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

ADJACENT BAND COMPATIBILITY OF UIC DIRECT MODE WITH TETRA ADVANCED PACKET DATA SERVICE (TAPS)

Baden, June 2002

EXECUTIVE SUMMARY

This report investigates adjacent band compatibility between TAPS and UIC DMO around 876 MHz. This study is based on a previous study in ERC Report 086 "Adjacent band compatibility of UIC direct mode with UIC GSM and 900 MHz TETRA - an analysis completed using a Monte Carlo based simulation tool" investigating compatibility between TETRA and UIC DMO. This study used the same assumptions as in the original document. The simulations have been carried out using a Monte Carlo simulation tool (SEAMCAT). Comparison studies are made for TETRA – UIC DMO compatibility with those in Report 086 and show that the simulation methods used are comparable.

Simulation results showed that in the case of UIC DMO interfering with TAPS BS, the risk of interference is low as long as the AID (Active Interferer Density) is reasonable low (1 or 3/km^2). AID higher than these levels are not expected to occur in practice as detailed in ERC Report 086.

In the case of TAPS MS interfering with UIC DMO, simulation results showed that the risk of interference is low if the guard band is 400 kHz. If the guard band were reduced to 200 kHz, interference levels are only acceptable if the active interferer density (AID) is low (5/km^2).

It is concluded that if a guard band of 400 kHz is used, TAPS and UIC DMO should be able to coexist with no additional requirements.

INDEX TABLE

ADJACENT BAND COMPATIBILITY OF UIC DIRECT MODE WITH TETRA ADVANCED PACKET DATA SERVICE (TAPS)

1 BACKGROUND

The frequency band 870–876 MHz is nominally assigned to TETRA uplink. On the other hand, the adjacent band 876–880 MHz will be used by the UIC mainly for GSM-R system. The first 100 kHz (876–876.1 MHz) of the GSM-R band will be used for Direct Mode Operation (DMO). Five direct mode channels shall exist between 876.0125 MHz and 876.0625 MHz based on 12.5 kHz analogue FM. The proposed UIC usage of Direct Mode is in areas where there is no GSM-R coverage or system failure has occurred. It would not normally be used in areas where GSM-R is operational.

A previous study (ERC Report 086) investigated compatibility issues between TETRA and UIC DMO in this band. It concluded that there was no risk of TETRA interfering with UIC DMO, but there was a risk of UIC DMO interfering with TETRA if the Active Interferer Density (AID) of UIC DMO was very high. In fact the AID of UIC DMO had to be unrealistically high to produce significant interference to TETRA.

TETRA Advanced Packet data Service (TAPS) has been standardised within ETSI and commercial services are expected to be available end of 2002.

There has been a proposal to deploy TAPS in the TETRA band at 900 MHz, namely 870–876 MHz for the uplink, and 915–921 MHz for the downlink. Compatibility studies were carried out to investigate spectrum requirements (e.g. guard bands) of introducing TAPS in the existing harmonised TETRA bands. A separate report has examined the compatibility requirements for TAPS at 915 MHz. This report covers the compatibility with UIC DMO at 876 MHz.

2 INTRODUCTION

This report investigates adjacent band compatibility between TAPS and UIC DMO around 876 MHz. This study is based on a previous study ERC Report 086 “Adjacent band compatibility of UIC direct mode with UIC GSM and 900 MHz TETRA - an analysis completed using a Monte Carlo based simulation tool” investigating compatibility between TETRA and UIC DMO. This study used the same assumptions as in the original document.
The simulations have been carried out using a Monte Carlo simulation tool (SEAMCAT). The basis for the Path Loss Calculation is the modified Hata model as applied in ERC Report 086.

Firstly, a TETRA – UIC DMO compatibility study is done. This is compared with the results in ERC Report 086, which were carried out using another Monte Carlo based simulation tool, to gain confidence in the simulations. Then the same simulations are done again but with TAPS replacing TETRA. Section 3 investigates the scenario when a UIC DMO is interfering with TAPS BS. Section 4 investigates the scenario when a TAPS MS is interfering with UIC DMO. Finally, some conclusions are presented in section 5.

3 UIC DMO INTERFERING WITH TAPS BS

This simulation corresponds to the one in section 4.1 in ERC Report 086. In this simulation, the guard band was taken to be 400 kHz, which is that considered acceptable in Report 086. The results are shown in tables 1 – 3 as follows:

1) Results of the ERC Report 086 simulations of UIC DMO - TETRA case.
2) Results of SEAMCAT simulations of UIC DMO - TETRA case.
3) Results of SEAMCAT simulations of UIC DMO - TAPS case.

The tables show the effect of cell radius and various active interference densities (AID).

TETRA cell radius	AID = 1/sq km	AID = 3/sq km	AID = 5/sq km	AID = 10/sq km	AID = 20/sq km
2	0.1	0.1	0.2	0.2	0.2
3	0.1	0.1	0.4	0.7	0.8
4	0.2	0.3	0.4	1.8	2.0
5	0.4	0.8	0.9	2.2	2.8
6	0.5	1.4	1.9	4.3	4.4
10	1.9	2.9	5.5	7.0	7.2

Table 1: Results (in %) of the ERC Report 086 simulations of UIC DMO to TETRA BS case

TETRA cell radius	AID = 1/sq km	AID = 3/sq km	AID = 5/sq km	AID = 10/sq km	AID = 20/sq km
2	0.1	0.1	0.2	0.3	0.5
3	0.1	0.2	0.4	0.8	1.1
4	0.2	0.3	0.6	1.8	2.2
5	0.2	0.8	0.8	2.4	3.1
6	0.3	1.2	1.4	2.9	4.7
10	0.6	1.6	2.2	4.6	7.9

Table 2: Results (in %) of SEAMCAT simulations of UIC DMO to TETRA BS case

TAPS cell radius	AID = 1/sq km	AID = 3/sq km	AID = 5/sq km	AID = 10/sq km	AID = 20/sq km
2	0.2	0.6	1.3	1.9	3.3
3	0.3	1.3	2.0	3.4	6.6
4	0.5	1.5	2.3	4.8	8.9
5	0.6	1.9	3.2	6.1	10.4
6	0.8	2.3	3.6	7.3	12.0
10	1.0	3.0	4.8	8.6	14.7

Table 3: Results (in %) of SEAMCAT simulations of UIC DMO to TAPS BS case

The results of the SEAMCAT simulations for the UIC DMO to TETRA BS case are reasonably close to those in the original ERC Report 086. This strengthens the credibility of the SEAMCAT simulations, and gives confidence in the results for the TAPS case.

Results for the UIC DMO to TAPS BS case show that interference levels are acceptable as long as the active interferer density (AID) of UIC DMO is low (1 or 3 / km^2). If AID exceeds these levels, interference from UIC DMO into TAPS becomes unacceptably high. High active interferer densities are not expected to occur given the UIC's proposed usage of DMO as a replacement system under failure conditions or where no coverage exists. Furthermore, TAPS is expected to be rolled out only in urban areas. Therefore, the maximum TAPS cell radius will be 3 – 4 km. Taking the realistic assumptions of maximum DMO AID of 3 and maximum TAPS cell radius of 4 km, the risk of UIC DMO interfering with TAPS BS is 1.5%, which is considered acceptable.

4 TAPS MS interfering with UIC DMO

This simulation corresponds to the one in section 5.1 in ERC Report 086. The simulation in the original document assumes a guard band of 400 kHz. The results are shown in tables 4 – 7 as follows:

1) Results for the ERC Report 086 simulations of TETRA – UIC DMO case.
2) Results for SEAMCAT simulations of TETRA – UIC DMO case.
3) Results for SEAMCAT simulations of TAPS – UIC DMO (guard band = 200 kHz).
4) Results for SEAMCAT simulations of TAPS – UIC DMO (guard band = 400 kHz).

UIC DMO Link Distance	AID = 5/sq km	AID = 10/sq km	AID = 20/sq km
200 m	0	0	0
400 m	0	0	0
600m	0	0.001	0.002
800 m	0	0.001	0.008
1 km	0.005	0.01	0.09
1.5 km	0.01	0.18	0.24
2 km	0.1	0.8	1.6

Table 4: Results (in %) of the ERC Report 086 simulations of TETRA MS- UIC DMO case

UIC DMO Link Distance	AID = 5/sq km	AID = 10/sq km	AID = 20/sq km
200 m	0	0	0.1
400 m	0	0.1	0.2
600m	0.1	0.2	0.3
800 m	0.1	0.3	0.5
1 Km	0.2	0.3	0.8
1.5 Km	0.3	0.5	1.3
2 Km	0.4	0.9	1.6

Table 5: Results (in %) of SEAMCAT simulations of TETRA MS- UIC DMO case

UIC DMO Link Distance	AID = 5/sq km	AID = 10/sq km	AID = 20/sq km
200 m	0.4	0.7	1.4
400 m	0.6	1.5	2.7
600m	1.2	2	3.4
800 m	1.3	2.4	4.6
1 km	1.5	2.9	5.4
1.5 km	2	3.6	7.2
2 km	2.3	4.1	7.9

Table 6: Results (%) of SEAMCAT simulations of TAPS MS- UIC DMO case, guard band 200 kHz

UIC DMO Link Distance	AID = 5/sq km	AID = 10/sq km	AID = 20/sq km
200 m	0	0	0.1
400 m	0.1	0.1	0.3
600m	0.1	0.2	0.5
800 m	0.2	0.4	0.8
1 km	0.2	0.5	0.9
1.5 km	0.3	0.8	1.6
2 km	0.4	0.9	1.8

Table 7: Results (%) of SEAMCAT simulations of TAPS MS - UIC DMO case, guard band 400 kHz

As before, results in tables 4 and 5 are acceptably close giving confidence in the simulations.

Results for the TAPS – UIC DMO case show that there is no risk of TAPS MS's interfering with UIC DMO if the guard band is 400 kHz. If the guard band is reduced to 200 kHz, risk of interference will remain low if the active interferer density is low, but the risk of interference becomes high if the AID becomes unrealistically high (e.g. 10 or 20 / km^2). TAPS MS AID are not expected to exceed 5 /km^2 given the cell parameters of TAPS. Therefore, the risk of TAPS MS interfering with UIC DMO is only 2.3%, which is considered acceptable.

5 CONCLUSION

This report examined adjacent band compatibility between TAPS and UIC DMO around 876 MHz. This study was based on the previous study (ERC Report 086) investigating compatibility between TETRA and UIC DMO.

Simulation results show that in the case of UIC DMO interfering with TAPS BS, the risk of interference is low as long as the AID is reasonable low (1 or 3/km^2). AIDs (Active Interferer Densities) higher than these levels are not expected to occur in practice as detailed in ERC Report 086. Besides, since TAPS is expected to be rolled out only in urban areas, the maximum TAPS cell radius will be 3–4 km. Therefore, the risk of UIC DMO interfering with TAPS BS is only 1.5%, which is considered acceptable.

In the case of TAPS MS interfering with UIC DMO, simulation results show that the risk of interference is low if the guard band is 400 kHz. If the guard band is reduced to 200 kHz, interference levels are only acceptable if the active interferer density (AID) is low (5/km^2).

It is concluded that if a guard band of 400 kHz is used, TAPS and UIC DMO should be able to coexist with no additional requirements. Where a guard band of 200 kHz is used, the risk of TAPS interfering with UIC DMO is low for realistic levels of AID. However, there will be a significant risk of interference from UIC DMO affecting TAPS BS's, and therefore some mitigating measures have to be considered. Examples of such considerations can be:

- Careful cell planning to avoid TAPS base stations being close to main operations areas of UIC (e.g. railway centres and operations), typically 500 m;
- Add additional filters to enhance the blocking performance of TAPS base stations where necessary.

APPENDIX A : Technical Characteristics

A1. Technical Characteristics of TAPS

Parameter	**Mobile Station**	**Base Station**
Frequency Band Range	870 - 876 MHz	915 - 921 MHz
Channel Spacing	200 kHz	200 kHz
Transmit Power	33 dBm	43 dBm
Receiver Bandwidth	200 kHz	200 kHz
Antenna Height	1.5 m	30 m
Antenna Gain	0 dBi	9 dBi
Receiver Sensitivity	- 102 dBm	-104 dBm
Receiver Protection Ratio	9 dB	9 dB
TDMA users / carrier	8	8
Power Control Characteristic	2 dBm steps to a minimum of 5 dBm Threshold = - 84 dBm	not used

Table A1.1: Parameters Assumed for the TAPS System

Frequency Offset	**Mobile Station**
100 kHz	33.5 dBm
200 kHz	3 dBm
250 kHz	0 dBm
400 kHz	- 21 dBm
600 – 1200 kHz	- 27 dBm
1200 – 1800 kHz	- 27 dBm
1800 – 3000 kHz	- 35 dBm
3000 – 6000 kHz	- 37 dBm
> 6000 kHz	- 43 dBm

Table A1.2: The Specification for TAPS MS Unwanted Emissions measured in a 30 kHz Bandwidth

Frequency Offset	**BS**
600 – 800 kHz	- 26 dBm
800 – 1600 kHz	- 16 dBm
1600 – 3000 kHz	-16 dBm
> 3000 kHz	- 13 dBm

Table A1.3: The Specification for TAPS BS Receiver Blocking

A2. Technical Characteristics of UIC DIRECT MODE

The ETSI standard ETS 300 086 has been used to obtain most of the UIC DMO system parameters. Tables A2.1, A2.2 and A2.3 list all of the parameters required by the Monte Carlo simulation to model a UIC DMO system.

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

Table A2.1: Parameters Assumed for 12.5 kHz FM Systems

Frequency Offset	Mobile Station
12.5 kHz	- 23 dBm
100 - 250 kHz	- 43 dBm
250 - 500 kHz	- 60 dBm
500 Khz - 1 MHz	- 64 dBm
1 MHz - 10 MHz	- 69 dBm
> 10 MHz	- 71 dBm
Linear interpolation (in dB) is used between 12.5 kHz and 100 kHz	

Table A2.2: Unwanted Emissions for 12.5 kHz FM Systems (measurement bandwidth of 8 kHz)

Frequency Offset	Mobile Station
50 - 100 kHz	- 23 dBm

Table A2.3: Receiver Blocking for 12.5 kHz FM Systems

A3. Technical Characteristics of TETRA

The ETSI standard ETS 300 392-2 has been used to obtain most of the TETRA system parameters. This standard is titled ‘Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air Interface (AI)’. Those parameters, which can not be obtained from the standard are assumed values believed to accurately model operational TETRA systems. Tables B2.1, B2.2 and B2.3 list all of the parameters required by the Monte Carlo simulation to model a TETRA system.

Parameter	Mobile Station	Base Station
Frequency Band Range	870 - 876 MHz	915 - 921 MHz
Minimum Size of Frequency Band Required for System Operation	2 MHz	2 MHz
Channel Spacing	25 kHz	25 kHz
Number of Channels	80	80
Transmit Power	30 dBm	44 dBm
Receiver Bandwidth	18 kHz	18 kHz
Antenna Height	1.5 m	30 m
Antenna Gain	0.0 dBi	9 dBi
Receiver Sensitivity	-103 dBi	- 106 dBi
Receiver Protection Ratio	19 dB	19 dB
TDMA users / carrier	4	4
Power Control Characteristic	5 dBm steps to a minimum of 15 dBm. Threshold = - 86 dBm	not used

Table A3.1 - Parameters Assumed for the TETRA System

Frequency Offset	30 dBm Mobile Station	44 dBm Base Station
25 kHz	- 30 dBm	- 16 dBm
50 kHz	-40 dBm	- 26 dBm
75 kHz	-40 dBm	- 26 dBm
100 - 250 kHz	-45 dBm	- 36 dBm
250 - 500 kHz	-50 dBm	- 41 dBm
500 kHz - frb	- 50 dBm	- 46 dBm
> frb	- 70 dBm	- 56 dBm

Table A3.2: The Specification for TETRA Unwanted Emissions measured in an 18 kHz Bandwidth

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

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

Table A3.3: The Specification for TETRA Receiver Blocking