European Radiocommunications Committee (ERC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

COMPATIBILITY BETWEEN DECT AND DCS1800

Brussels, June 1994

1. SUMMARY

Practical as well as theoretical papers have been considered during this compatibility study.

The following recommendations are seen (together) as a means of reducing potential interference:

- Increased frequency separation between carriers in adjacent systems.

- Improve blocking requirements of DECT receiver equipments (particularly for telepoint implementations) at offsets greater than twice the channel bandwidth.

- Investigate possible escape mechanisms (for both systems), to avoid local interference problems and the consequent reduction in capacity.
  Such mechanisms could include:
    - Dynamic channel selection (for DECT)
    - Frequency hopping
    - Intra-cell handover
    - Careful location of the BCCH (control) channels.

- Note should be made of proposed solutions detailed in ETSI PT10(92)083, Version 01.02.

- Introduction of an additional 4 watt MS power class within the parameters indicated by SMG, will have only a marginal effect on the compatibility situation.

2. INTRODUCTION

This paper examines the potential compatibility problems between two digital radiocommunications systems which are planned to operate around 1800 MHz. These systems are DECT (Digital European Cordless Telephone), and DCS1800 (Digital Communications System or Public Communications Network - PCN),

As a result of both theoretical work, based on ETSI specifications and practical measurements carried out under laboratory controlled conditions, the isolation requirements for different interference mechanisms were determined. These were expressed in dB's and translated into separation distances using the agreed propagation models.

Owing to the various configurations identified for typical DECT applications. Several interference scenarios were analyzed to identify those that exhibited significant interference ranges.

The following three interference mechanisms were identified as being the most problematic;
- Blocking of DECT from $DCS1800_{base}$
- DECT out of band emission interfering with $DCS1800_{mobile}$
- Blocking of $DCS1800_{mobile}$ from DECT

The following measure are seen (together) as being a means of reducing the compatibility problems.

Changing the Frequency Separation Between the two Systems

Based on the existing specifications and the assumptions made in section 5, a frequency separation would significantly reduce the incompatibility between the systems. At present approximately 2.2 MHz is achieved, 1.8 MHz within the DECT band, and 400 kHz within the DCS1800 band when channel number 885 is not used. The minimum frequency separation required between DCS1800 and DECT carriers, to significantly alleviate the problem without changing the standards is 5 MHz.

If this is implemented, the separation distances required in most instances are deemed acceptable. However, individual operational problems occurring in the following specific cases will need to be addressed:

(a) In case 1, model A, DECT installations in the upper parts of high buildings facing a DCS1800 BS should plan for extra wanted signal, and therefore reduced coverage, if the distance between installations is <60 m.

(b) In case 3, DECT telepoint base stations using 12 dBi antenna gain should, if the distance is less than 60 m to a DCS1800 BS, require 10 dB extra blocking (f>1780 MHz) or plan for 10 dB extra wanted signal.

A 5 MHz separation between the highest carrier frequency of DCS1800 (1876.6 MHz: ARFCN 869) and the lowest carrier frequency of DECT (1881.792 MHz) requires 16 x DCS1800 channels to be sterilised, effectively 3.1 MHz of spectrum. A similar procedure could be envisaged in the upper adjacent band.

Changing the Standards

Without a guard band the minimum frequency separation between DCS1800 and DECT carriers is 2.2 MHz. This is in the 2nd adjacent channel of the DECT system. The compatibility problem could be reduced by improving the minimum blocking performance and the adjacent channel selectivity of the DECT receiver. However, the amount of improvement required in this parameter alone to achieve a reasonable separation distance seems unrealisable in practice. The feasibility of improving the DECT specification increases as the frequency separation increases.

DCS1800 mobile receivers will also be affected (as in case 2), where there are out of band emissions from a DECT transmitter falling on the DCS1800 receive frequency. The out of band emissions from DECT are not high, and the amount of improvement in this parameter alone required to achieve a reasonable separation distance seems unrealisable in practice.

It can be seen from figure 2 that improving the DCS1800 mobile blocking specification will not alleviate the problem with cases 2 and 5 which are limited by the DECT out of band emissions.

Reducing System Capacities

The dynamic channel selection of DECT will avoid blocking from DCS1800 but this will result in a capacity reduction for DECT. Similarly DCS1800 mobiles can avoid interference from DECT if the control channels for DCS1800 (BCCH carriers) are allocated more than 3.5 MHz from the DECT band edge, and the options of frequency hopping and possibly intra-cell hand over is employed.

An assessment of the economic and practical implications of improving the performance standards for DECT and DCS1800 described above will require work to be done by ETSI.

3. BACKGROUND

DECT is the term used for the Digital European Cordless Telecommunications system located between **1880 and 1900 MHz**. The DECT specification (ETSI prETS 300175-2) provides for ten wide band channels with centre frequencies defined by f_C=1897.344 MHz-c.1728 kHz, where c= 0,1,.,.,9.

DCS1800 is the standard developed by ETSI for Digital Cellular Systems for use between **1710 to 1785 MHz** (Mobile Transmit) and **1805 to 1880 MHz** (Base Station Transmit). Different parts of the band can be allocated for DCS services on a national basis.

Radiocommunications systems operating in adjacent bands may adversely effect each other due to the presence of a number of potential interference mechanisms e.g.:

- receiver blocking,
- spurious responses,
- transmitter spurious emissions,
- intermodulation products generated within the transmitter,
- intermodulation products generated within the receiver.

The basic methodology adopted for addressing the perceived problems associated with the DECT-DCS1800 adjacent band allocations, was to look at:

- theoretical values (laid down in the system specifications),

- practical values (obtained from tests on real equipment).

The maximum permissible level of **received interference power**, can be related to the following equipment performance parameters defined within the system standards, including:

- co-channel,
- adjacent channel,
- blocking,
- intermodulation.

this, in conjunction with knowledge of the following:

- interfering transmitters power,
- level of spurious emissions,
- antenna configurations,

...can be used to derive the required isolation for interference free operation. Practical measurement of a receiver's ability to reject interfering signals (intrinsic immunity) can also be used in this analysis.

The required isolation can then be translated into an interference range, through the application of an appropriate propagation model. This, will then yield a number of interference ranges relating to the different interference mechanisms, frequency separations, transmitter powers and receiver sensitivities.

Since short range propagation at 1800 MHz depends on the local environment, many different propagation models were considered. Finally, six propagation models were selected to represent the propagation conditions appropriate to the five different interference scenarios.

The interference ranges for different scenarios may range from metres to kilometres. The probability of each interference scenario occurring depends on a number of factors. Some scenarios will be much more likely to occur than others.

It is the highly probable scenarios that exhibit significant interference ranges that are of major concern and have been identified and addressed in this paper.

The r.f. aspects of the DCS1800 specification (ETSI GSM 05.05-DCS) are based upon the GSM 900 specification. The carrier frequencies are defined by $f_l(n) = 1710.2 + 0.2(n-512)$ MHz, $512 \leq n \leq 885$; $f_u(n) = f_l(n) + 95$ MHz.

A pictorial overview of the major interference scenarios (Figure 1), propagation models and interference ranges are given in section **4. SCENARIOS** of this report.

4. SCENARIOS

The following five major interference scenarios were identified as giving cause for concern regards compatibility between DECT and DCS1800;

Case	Interferer	Victim
1	DCS1800 base outdoors	DECT base indoors
2	DECT base indoors	DCS1800 mobile indoors
3	DCS1800 base outdoors	DECT base outdoors
4	DCS1800 base outdoors	DECT mobile outdoors
5	DECT base outdoors	DCS1800 mobile outdoors

For each scenario an appropriate propagation model was chosen, see below.

Case 1

the **DCS1800 base station** (antenna) is assumed to be **located on a roof top**. To take account of all of the possible locations of the DECT base station (within a multi-level building), many different propagation models were considered.
Three models were agreed as appropriate, A, B, and C see below and overview diagram.

Line of site.

In the worst situation, the DECT receiver may be located within line of sight to the DCS1800 base station. **"Model A"** is assumed to be appropriate.

Oblique.

In this general situation, more complicated propagation conditions apply. **"Model B"** is assumed to be appropriate.

Ground level.

When the DECT base station is located at ground level, **"Model C"** is assumed to be appropriate.

Case 2

When **both** the DCS1800 base station **and** the DECT mobile station are located within the same building, **"Model D"** is assumed to be appropriate.

Case 3 and 4

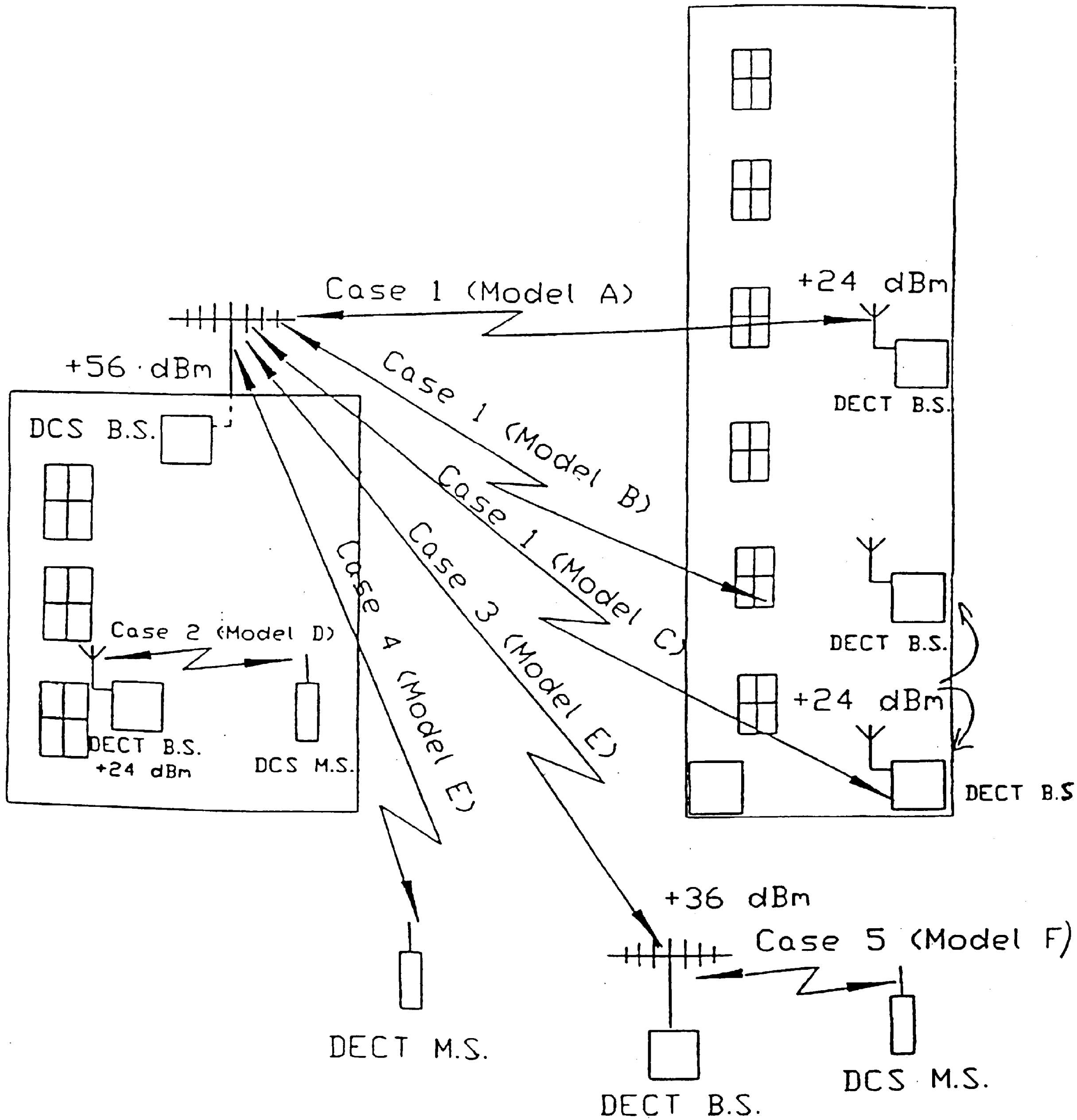
When the DCS1800 base station (antenna) is located at roof level and the DECT base or mobile station is located in the street, **"Model E"** is assumed to be appropriate.

Case 5

When the DECT base station and the DCS 1800 mobile station are located in the street, **"Model F"** is assumed to be appropriate.

FIGURE 1

OVERVIEW OF MAJOR SCENARIOS



5. PROPAGATION MODELS

"Model A"
This model assumes free space propagation for all distances, plus an additional 15 dB to account for building attenuation. This can be expressed with the following equations:

$$Lb=53+20\log d$$

"Model B"
This model assumes free space propagation for distances below 10 m, and a 4th power law for greater distances, plus an addition 15 dB to account for building attenuation. This can be expressed with the following equations:

$$Lb=53+20\log d,\ d<10m$$

$$Lb=73+40(\log d-1),\ d>10m$$

"Model C"
The COST obstruction model is described in doc FM10/SE7(92)22. An extension is made by linear extrapolation for distances below the range of the model. 15 dB has been added to account for building attenuation. The following equations can be used:

$$Lb=83+20\log d,\ 0<d<130m$$

$$Lb=61.6+30\log d,\ 130<d<300m$$

$$Lb=36+40\log d,300<d<6000m$$

"Model D"
This model assumes free space propagation for distances below 10 m, and a 4th power law for greater distances. This can be expressed with the following equations:

$$Lb=38+20\log d,\ d<10m$$

$$Lb=58+40(\log d-1),d>10m$$

"Model E"

The COST obstruction model is described in doc FM10/SE7(92)22. An extension is made by linear extrapolation for distances below the range of the model. The following equations can be used:

$$Lb=68+20\log d,0<d<130m$$

$$Lb=46.6+30\log d,130<d<300m$$

$$Lb=21+40\log d,300<d<6000m$$

"Model F"

This propagation model is an interpolation between free-space loss at 10 m, free-space + 10 dB loss at 100 m, and values from CCIR report 567-4 at 1 km and 10 km. The CCIR values have been increased by 6 dB to take account of the higher frequency. The antenna heights are 30 m and 1.5 m. The following equations can be used to calculate the propagation loss [dB].

$$Lb=38+20\log d,\ d<10m$$

$$Lb=58+30(\log d-1),10<d<100m$$

$$Lb=88+42(\log d-2),100<d<1000m$$

$$Lb=130+38(\log d-3),\ 1000<d<10000m$$

5. RESULTS - THEORETICAL STUDY

Case 1 (Models A, B & C).

TABLE 1

MECHANISM- FORWARD PATH	ISOLATION (dB's)	RANGE (metres)		
		Model A	Model B	Model C
Out-of-band emissions, Δf < 6 MHz from carrier	71	8	8	<1
Out-of-band emissions, Δf > 6 MHz from carrier	61	3	3	<1
Spurious emissions, Δf < 5 MHz from band edge	81	25	16	<1
Spurious emissions, Δf < 10 MHz from band edge	76	14	12	<1
Spurious emissions, Δf < 20 MHz from band edge	71	8	8	<1
Receiver IM	95	12 6	35	4
Blocking, Δf = 2.2 MHz from carrier	109	63 1	79	20
Blocking, Δf > 5 MHz from carrier	89	63	25	2

TABLE 2

MECHANISM- REVERSE PATH	ISOLATION (dB's)	RANGE (metres)		
		Model A	Model B	Model C
Out-of-band emissions	72	9	9	<1
Spurious emissions	84	40	19	1
Receiver IM	93	10 0	32	3
Blocking	40	<1	<1	<1

Case 2 (Model D).

TABLE 3

MECHANISM- FORWARD PATH	ISOLATION (dB's)	RANGE (metres) Model D
Out-of-band emission, Δf = 3.5 MHz from carrier	67	17
Out-of-band emission, Δf = 5 MHz from carrier	50	4
Spurious emissions, Δf < 5 MHz from band edge	82	40
Spurious emissions, Δf < 10 MHz from band edge	77	30
Spurious emissions, Δf < 20 MHz from band edge	72	22
Receiver IM	71	21
Blocking, Δf < 3 MHz from carrier	55	7
Blocking, Δf > 3 MHz from carrier	48	3

TABLE 4

MECHANISM- REVERSE PATH	ISOLATION (dB's)	RANGE (metres) Model D
Out-of-band emissions	35	<1
Spurious emissions	43	2
Receiver IM	64	14
Blocking	45	2

Case 3 (Model E).

TABLE 5

MECHANISM- FORWARD PATH	ISOLATION (dB's)	RANGE (metres) Model E
Out-of-band emissions, Δf < 6 MHz from carrier	86	8
Out-of-band emissions, Δf > 6 MHz from carrier	76	3
Spurious emissions, Δf < 5 MHz from band edge	96	25
Spurious emissions, Δf < 10 MHz from band edge	91	14
Spurious emissions, Δf < 20 MHz from band edge	86	8
Receiver IM	110	126
Blocking, Δf = 2.2 MHz from carrier	124	376
Blocking, Δf > 5 MHz from carrier	104	63

TABLE 6

MECHANISM- REVERSE PATH	ISOLATION (dB's)	RANGE (metres) Model E
Out-of-band emissions	84	6
Spurious emissions	96	25
Receiver IM	105	71
Blocking	52	<1

Case 4 (Model E).

TABLE 7

MECHANISM-FORWARD PATH	ISOLATION (dB's)	RANGE (metres) Model E
Out-of-band emissions, Δf < 6 MHz from carrier	66	<1
Spurious emissions, Δf < 5 MHz from band edge	76	3
Receiver IM	90	13
Blocking, Δf = 2.2 MHz from carrier	104	63
Blocking, Δf > 5 MHz from carrier	84	6

TABLE 8

MECHANISM-REVERSE PATH	ISOLATION (dB's)	RANGE (metres) Model E
Out-of-band emissions	61	<1
Spurious emissions	79	4
Receiver IM	88	10
Blocking	35	<1

Case 5 (Model F).

TABLE 9

MECHANISM- FORWARD PATH	ISOLATION (dB's)	RANGE (metres) Model F
Out-of-band emission, Δf = 3.5 MHz from carrier	79	50
Out-of-band emission, Δf = 5 MHz from carrier	62	14
Spurious emissions, Δf < 5 MHz from band edge	94	140
Spurious emissions, Δf < 10 MHz from band edge	89	106
Spurious emissions, Δf < 20 MHz from band edge	84	74
Spurious emissions, Δf < 30 MHz from band edge	79	50
Spurious emissions, Δf >30 MHz from band edge	74	34
Receiver IM	83	68
Blocking, Δf < 3 MHz from carrier	67	20
Blocking, Δf > 3 MHz from carrier	60	12

TABLE 10

MECHANISM- REVERSE PATH	ISOLATION (dB's)	RANGE (metres) Model F
Reverse path Out-of-band emissions	50	4
Spurious emissions	58	10
Receiver IM	79	50
Blocking	60	12

Observations.

The following comments can be made regarding the different interference mechanisms:

Spurious emissions:

The required isolation values due to spurious emissions are generally higher than those for out-of-band emissions. These levels should be treated as a mask rather than a continuous noise floor. The spurious signals will appear at a few specific frequencies, and therefore these problems could be solved by the Dynamic Channel Selection in DECT and by intra-cell handover in DCS1800.

Receiver intermodulation:

In general the most likely interference resulting from unwanted intermodulation effects in receivers is the third order product, described by:

$$\Delta \quad fIM=2f1-f2=f1\pm\Delta f$$

The implications of this are that no 3rd order products will appear in the DECT band due to DCS1800 mobile transmissions, and that the 3rd order products due to DECT transmissions are limited to the upper 20 MHz of the DCS1800 mobile receive band.

Since the probability of IM interference is low, these problems could also be solved by intra-cell handover in DCS1800 and by the Dynamic Channel Selection in DECT.

NOTE: A recent propagation experiment has indicated that in one installation case, similar to cases 3 and 4, the propagation loss was **less** than predicted by the propagation model (Model E).

6. RESULTS - PRACTICAL STUDY

Practical tests made on some pre-production DECT equipment tends to indicate that;

- DECT equipment on the market is likely to have better blocking performance than the minimum requirement except for the few MHz closest to the DECT carrier.

  Close to the band edge, adjacent channel selectivity determines the blocking performance.

  This conclusion is supported by tests made by two manufacturers.

  - In one of these tests the blocking level was registered as the point at which a listener could discern interference to the link.

  - The other test was made using a BER of 10^{-3} to determine the blocking level.

- DCS1800 interferer will not be worse than a CW interferer except, possibly, within a few MHz from the DECT carrier.

7. CONCLUSIONS

Based upon the findings of the theoretical studies and the results of some limited practical blocking measurements, it is concluded that the following topics should be considered together as a means of reducing the potential compatibility problems:

Arrangements for an increased frequency separation between carriers in adjacent systems;

and,

Improved blocking requirements of DECT receiver equipments (particularly for telepoint implementations) at offsets greater than twice the channel bandwidth;

and,

An investigation into the possible escape mechanisms for both systems to avoid local interference problems and the consequent reduction in capacity.

These mechanisms could include:

Dynamic channel selection (for DECT)

Frequency hopping

Intra-cell handover

Location of the BCCH (control) channels.

ETSI should be asked to consider the identified use to assess whether they are in agreement that there is a significant compatibility problem.

A final decision on the actual improvements to the performance standards of DECT and DCS1800 and/or the acceptable frequency separation between carriers should be taken after discussion between CEPT and ETSI taking into account the economical, technological and spectrum utilisation implications.