 97 dBc
1 MHz - 10 MHz	- 106 dBc	- 102 dBc
> 10 MHz	- 108 dBc	- 104 dBc

Table 13. Unwanted Emissions relative to carrier for 12.5 kHz FM Systems (measurement bandwidth of 8 kHz)

ETSI Two-way Paging System Narrow Band - 12.5 kHz / 25 kHz : -

Parameter	Mobile Station (Transmit)	Base Station (Receive)
Channel Spacing	12.5 kHz / 25 kHz	12.5 kHz / 25 kHz
Transmit Power	30 dBm	-
Receiver Bandwidth	-	10.5 kHz / 18 kHz
Antenna Height	1.5 m	30 m
Antenna Gain	-12 dBi	6 dBi
Active Interferer Density Range	-	Variable & Fixed
Receiver Sensitivity (dynamic)	-	- 115 dBm
Receiver Protection Ratio	-	19 / 17 dB
Power Control Characteristic	not used	Not used

Table 14. Parameters Assumed for 12.5 kHz / 25 kHz ETSI Two-way Narrow Band Return Channel System

Frequency Offset	Mobile Station	Base Station
12.5 kHz / 25 kHz	- 60 / - 65dBc	-
100 250 kHz	- 80 / - 85 dBc	-
250 500 kHz	- 97 dBc	-
500 kHz – 1 MHz	- 101 dBc	-
1 MHz - 10 MHz	- 106 dBc	-
> 10 MHz	- 108 dBc	-

Table 15. Unwanted Emissions relative to carrier for 12.5 kHz / 25 kHz ETSI Two-way Narrow Band Return Channel System (measurement bandwidth of 8 kHz / 18 kHz)

Analogue PMR - Base station Tx. Interfering with Two-way Base station Rx.
The relevant radio parameters required by the analysis are provided in **Table 16**.

Parameter	Value
Interferer Transmit Power	44 dBm (25watts)
Bandwidth Conversion Factor	/0 dB
Multiple Carrier Margin	0 dB
Base Antenna Gains	9 / 6 dBi
Victim Sensitivity	- 127 dBm
Victim Protection Ratio	19 / 17 dB

Table 16. Radio System Parameters (for Unwanted Emissions MCL Analysis)

The isolation requirement in dB is given by -

Isolation = $P_{INT} + dB_{BW} + MC_{INT} + G_{VICT} + G_{INT} - (S_{VICT} - C/I_{VICT}) + f(dBc_{INT,}, P_{INT})$

= $44 – 0 + 0 + 6 + 9 - (-115 - 19) + f(dBc_{INT,}, P_{INT})$ (12.5 kHz Ret. Ch.)

= $44 + 0 + 0 + 6 + 9 - (-115 - 17) + f(dBc_{INT,}, P_{INT})$ (25 kHz Ret. Ch.)

= $193 + f(dBc_{INT,}, P_{INT})$ (12.5 kHz Ret. Ch.)

= $191 + f(dBc_{INT,}, P_{INT})$ (25 kHz Ret. Ch.)

Physical separations

The required isolations can be achieved through physical separation and standard site engineering. In the first case assuming that no site engineering is used, the only isolation comes from physical separation.

The path loss model for an urban area specified by WG SE in the Monte Carlo specification[3] was used in the study. Distances above 100 m are only considered so the modified Hata propagation model is assumed.

For the following operational conditions:-

Frequency	= 440 MHz
Paging Base station antenna height	= 1.5 m
PMR Base station antenna height	= 30 m
Distance between systems "d"	= 100 m < d < 20km.

The propagation models from [1] (Sub-annex B.a.1) are :-
Urban;
Median path loss L = 90.152 + 35.22 log d dB
Suburban;
Median path loss L = 81.891 + 35.22 log d dB
(where d is in km).

The selection of the appropriate propagation model will depend on the siting of the base station antenna systems and the topography. These propagation models were used together to obtain the physical separations shown in Tables. This is done in **Tables 17** and **18** assuming that no site engineering is used.

Urban model PMR :-

Frequency Offset	Physical Separation assuming **Urban model** 12.5 kHz Return Ch.	25 kHz Return Ch.
12.5 kHz / 25 kHz	21.4 km	9.8 km
100 – 250 kHz	5.7 km	2.6 km
250 - 500 kHz	1.9 km	1.6 km
500 kHz – 1MHz	1.4 km	1.3 km
1 MHz - 10 MHz	1.0 km	0.9 km
> 10 MHz	0.9 km	0.8 km

Table 17. The Variation in Physical Separation for System B (Analogue PMR 12.5 / 25 kHz) to System A (Paging return channel) Base Stations at different Frequency Offsets (BS to BS)

[3] CEPT ERC SE Monte Carlo Radio Compatibility Tool, Doc. SE(97)30, http://www.ero.dk/eroweb/monte/SE973001.pdf

Suburban model PMR : -

Frequency Offset	Physical Separation assuming **Suburban model** 12.5 kHz Return Ch.	25 kHz Return Ch.
12.5 kHz / 25 kHz	36.7 km	16.7 km
100 – 250 kHz	9.9 km	4.5 km
250 - 500 kHz	3.3 km	2.9 km
500 kHz – 1MHz	2.5 km	2.2 km
1 MHz - 10 MHz	1.8 km	1.6km
> 10 MHz	1.6 km	1.4 km

Table 18 - The Variation in Physical Separation for System B (Analogue PMR 12.5 / 25 kHz) to System A (Paging return channel) Base Stations at different Frequency Offsets (BS to BS)

3.2.2.1 Conclusions

The results in this report are presented as separation distances which are comparable to those in the 450-470 MHz band but coordination would be subject to smaller distances. However due to the fact the methodology used is based on worst case assumptions, the actual separation distances are expected to be lower than those calculated. These distances could be reduced by the use of planning and/or site engineering.

3.3 862 to 871 MHz Band

Compatibility of TWP with other services in this band were performed using path loss methodology and a statistical Monte Carlo simulation tool presented in CEPT SE33/FM35 (98)35 " A compatibility study of ReFLEX sharing with CT2 in the Band 864.1 – 868.1 MHz". Extracts from the Monte Carlo simulation (based on the ReFlex)are presented in this report and should be referenced for a complete description of the analysis.

From the contributions received and using the ECA Table the following analysis has been performed:

3.3.1 862 – 863 MHz Emergency services

The UK has stated absolutely that this band is not to be used by any new services as it is reserved solely for emergency purposes. **Consequently SE33 did not perform an analysis on the band.**

3.3.2 863 – 865 MHz Wireless Audio Applications

SE33 studied this band and from the information contained in document CEPT / ERC / REC 70-03 E " Relating to the use of Short Range Devices (SRD)" it concluded that this band could not be used for the ETSI Two-way paging Return Channel.

This band is characterised by ERP levels of approximately 10 mW and continuous transmission (e.g. transmissions lasting a few hours). It is also a rapidly growing market with increasing use of the spectrum and dense population of transmitting units.

The ETSI standard specifies a max ERP of 500 mW and a typical output power of 60 mW. These power levels are well out side the levels allowed in this band.

This band is very close to the television broadcast bands (see below) and the military tactical radio band used in Germany. The Cordless Audio Devices transmissions however are short range and non critical in nature. The performance of a CAD can be improved by the user by adjusting the distance or manually changing the operating frequency. The nature of the CAD use is very different to that of a national public Two-way paging service.

SE33 has thus concluded that the band 863 to 865 MHz is not suitable for the Two-way paging Return Channel.

3.3.3 864.1 – 868.1 MHz CT2 services

This band is characterised by ERP levels of approximately 10 mW and transmissions that last minutes rather than hours. The market is thought to be declining and the use of this spectrum by CT2 units is thought to be reducing. Many units may be concentrated in localised areas so the effect of continuous transmission from fixed locations is created. The transmission is short range and non critical in nature. Like the Wireless Audio Applications (Cordless Audio Devices) the performance can be improved by the user by adjusting the distance. Unlike the CADs the CT2 units can automatically select one of 40 frequencies that are free of interference. The impact these units can have on an ETSI Two-way paging return channel base station receiver has been studied in depth by SE33.

It is noted that CT2's and CADs share the 864.1 – 865 MHz band. However they are both short range services that are local, personal, and not public or national. While the ERMES return channel is a long range service that is public, national and not local or personal.

SE33 studied input papers presented by the UK CEPT SE33/FM35 (99)34 "Report from the Radiocommunications Agency on CT2 Interference to Paging return Path for SE33" and Motorola Germany CEPT SE33/FM35 (98)35 " A compatibility study of ReFLEX sharing with CT2 in the Band 864.1 – 868.1 MHz" , on the sharing of Two-way paging with CT2 using the Monte Carlo methods described in CEPT/ERC/SE(97)30.

The UK also conducted extensive field trials on the traffic profile of CT2 units in operation in 1999 presented in CEPT SE33/FM35 (99) 20 "Results of CT2 monitoring at a commercial site". The CT2 occupancy/busy hour and CT2 channel usage across the band measured are shown in **Figures 1** and **2** in this paper.

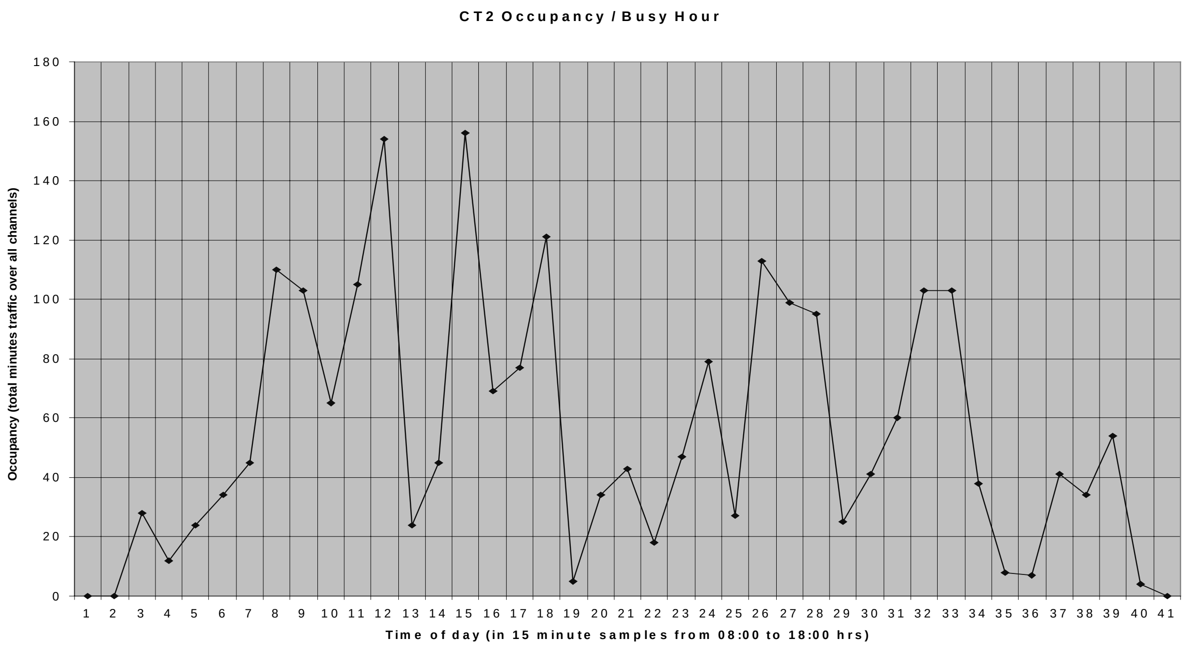

Figure 1

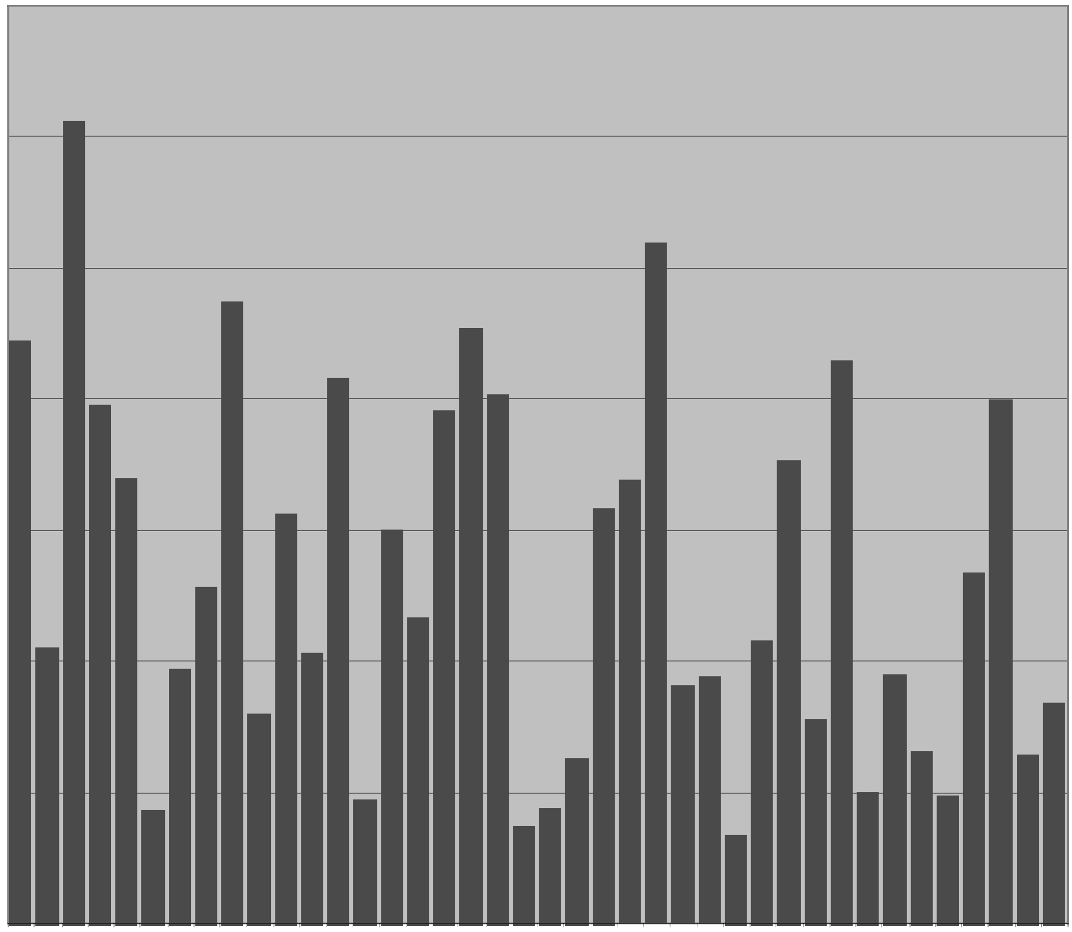

Figure 2

The number of CT2 units in service was analysed from data made available from administrations in UK, Germany, Finland and France. The power levels measured in an operational commercial CT2 service were also obtained by the UK Administration.
The Monte Carlo analysis from both sources gave the results shown in **Table 19**. The interference from the CT2 base station being more important than that from the CT2 mobile.

Density of CT2 users	Standard Data Rate Return channel		Higher Data Rate Return channel	
	Upper end CT2 Band	Centre of CT2 Band	Upper end CT2 Band	Centre of CT2 Band
5 /km^2	15%	20%	3.5%	6%
10 /km^2	21%	32%	5.5%	9%
30 /km^2	35%	51%	10.5%	16%
50 /km^2	42%	61%	14%	21%

Table 19. The probability of interference from a CT2 base station interfering with a Two-way paging base station.

CT2 units in service

The following information has been supplied by Administrations regarding the use of CT2 in their country.

a) France

Question	Answer
1 The number of CT2 hand sets sold prior to 1998	155000
2 The number of CT2 base station units sold prior to 1998	31400
3 The number of CT2 hand sets sold in 1998	1150
4 The number of CT2 base station units sold in 1998	1100
5 The number of CT2 hand sets expected to be sold during the years 1999 – 2005	0
6 The number of CT2 base station units expected to be sold during the years 1999 – 2005	0
7 For the quantities above what percentage were for business and what for domestic	90 % for domestic 10 % for business
8 For the quantities above how were the shipments distributed across the European countries.	Percentage of the French market : - 100 % for hand sets - 99 % for base stations

The figures are based only on responses received following a questionnaire, however it may be assumed that there is a greater number of CT2 units in operation.

b) UK.

Background.

1. Due to the Licence Exempt nature of the service the Agency has no records from which to draw an estimate of the number CT2 stations currently in use. This document presents indicative evidence garnered from the technical press regarding the nature and extent of CT2 use within the UK. It is the Agency's intention to review the long term availability of CT2 spectrum, this decision stems from the limited take up of CT2 (only **60,000** users after 8 years' availability). [4]

Extent of Current Use.

Size of Cordless Market.

2. According to telecoms consultant Frost and Sullivan, 3.3 m cordless telephones were shipped to western Europe in 1991. This is expected to reach a total of 22.3m by the end of 2001. Of these, the vast majority are for domestic use, 76.7 per cent 1991 and about 93 per cent in 2001[5] . 30 per cent of domestic cordless phones in Europe are DECT, a percentage that is expected to increase as it pushes CT2 and the analogue CT1 out of the market.

Business applications of Cordless Technology.

3. Examination of the technical press indicates that digital cordless technologies generally aim at a niche market in the workplace, namely those organisations such as hospitals, shopping centres and factories where on-site mobility is essential but where there is little need for mobility off-site. For these organisations, cordless systems based on DECT and CT2 are ideal. Current major users of CT2 include BT and a number of large super market chains.

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[4] Minutes if RA-CT2 Industry meeting on the 15th October 1996.

[5] FT Telecoms. 19 November 1997

CT2 in the residential market.

4. Industry is now starting to address the residential market with CT2. A CT2 cordless phone has been launched by Nortel and HB Electronics under the BT brand name. This device is priced to undercut existing DECT products.

5. Digital residential cordless products are projected to represent 27% of the total European residential market by 1999[6]. In the business arena the market size is projected to be 62 thousand systems per annum in 1999. Currently DECT accounts for 74% of the business cordless handset market. By 1999 it will account for 84%, leaving CT2 with just 16%. Consideration of these percentages would indicate a total usage in Europe of approximately **1 million** CT2 units in use by 1999

Limitations on available information.

6. The literature search of the technical and financial press only identified a very limited amount of information on CT2. No authoritative evidence was found detailing the true extent of the CT2 market in the UK.

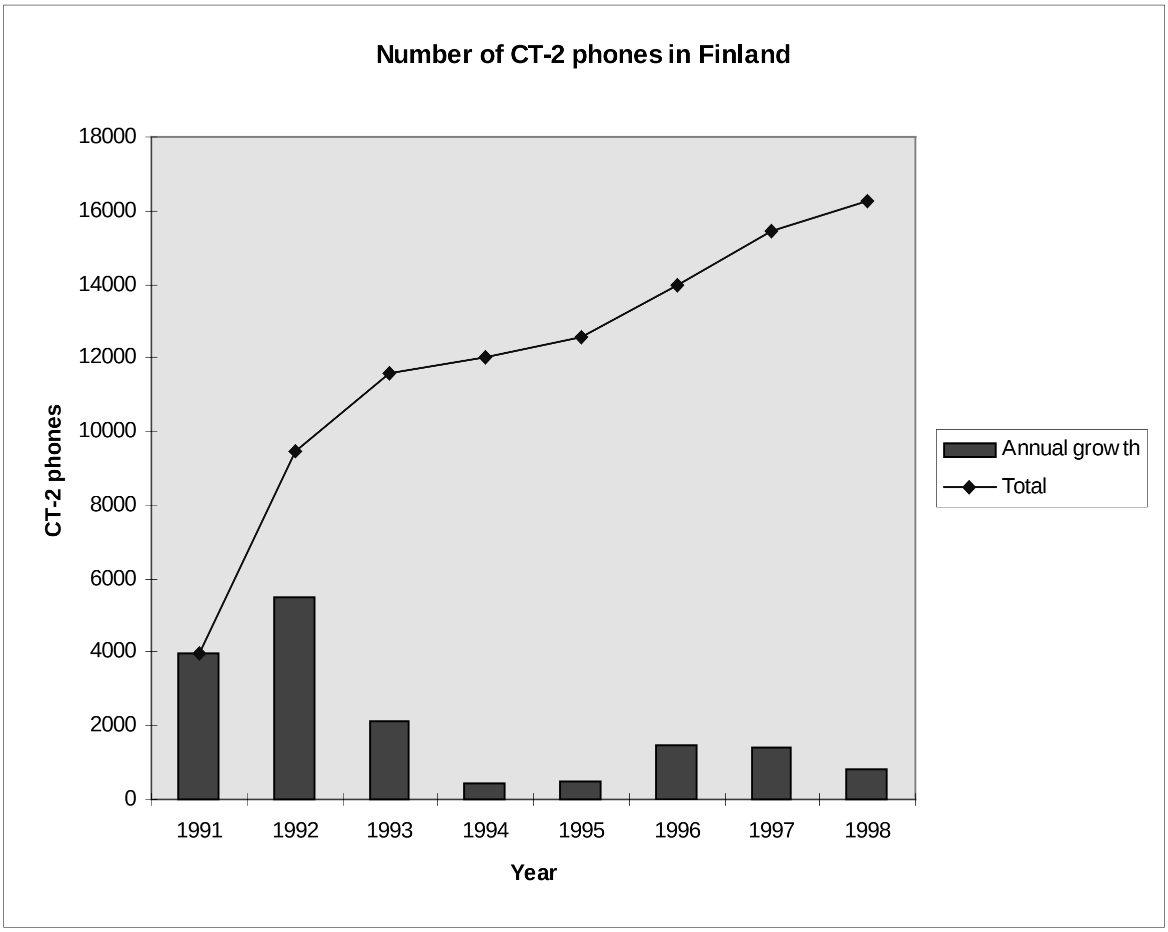
a) Finland

Information presented in this document concerning the amount of CT-2 usage in Finland is based on the number of approval labels acquired annually. The importer or manufacturer of CT-2 equipment is obliged to acquire the label from the Administration and to affix the label in every CT-2 phone. The number of acquired approval labels corresponds with the number of imported or manufactured CT-2 equipment in Finland.

Figures from 1991 to 1993 show the effect of the Telepoint service, which has totally died out after the early 90's. At present the CT-2 equipment in Finland are mainly used by business and residental users.

	Number of CT-2 phones in Finland	
Year	Annual growth	Total
1991	3988	3988
1992	5500	9488
1993	2100	11588
1994	450	12038
1995	500	12538
1996	1460	13998
1997	1436	15434
1998	800	16234

[6] Telecomeuropa's advanced Cordless Communications, March 1996



a) Germany

Due to a new decision made in Germany, the time limitation for CT2 is as follows:

1. In Germany the general frequency assignment for CT2 equipment is limited until the end of the year 2008. New equipment can be type approved until the end of the year 2000.

2. As from the beginning of the year 2003, CT2 equipment can not claim protection and is not allowed to interfere with other radio services operating in the same band (secondary status for CT2).

3.3.3.1 Monte Carlo analysis from CEPT SE33/FM35 (98)35

Placing ReFLEX uplink channels in the same band as CT2 requires co-channel compatibility with CT2 and adjacent band compatibility with CT2, CADs and SRDs.

ReFLEX channels could be placed either within the CT2 band or in the CAD/CT2 guard band. The latter has not been considered as it would restrict the ReFLEX allocation to 100 kHz and in addition, in the future this area of spectrum is likely to become a CAD extension band. Figure 3 illustrates the ReFLEX allocations considered - at the lower frequency end of the CT2 band, at the center of the CT2 band and at the upper frequency end of the CT2 band.

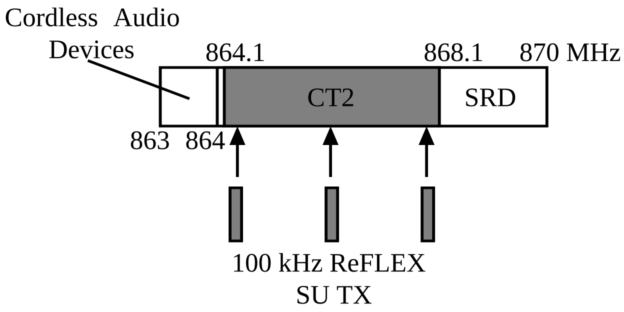


Figure 3 - Allocation of ReFLEX channels within the CT2 band

Four interference scenarios can be identified -

- ReFLEX SU interfering with an CT2 MS
- ReFLEX SU interfering with an CT2 BS
- CT2 MS interfering with a ReFLEX BS
- CT2 BS interfering with a ReFLEX BS

3.3.3.1.1 ReFLEX Subscriber Unit interfering with a CT2 Mobile Station

This scenario involves a population of ReFLEX subscriber units interfering with a victim CT2 mobile station. The interferer to victim link includes two low gain antennas. The wanted signal strength arriving at the CT2 mobile station will be the same as that arriving at a base due to equal base and mobile transmit powers. In all of the simulations in this section the victim CT2 system is assumed to have a 77 m cell radius which provides 95 % area availability. Simulations have been completed for high and standard data rate ReFLEX systems.

ReFLEX System Configured for Standard Data Rate

A range of ReFLEX subscriber unit densities have been assumed - from 5 / km^2 to 100 / km^2. This is intended to model various scenarios within an urban area. The lower densities could represent those belonging to a residential area and the higher densities those belonging to a business unit where many employees carry ReFLEX units. Levels of interference are determined by the density of ReFLEX subscriber units that are active. For the vast majority of the time ReFLEX subscriber units transmit only an acknowledgment or a single packet of data. This means that only a very small proportion of the total subscriber unit population is active at any one time. A ReFLEX uplink packet contains 154 bits, transmitted in this case at 800 bps. This leads to a transmit period of 192.5 msecs and if it is assumed that 30 % of users make a transmission during the busy hour then the active interferer densities specified in **Table 20** can be calculated from the total interferer densities.

ReFLEX Subscriber Unit Density	Active ReFLEX Subscriber Unit Density
5 / km^2	0.00008 / km^2
10 / km^2	0.00016 / km^2
50 / km^2	0.00080 / km^2
100 / km^2	0.00160 / km^2

Table 20 - Total and active ReFLEX subscriber unit densities for a standard data rate system

The Monte Carlo simulation did not register a probability of interference for any of these active interferer densities. This indicates very low levels of interference.

<u>ReFLEX System Configured for High Data Rate</u>

The same ReFLEX subscriber unit densities have been assumed as for a standard data rate system - from 5 / km^2 to 100 / km^2. In this case transmissions are made at a greater data rate and so the transmit time for a specific number of bits is less. Assuming that a ReFLEX uplink packet contains 154 bits, transmitted in this case at 9600 bps. This leads to a transmit period of 16.0 msecs and if it is assumed that 30 % of users make a transmission during the busy hour then the active interferer densities specified in **Table 21** can be calculated from the total interferer densities.

ReFLEX Subscriber Unit Density	Active ReFLEX Subscriber Unit Density
5 / km^2	0.000007 / km^2
10 / km^2	0.000013 / km^2
50 / km^2	0.000067 / km^2
100 / km^2	0.000134 / km^2

Table 21. Total and active ReFLEX subscriber unit densities for a high data rate system

The Monte Carlo simulation did not register a probability of interference for any of these active interferer densities. This indicates very low levels of interference.

3.3.3.1.2 ReFLEX Subscriber Unit interfering with a CT2 Base Station

This scenario involves a population of ReFLEX subscriber units interfering with a victim CT2 base station. The interferer to victim link includes one low gain antenna and one medium gain antenna. The wanted signal strength arriving at the CT2 base station will be the same as that arriving at a mobile due to equal mobile and base transmit powers. In all of the simulations in this section the victim CT2 system is assumed to have a 77 m cell radius which provides 95 % area availability. Simulations have been completed for high and standard data rate ReFLEX systems.

<u>ReFLEX System Configured for Standard Data Rate</u>

The same ReFLEX active subscriber unit densities are considered in this section as in Section 3.3.1.1. The Monte Carlo simulation did not register a probability of interference for any of these active interferer densities. This indicates very low levels of interference.

<u>ReFLEX System Configured for High Data Rate</u>

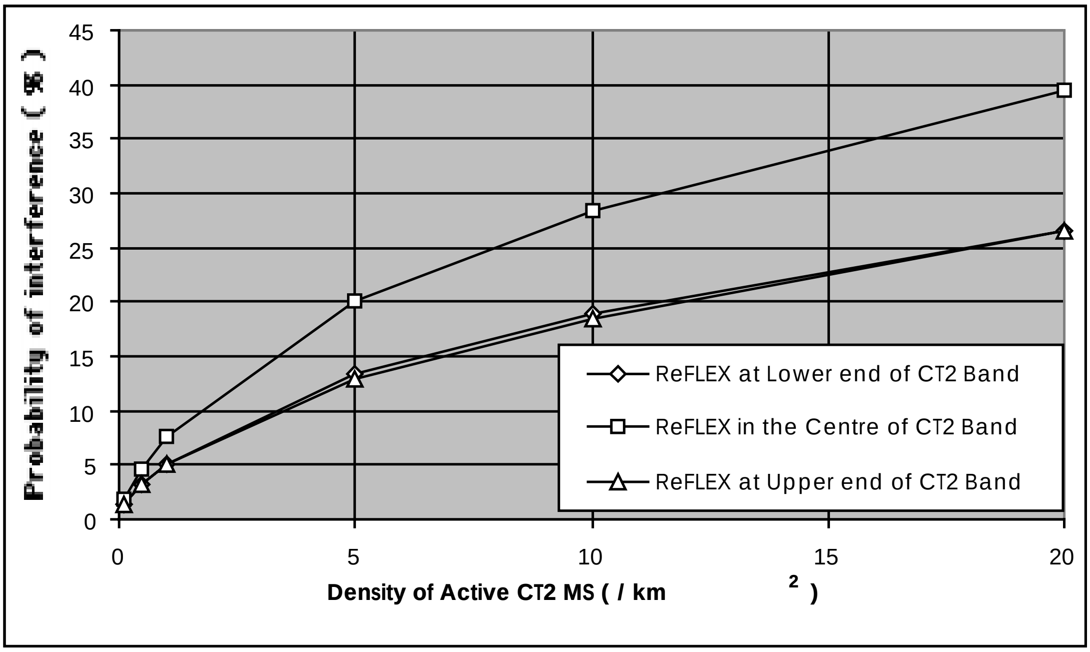
The same ReFLEX active subscriber unit densities are considered in this section as in Section 3.3.1.1. The Monte Carlo simulation did not register a probability of interference for any of these active interferer densities. This indicates very low levels of interference.

3.3.3.1.3 CT2 Mobile Station interfering with a ReFLEX Base Station

This scenario involves a population of CT2 mobile stations interfering with a victim ReFLEX base station. The interferer to victim link includes one low gain antenna and one high gain antenna. The wanted signal strength arriving at the ReFLEX base station will be less than that arriving at a mobile due to the uplink and downlink power budgets. Simulations have been completed for high and standard data rate ReFLEX systems.
A range of active CT2 mobile station densities is considered ranging from 0.1 to 20 / km^2. Simulations have been completed for high and standard data rate ReFLEX systems.

ReFLEX System Configured for Standard Data Rate

In this section the victim ReFLEX system is assumed to have a 1.325 km cell radius which provides 95 % area availability for the sensitivity level corresponding to an 800 bps data rate. **Graph 1** presents the resulting levels of interference.

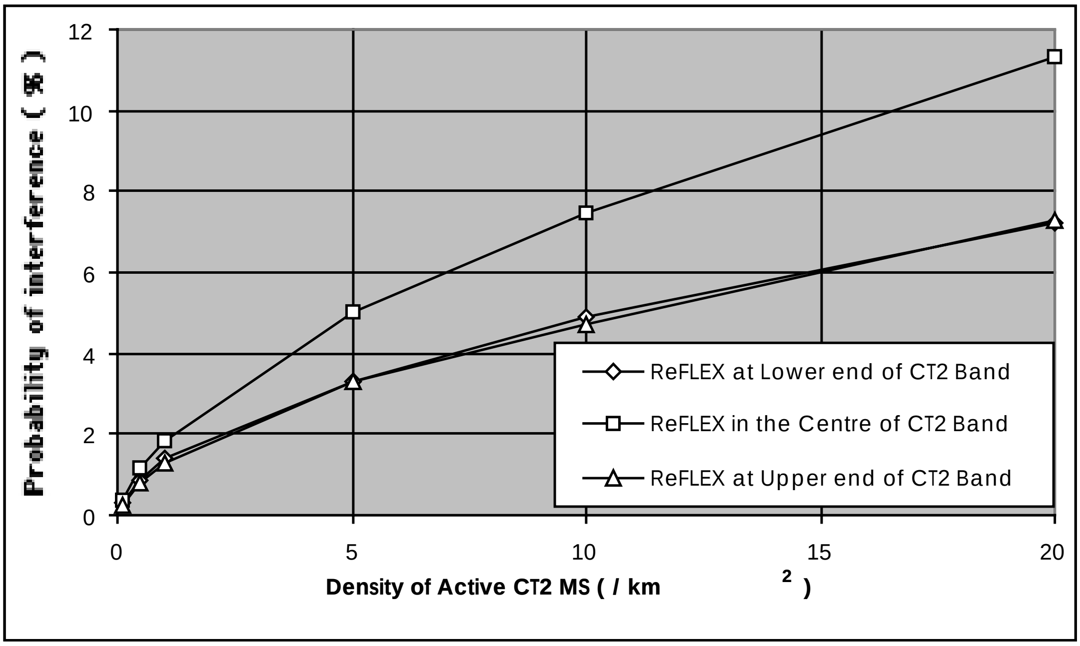


Graph 1 - The probability of interference for a CT2 mobile station interfering with a ReFLEX base station - standard data rate ReFLEX system

For an active CT2 mobile station density of 1 / km^2 then levels of interference are greater than 5 % - reaching 7 % when the ReFLEX channels are placed in the center of the CT2 band. Levels of interference are greater when the ReFLEX channels are placed in the center of the CT2 band due to a higher probability of a low frequency offset between victim and interferer. All of the interference levels are relatively high due to the possibility of co-channel interference. The level of interference increases with the active CT2 mobile station density. The higher densities are only likely to occur in an office or factory where employees are equipped with CT2 mobiles. In this case levels of interference will be reduced by physical isolation of the CT2 mobiles and ReFLEX base - assuming the ReFLEX base is not placed within the office or factory.

<u>ReFLEX System Configured for High Data Rate</u>

In this section the victim ReFLEX system is assumed to have a 175 m cell radius which provides a 95 % area availability for the sensitivity level corresponding to a 9600 bps data rate. This cell radius corresponds to the radius of the cells formed by the receive only antennas. **Graph 2** presents the resulting levels of interference.



Graph 2 - The probability of interference for a CT2 mobile station interfering with a ReFLEX base station - high data rate ReFLEX system

Levels of interference are significantly lower than for a standard data rate ReFLEX system due to the greater wanted signal strength at the ReFLEX base.

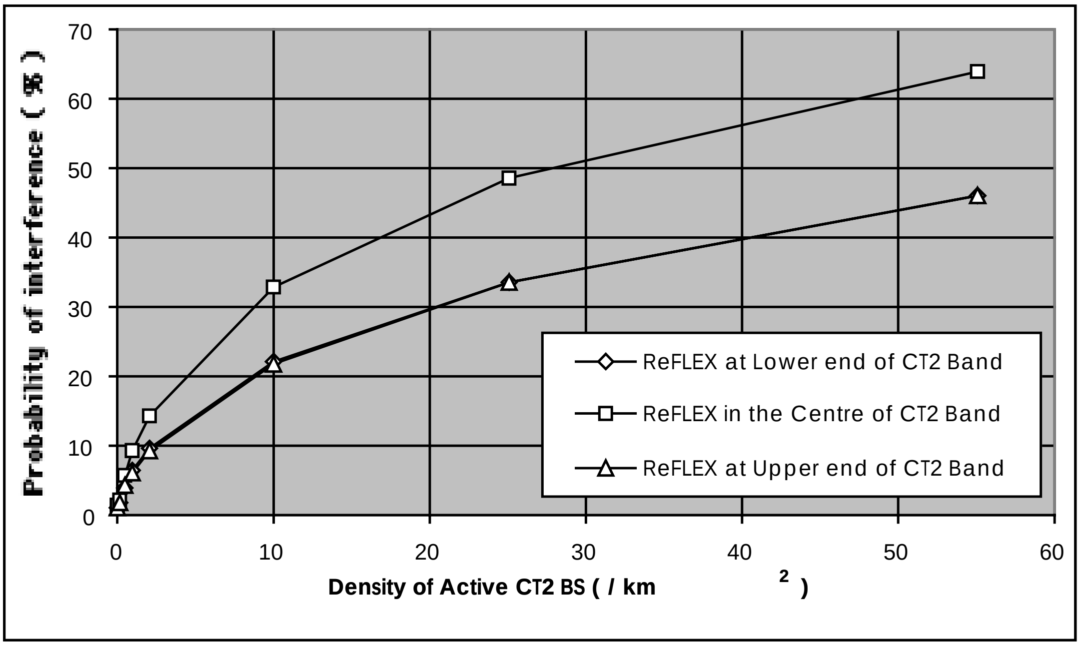
3.3.3.1.4 CT2 Base Station interfering with a ReFLEX Base Station

This scenario involves a population of CT2 base stations interfering with a victim ReFLEX base station. The interferer to victim link includes one low gain antenna and one high gain antenna. The wanted signal strength arriving at the ReFLEX base station will be less than that arriving at a mobile due to the uplink and downlink power budgets. Simulations have been completed for high and standard data rate ReFLEX systems.

A range of active CT2 base station densities is considered ranging from 0.5 to 55 / km^2. Simulations have been completed for high and standard data rate ReFLEX systems.

ReFLEX System Configured for Standard Data Rate

In this section the victim ReFLEX system is assumed to have a 1.325 km cell radius which provides 95 % area availability for the sensitivity level corresponding to an 800 bps data rate. **Graph 3** presents the resulting levels of interference.

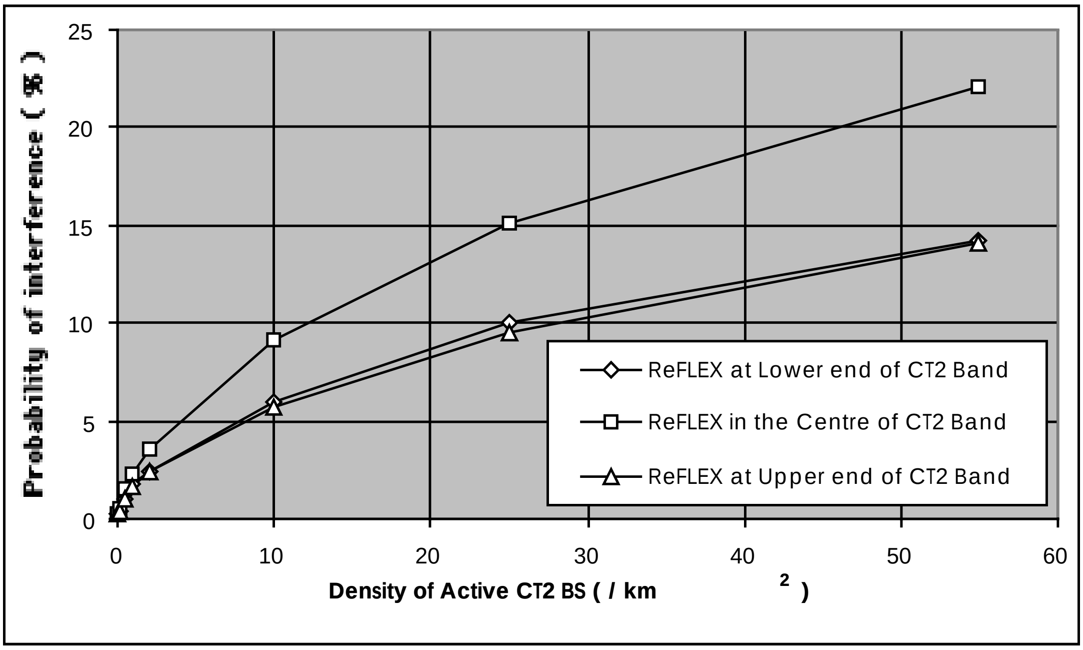


Graph 3 - The probability of interference for a CT2 base station interfering with a ReFLEX base station - standard data rate ReFLEX system

For an active CT2 base station density of 1 / km^2 then levels of interference are greater than 6 % - reaching 9 % when the ReFLEX channels are placed in the center of the CT2 band. Levels of interference are greater when the ReFLEX channels are placed in the center of the CT2 band due to a higher probability of a low frequency offset between victim and interferer. All of the interference levels are relatively high due to the possibility of co-channel interference. The level of interference increases with the active CT2 base station density. The higher densities are only likely to occur in an office or factory where employees are equipped with CT2 mobiles. In this case levels of interference will be reduced by physical isolation of the CT2 and ReFLEX base stations - assuming the ReFLEX base is not placed within the office or factory.

ReFLEX System Configured for High Data Rate

In this section the victim ReFLEX system is assumed to have a 175 m cell radius which provides a 95 % area availability for the sensitivity level corresponding to a 9600 bps data rate. This cell radius corresponds to the radius of the cells formed by the receive only antennas. **Graph 4** presents the resulting levels of interference.



Graph 4 - The probability of interference for a CT2 base station interfering with a ReFLEX base station - high data rate ReFLEX system

Levels of interference are significantly lower than for a standard data rate ReFLEX system due to the greater wanted signal strength at the ReFLEX base.

3.3.3.1.5 Analysis of results

Compatibility issues between CT2 and ReFLEX include both co-channel and adjacent channel interference mechanisms. The levels of interference presented in **Table 22** are representative of those in an office or factory area within which employees are equipped with CT2 handsets. For residential and telepoint CT2 applications the density of CT2 units will be considerably lower and intra - system compatibility will not be as much of an issue. Results are provided for both standard and high data rate ReFLEX systems.

Scenario	**Typical Level of Interference assuming a Standard Data Rate ReFLEX System**	**Typical Level of Interference assuming a High Data Rate ReFLEX System**	**Comments**
ReFLEX SU interfering with CT2 MS	Alloc. 1 : 0.00 % Alloc. 2 : 0.00 % Alloc. 3 : 0.00 %	alloc. 1 : 0.00 % alloc. 2 : 0.00 % alloc. 3 : 0.00 %	Low active interferer density leads to a negligible level of interference
ReFLEX SU interfering with CT2 BS	Alloc. 1 : 0.00 % Alloc. 2 : 0.00 % Alloc. 3 : 0.00 %	alloc. 1 : 0.00 % alloc. 2 : 0.00 % alloc. 3 : 0.00 %	Low active interferer density leads to a negligible level of interference
CT2 MS interfering with ReFLEX BS	Alloc. 1 : 26.5 % Alloc. 2 : 39.5 % Alloc. 3 : 26.5 %	alloc. 1 : 7.23 % alloc. 2 : 11.3 % alloc. 3 : 7.29 %	High data rate ReFLEX systems have a better uplink signal strength margin
CT2 BS interfering with ReFLEX BS	Alloc. 1 : 46.0 % Alloc. 2 : 64.1 % Alloc. 3 : 46.0 %	alloc. 1 : 14.2 % alloc. 2 : 22.1 % alloc. 3 : 14.1 %	High data rate ReFLEX systems have a better uplink signal strength margin

Table 22. Typical levels of interference between CT2 and ReFLEX

The observations listed below can be made:
- ReFLEX has a negligible effect upon the CT2 system due to the low active density of ReFLEX subscriber units
- levels of interference are greatest when the ReFLEX allocation is at the center of the CT2 band.

3.3.3.2 Conclusion of Sharing in the 864.1 868.1 MHz band

From this work it was concluded that the use of CT2 was very limited and mostly limited to domestic use and commercial PABX systems. The interference would be localised and, with the known probabilities, not a problem for the two-way paging return channel. The defined grade of service of 90% return channel message reliability on the first attempt would be met and the maximum message delay of 1 minute following repeated attempts to obtain return channel communication achieved. Local problems could be addressed by engineering the Two-way paging base receiver antennas to eliminate interference.

Based on the results of these studies and the diminishing usage of CT2 the band 867.6-868.0 MHz is considered feasible for TWP. However, it should be noted that for countries which deploy Tactical Radio Relay systems based on the parameters in the Report, sharing is not considered feasible.

3.3.4 868 – 870 MHz SRD Short Range Devices

This band is characterised by various ERP levels varying from 5 mW to 500 mW and characterised by transmissions with a transmission time cycle varying from 0.1% to 100 %. See CEPT / ERC / REC 70-03 E. It is also a rapidly growing market with increasing use of the spectrum and dense population of transmitting units.
The transmission is short range and non critical in nature. The performance can be improved by the user by adjusting the distance. A detailed breakdown of the band in terms of maximum ERP and transmission duty cycle is shown in **Table 23**.

For details of the propagation model used for the construction of Figure 1 can be found in CEPT SE33/FM35(98)44 or SE33SG1(98)11.

Frequency range MHz	Max Radiated power ERP MW	Transmitting time cycle %
868.00 – 868.60	25	1
868.60 – 868.70	10	0.1
868.70 – 869.20	25	0.1
869.20 – 869.25	10	0.1
869.25 – 869.30	10	0.1
869.30 – 869.65	500	10
869.65 – 869.70	25	10
869.70 – 870.00	5	100

Table 23

As this is a rapidly growing market it will be against the recommendations of CEPT / ERC / REC 70-03 E. to allow a long range service with national coverage to operate at power levels well in excess of those at present permitted by the other users. There is only one band of 350 kHz (869.300 – 869.650 MHz) permitted to operate above 25 mW (e.g. 500 mW) and this is for unlicensed users.

From a consideration of this band it was concluded by SE33 not to be suitable for the ETSI Two-way paging narrow band return channel.

3.3.5 870 to 871 MHz

SE33 did not perform any technical studies relating to this band.

3.4 Compatibility studies with TV Broadcast services

Compatibility of TWP with TV services were calculated by two methods; a theoretical method based on TV spectrum masks and using a mask based on UK monitoring of TV broadcast emissions (CEPT SE33/FM35 (99) 40 “Television Transmitter Out of Band Radiation Emissions in the UK”, as described in the sections below.

3.4.1 Theoretical calculations

The effect of Television transmissions were also studied by SE33. Television transmitters have high power transmitters and it was thought could be a source of interference to the very sensitive Two-way paging base station receivers.

Data from the liaison statement to ITU-R TG 1/5 from WP 11C was used. This data gave the parameters of the analogue TV 8 MHz spectrum mask for out of band emissions The path loss model from CEPT/ERC/SE(97)30 was used for the open space environment together with the Minimum Coupling Loss method.

The separation distances calculated by SE33 vary quite considerably with frequency offset reflecting the steps in the TV transmitters base station unwanted emission characteristics. Considering the effect of TV transmitter output power then **Table 24** was created.

	Transmitter Power			
Frequency Offset (MHz)	0.1 kw	1 kw	10 kw	100 kw
6.94	173 km	537 km	776 km	1584 km
13	114 km	239 km	501 km	1032 km
14.75	60 km	125 km	257 km	537 km
22.75	9 km	20 km	42 km	87 km

Table 24. The Impact of TV transmitter power on the Variation in Physical Separation with Frequency Offset assuming open space path loss model and "analogue TV 8 MHz mask" and no Site Engineering is used (TV transmitter base station to Paging receiver base station)

These offset frequencies were mapped onto the TV channel frequencies. Thus **Table 25** was created and the overlap into the 867.6 – 868 MHz band identified.

Channel Number	The actual frequency with the offset defined (MHz)			
	6.94 MHz	13 MHz	14.75 MHz	22.75 MHz
66	838.19	844.25	846	854
67	846.19	852.25	854	862
68	854.19	860.25	862	870
69	862.19	868.25	870	878

Table 25. The actual frequencies represented by a defined set of offsets from the TV vision carrier frequency by TV channel number.

From **Table 25** it can be seen that at offsets of 13, 14.75 and 22.75 MHz TV channel 69 would give problems to a Two-way paging service with a return channel in the 867.6 – 868 MHz band. These problems from channel 69 would be difficult to overcome . At an offset of 22.75 MHz it can be seen that channel 68 can be a problem. **Table 24** shows the separation required.

If the effect of reducing the paging base station receiver sensitivity is considered to help overcome any problems in the region of the TV transmitter then a new **Table 26** can be created. In this table the paging base station receiver is assumed to have a sensitivity of –117 dBm which is a reduction of 10 dB . This would result in reducing the range from the pager to the base station on the return channel by half (e.g. from 12 km to 6 km). This would mean four base station receiver sites instead of one in a region that could be affected by a TV transmitter.

	Transmitter Power			
Frequency Offset (MHz)	0.1 kw	1 kw	10 kw	100 kw
6.94	87 km	173 km	537 km	776 km
13	56 km	114 km	239 km	501 km
14.75	29 km	60 km	125 km	257 km
22.75	5 km	9 km	20 km	42 km

Table 26. The Impact of TV transmitter power on the Variation in Physical Separation with Frequency Offset assuming open space path loss model and "analogue TV 8 MHz mask" and no Site Engineering is used (TV transmitter base station to Paging receiver base station). In the location of the TV transmitter the number of Paging Base stations is increased by a factor of four.

The impact of television transmitter networks on two-way paging will be influenced by the number of transmitters, their power, their frequency and the height of the transmitting masts. From an analysis of the transmitters in the UK **Tables 27** and **28** have been constructed. These show the number of transmitters and their powers on channels 65, 66, 67, 68 and 69. It can be seen that in the UK at present there are no transmitters on channel 69.

Channel Number	Number of Tx.'s	Highest Power Tx.	Lowest Power Tx.
65	?	500 kilowatts	1 watt
66	47	250 kilowatts	1 watt
67	35	100k kilowatts	4 watts
68	60	100k kilowatts	0.5 watt
69	0	-	-

Table 27. TV transmitters in the UK

Channel Number	Number of TV Transmitters with powers equal to or above:-			
	100 W	1000 W	10 kW	100 kW
65	?	?	5	4
66	8	4	2	2
67	8	2	2	1
68	11	3	1	1
69	0	0	0	0

Table 28. TV transmitters in the UK

3.4.2 Analogue TV Transmitter Measurements

Most analogue TV transmitters, operating in Channel 68 are low power relays. There are only 3 transmitters with ERP's of 40 dBW and above. Of these, Midhurst has the highest transmit power, so it was chosen to represent the analogue worst case.

Transmitter Specifications for Midhurst, West Sussex

NGR: SU 912 250 (ground height approx. 190 m ASL)

Antenna Height 300 m ASL (mast height approx. 115 m)

Channel: 68 (Vision Carrier 847.250 MHz)

Vision Carrier Offset: Negative at 20 /12 Line Frequency

ERP: 50 dBW (peak sync.) Horizontal Polarisation

Measurement Location

NGR: SU906249 (ground height approx. 185 m)

Distance to Transmitter: approx. 600 m

Equipment Set Up

Chelton Log Periodic Antenna 10 metres above ground with 10 metres of RG214 cable connected to a Rohde & Schwarz ESCS30 Measuring Receiver.

Field Strength: Receiver reading + 21.2 dB correction factor.

Method

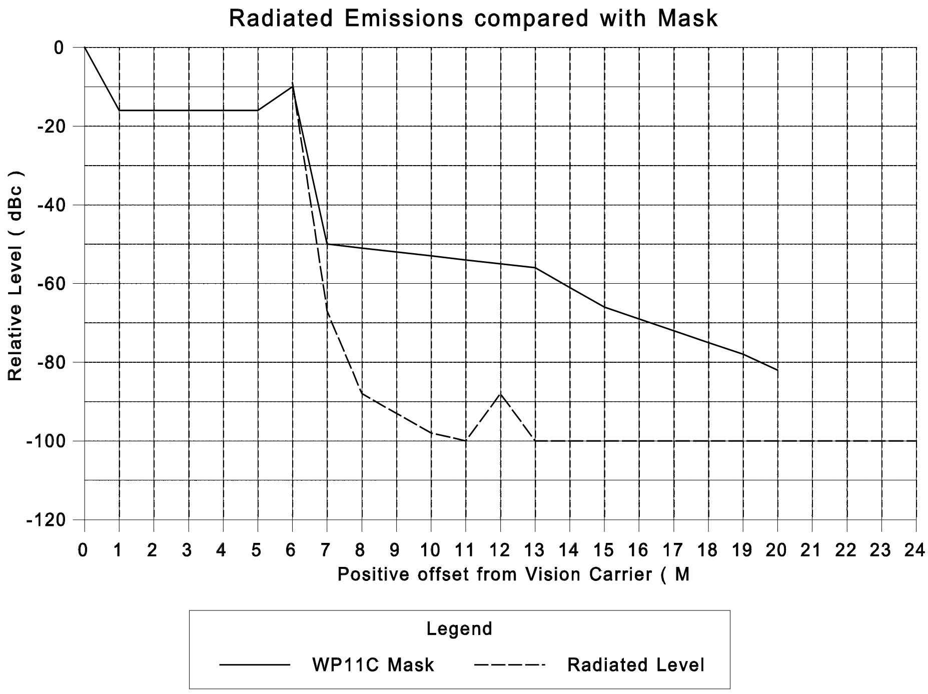
The Antenna was directed towards the transmitter and rotated for maximum signal. A check was made to ensure the antenna height did not correspond to a signal null due to multipath reception.

Maximum Signal into Measuring Receiver

1 MHz bandwidth, Peak detector	90 dBµV	(847.223 MHz, peak sync.)
120 kHz bandwidth, Peak detector	89 dBµV	(847.223 MHz, peak sync.)
9 kHz bandwidth, Peak detector	88 dBµV	(847.223 MHz, peak sync.)

Freq. **MHz**	**Peak Level in 9 kHz dBµV**	**Peak F.S. in 9 kHz dBµV/m**	**Level Relative to peak sync. dBc**	**Notes**
847.223	88	109	0	Vision Carrier Peak Sync
853.223	79	100	-9	Sound Carrier
854.223	21	42	-67	
855.223	0	21	-88	
856.223	-5	16	-93	
857.223	-10	11	-98	
858.223	-12	< 9	-100	
859.223	0	21	-88	Intermodulation of Sound & Vision carriers
860.223	-12	< 9	-100	System Noise Floor
861.223	-12	< 9	-100	System Noise Floor
862.223	-12	< 9	-100	System Noise Floor
863.223	-12	< 9	-100	System Noise Floor
863.223	-12	< 9	-100	System Noise Floor
865.223	-12	< 9	-100	System Noise Floor
866.223	-12	< 9	-100	System Noise Floor
867.223	-12	< 9	-100	System Noise Floor
868.223	-12	< 9	-100	System Noise Floor
869.223	-12	< 9	-100	System Noise Floor
870.223	-12	< 9	-100	System Noise Floor
871.223	-12	< 9	-100	System Noise Floor

Table 27. Signal Levels and Field Strength



Plot 1: Analogue TV Radiated Emissions compared to Mask

Notes on the Measurements

The measured receiver noise floor (peak) in a 9 kHz bandwidth with a 50 Ω termination was -12 dBμV. This is equivalent to a measuring system noise floor of 9 dBμV/m

3.4.3 Conclusions

The height of all the TV antennas is not known and this will influence the choice of propagation model to be used. It is noted that owing to the uncertainty of digital TV services regarding use in the upper TV Band 5 no studies are presented here.

From the data used in this paper the following can be concluded.

a. It is not desirable to use two-way paging in the 867.6 – 868 MHz band if channel 69 television transmissions are to be used.
b. If channel 69 transmissions are expected, special engineering of paging receiver base station antenna systems may be required and an increase in paging receiver sites in the region of a television transmitter.
c. It is important that measurements be made to determine the expected actual out of band power in the two-way paging return channels from television transmitters.
d. It is vital for a harmonised European service to have data on the use and plans for channel 69 television transmissions throughout the European countries.
e. More Two-way paging base station receivers will be required in areas near to TV transmitters radiating on channel 68.
f. Base station antenna engineering may be required by the installer of a Two-way paging network.
g. The ECA table states in the Band 838 to 862 MHz co-primary services are Radio microphones (on a tuning range basis), Mobile and Tactical Defence. SAB are on a Secondary Basis.

3.5 Sharing with Tactical Radio Relay systems

SE33 performed compatibility studies based on a French contribution SE33/FM35 (99) 45. The results of the study are presented below:

3.5.1 Introduction.

In France, Tactical Radio Relays are used for military applications in the frequency range 862-880 MHz. A compatibility study of the RITA system with two-way paging return channel has been made by the French military authorities. The aim of this paper is to present the main results of this study based on the minimum coupling loss theory. It appears that the main compatibility issue concerns the two-way paging system being interfered by the RITA system.

3.5.2 Parameters used for simulation.

The main compatibility issue being the interference from the tactical radio relays into the two-way paging return channel, the pertinent emission parameters of the RITA system and the pertinent reception parameters of the two-way paging system are given below. The system considered for two-way paging is the 25 kHz ETSI two-way narrow band return channel system whose specifications are given in document SE33/FM35(99)35.

ETSI Two-way Paging System Narrow Band -25 kHz

Parameter	**Base Station (Receive)**
Channel Spacing	25 kHz
Transmit Power	-
Receiver Bandwidth	18 kHz
Antenna Height	30 m
Antenna Gain	6 dBi
Active Interferer Density Range	Variable & Fixed
Receiver Sensitivity	- 115 dBm
Receiver Protection Ratio	17 dB
Power Control Characteristic	not used

Table 28. Parameters Assumed for 25 kHz ETSI Two-way Narrow Band Return Channel System

RITA Tactical Radio Relay System

Parameter	**Transmitter**
Transmit Bandwidth	750 kHz
Transmit Power	36 dBm
Antenna Gain	15 dBi
Antenna Height	17 m
Feeder Losses	3.8 dB
Polarisation Losses	3 dB
Polarisation	Cross-polarised

Table 29. Parameters given for RITA Tactical Radio Relay System

The adjacent channel for RITA corresponding to an out of band emission of –65 dBc is located at 2 MHz from the carrier frequency.

3.5.3 Compatibility analysis.

This analysis is based on the the Minimum Coupling Loss theory.

Required isolation values.

Isolation = P_{INT} + dB_{BW} + MC_{INT} + G_{VICT} + G_{INT} – (S_{VICT} – C/I_{VICT}) + f(dBc_{INT} , P_{INT})

Where,

P_{INT} is the maximum transmit power of the interferer
dB_{BW} is the bandwidth conversion factor between interferer and victim
MC_{INT} is the multiple carrier margin to account for when the interferer is a base site and has more than a single carrier being transmitted
G_{VICT} is the gain of the victim antenna (including cable loss)
G_{INT} is the gain of the interferer antenna (including feeder loss and polarisation loss)
S_{VICT} is the sensitivity of the victim
C/I_{VICT} is the protection ratio of the victim
f($dBc_{INT,}$,P_{INT}) is a function defining the power of the wideband noise at the frequency offset being considered relative to the interferer’s carrier power.

Four cases are considered :

- **Case 1 : cochannel sharing and on-axis case**
  In this case, G_{INT} = 15 dB-3.8 dB-3 dB and f($dBc_{INT,}$,P_{INT}) = 0 dBc

  Isolation = 36 – 16.2 + 0 + 6 + 15 – 3.8 – 3 + 115 + 17 + 0= 166 dB
- **Case 2 : cochannel sharing and off-axis case**
  In this case, G_{INT} = 0 dB-3.8 dB-3 dB and f($dBc_{INT,}$,P_{INT}) = 0 dBc

  Isolation = 36 – 16.2 + 0 + 6 + 0 – 3.8 – 3 + 115 + 17 + 0= 151 dB

- **Case 3 : adjacent channel sharing and on-axis case**
  In this case, G_{INT} = 15 dB-3.8 dB-3 dB and f($dBc_{INT,}$,P_{INT}) = -65 dBc

  Isolation = 36 – 16.2 + 0 + 6 + 15 – 3.8 – 3 + 115 + 17 – 65 = 101 dB

- **Case 4 : adjacent channel sharing and off-axis case**
  In this case, G_{INT} = 0 dB-3.8 dB-3 dB and f($dBc_{INT,}$,P_{INT}) = -65 dBc

Isolation = 36 – 16.2 + 0 + 6 + 0 – 3.8 – 3 + 115 + 17– 65 = 86 dB

Minimum separation distances.

The isolation values given above can be converted into separation distances using an appropriate propagation model. Considering the modified Hata model in suburban case at the frequency of 868 MHz with the antenna heights given in table 1 and table 2, the relation between the median loss and the separation distance is

L=90.2+35.2*log(d) where d is in kilometres

Case 1 : Isolation = 178 dB, distance = 142 km

Case 2 : Isolation = 163 dB, distance = 53.3 km

Case 3 : Isolation = 113 dB, distance = 2.0 km

Case 4 : Isolation = 98 dB, distance = 0.8 km

3.5.4 Conclusion.

From the separation distance values given above, it appears that co-channel sharing between RITA tactical radio relay systems and narrowband return channel paging systems is not feasible. If we consider the proposed allocation of 867.6 - 868 MHz for return channel paging and the frequency separation of 2 MHz between the adjacent channel and the RITA frequency carrier, it implies that the whole frequency range 865.6 - 870 MHz would be prohibited for the use of the RITA tactical radio relay system, which is not acceptable. Therefore, France considers that the frequency band 867.6 - 868 MHz is not suitable for narrowband return channel paging.