CEPT Report 17

Report from CEPT to the European Commission
in response to the Mandate to:

identify the conditions relating to the harmonised introduction in the European Union of radio applications based on ultra-wideband (UWB) technology

Complementary report

Final Report on 30 March 2007 by the

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

EXECUTIVE SUMMARY

This report by the European Conference of Postal and Telecommunications Administrations (CEPT) to the European Commission (EC) completes the report by CEPT submitted to EC November 2005 in response to the Second Mandate from the European Commission on UWB issued to CEPT 6 June 2005, concerning mitigation techniques.

It also responds to the Third Mandate from the European Commission on UWB issued to CEPT 5 July 2006, whereby CEPT is mandated to undertake all required activities to assess specific technical compatibility issues between UWB applications and potentially affected selected radio services, based on realistic interference scenarios, with a view to enable the use of UWB equipment in:

- terrestrial transport modes, in particular private and public vehicles, within the range between 3.1 and 10.6 GHz, or a subset thereof.
- the 8.5 – 9.0 GHz band, as an extension of the long-term 6.0-8.5 GHz frequency range

This report has been developed within ECC Task Group 3 (TG3) with contributions from administrations and observers (industry and international organisations) and was approved by the ECC meeting in March 2007.

The work undertaken and final results achieved are described in three separate annexes to this report:

- Annex 1: Mitigation techniques
- Annex 2: UWB devices installed in road and rail vehicles
- Annex 3: UWB operation in the frequency band 8.5 – 9 GHz

Annex 1 provides some key principles towards the definition of technical requirement for generic UWB employing mitigations techniques.

It is concluded that:

- Decision ECC/DEC/(06)04 on the harmonised conditions for devices using UWB technology in bands below 10.6 GHz shall remain the cornerstone of European regulatory package on UWB which is subject to future reviews like the other ECC Decisions on UWB.
- ECC has developed separate Decision ECC/DEC/(06)12 on UWB devices with low duty cycle which complements ECC/DEC/(06)04. When ECCTG3 complete the work to define technical requirement for DAA, ECCTG3 recommends to update ECC/DEC/(06)12 with the technical requirement for DAA.
- Technical requirements, including those applicable to mitigation techniques, may evolve based on new evidences.

Annex 2 presents the outcome of investigations concerning UWB devices installed in road and rail vehicles.

Based on the various considerations detailed in this annex, it is concluded that the activity factor of UWB devices installed in vehicles is less than the indoor activity factor and that the average screening attenuation is comparable with typical indoor/outdoor attenuation. In addition there is a strong absorption loss due to human passengers providing an additional mitigation.

The density of UWB devices installed in vehicles is also expected to be significantly less than the indoor density assumed in previous compatibility studies. Therefore it can be recommended to consider the additional impact of UWB devices installed in vehicles as negligible and to remove the prohibition to install UWB devices in vehicles from Decision ECC/DEC/(06)04.

However taking into account the alternative scenario extrapolation considerations in this report and that the transmit power can be reduced in a majority of the cases without significantly degrading performance of the in car applications due to smaller communication ranges, it is recommended to make a transmit power control (TPC) mandatory for UWB devices installed in road and rail vehicles, which are not LDC.

This precautionary mitigation factor will ensure the efficiency of the spectrum management as well as a safety margin recognizing the need of appropriate monitoring measures and to minimize outdoor activity of UWB as underlined in Decision ECC/DEC/(06)04.

Annex 3 covers the use of band 8.5 - 9 GH by UWB devices.

Based on the latest ECCTG3 compatibility study and measurement campaign results conducted for UWB impact analysis on surveillance radars deployed in 8.5 to 9 GHz band, this annex confirms the protection limit of a maximum average PSD of -65 dBm/MHz (referenced to 25 m protection distance) for these radiolocation systems.

Additionally, ECCTG3 proposes further work to be carried in order to define and validate adequate mitigation techniques to allow UWB operation with higher emission levels in this frequency band without causing any harmful interference to radiolocation systems. The performance verification of these mitigation techniques applied to radars, may be performed by measurement campaigns which will require the availability of radar systems and UWB equipments operating with these mitigation techniques.

As an initial minimum isolation between UWB devices and X-band radio location devices a isolation of 105dB (80dB at -65dBm/MHz → 105dB at -41.3dBm/MHz) could be envisaged. This isolation corresponds to a LOS mitigation distance of 500m and a NLOS mitigation distance of 35m.

Table of contents

List of Tables

Annex 1: Mitigation techniques

Introduction

This report by the European Conference of Postal and Telecommunications Administrations (CEPT) to the European Commission (EC) is dedicated to mitigation techniques for UWB technology for Generic applications.

Pursuant to art. 4 of the Radio Spectrum Decision, the second mandate requested CEPT to finalise all relevant work to identify harmonised conditions of use of radio spectrum in the European Union for all significant types of UWB applications (i.e. communications, imaging, location-tracking, etc.), with priority for applications considered to be closest to user take-up.

This report has been developed within ECC Task Group 3 (TG3) with contributions from administrations and observers (industry and international organisations) and was approved by the ECC meeting March 2007. It provides some key principles towards the definition of technical requirement for generic UWB employing mitigations techniques.

1 Principles for development of mitigation technique

ECCTG3 considered several mitigation techniques in order to increase the maximum e.i.r.p. in the band 3.1 to 4.8 GHz to a level sufficient to enable viable UWB operation in this band whilst ensuring the protection of the Radio Services. LDC and DAA mitigation technique have been studied as possible mitigation to allow coexistence with radiocommunication services.

For the 3.1 to 3.4GHz band, CEPT is in the process of investigating the feasibility of possible mitigation techniques to protect radiolocation services operating in this band.

For the 3.4 to 3.8GHz band, the victim service considered is FWA. ECCTG3 has focused on investigating efficiency of LDC and DAA mitigation technique to protect indoor IEEE802.16 WiMax system assuming that this is representative of typical FWA system.

ECCTG3 has not received further requested information on the characteristics of BWA and future IMT service. However, to consider technology neutrality, ECCTG3 will further investigate other non IEEE 802.16 FWA system and future mobile applications in bands above 3.4GHz, when the characteristics of such system are available. The associated Decision relating to the mitigation will need to be updated accordingly.

2 Low Duty Cycle (LDC) Mitigation Technique

The concept of LDC is based on allowing UWB to increase the maximum e.i.r.p with the limitations on burst duration (Ton) and burst intervals (Toff+Ton).

Applications foreseen for UWB operating with the LDC mitigation technique are mainly to support accurate indoor geolocalisation focused on sensor network in home, office or industrial environment.

ECCTG3 undertook two measurement campaigns between Nov 2005 and June 2006 (see ECC Report 94) to determine the appropriate Ton and Toff parameters to protect FWA

The impact was assessed for

- Representative WiMax user services (FTP(File Transfer Protocol), Video streaming, VoIP (Voice over Internet Protocol)) as well as ;
- WiMax operation (adaptive modulation, throughput , synchronisation)

The measurement led to conclusion that when the UWB activity factor is limited to 5%, the impact to WiMax system is acceptable for 1dB degradation at 1m separation distance. In most cases, separation distance of 0.5m does not result in significant degradation.

Considering the target applications for UWB LDC, CEPT agreed that minimum separation distance of 0.5m between UWB LDC and WiMax systems is acceptable noting that when the distance increases, the situation is better.

ECCTG3 in its June 2006 meeting approved the following technical requirement for UWB LDC mitigation technique:

Ton max = 5 ms
Toff mean >= 38 ms (averaged over 1 sec)
Σ Toff > 950 ms per second
Σ Ton < 5% per second and 0.5% per hour
PSD max -41.3 dBm/MHz

ECC adopted the ECC Report 94 on Technical Requirements for UWB LDC Devices to ensure the protection of FWA systems and ECC Decision (06)12 on harmonised conditions for devices using UWB technology with LDC in the frequency band 3.4 – 4.8GHz in Dec 06 after undergoing public consultation in July 06.

3 Detect And Avoid (DAA)

The concept for DAA is based on allowing UWB to increase the maximum e.i.r.p. when it does not ‘detect’ the presence of radio services and ‘avoid’ transmitting in the victim service bands when a victim signal is detected.

ECCTG3 has adopted a compromise level of -80dBm/MHz to protect FWA in the 3.4 to 3.8GHz band, referenced to protection distance of 36cm.

This compromise is enabling the UWB industry to investigate the feasibility of a flexible DAA mechanism providing an equivalent protection level to -80 dBm/MHz (referenced at 36cm), and operating with different avoid levels based on isolation distances.

ECCTG3 is considering the Flexible DAA approach which is based on combination of victim services DL and UL detection, is allowing to investigate a mitigation technique providing a real coexistence mechanism between UWB devices and victim services.

- Downlink detection to detect victim service deployment eg. broadcast mode
- Uplink detection to detect client victim service and isolation level
- Avoid operation based on different maximum UWB emission level

Currently the technical studies are at early stage, the regulatory requirements and performance criteria are not yet defined.

ECCTG3 has already considered how to perform an adequate definition of such DAA based on both uplink and downlink detection and has already identified some initial required parameters as shown in Table 1 and 2.

Technical studies are still required in order to finalize the identification of these parameters, and the definition of each of them.

TABLE 1

Summary of performance requirements for dynamic DAA mitigation techniques based upon Uplink detection

Parameter	Value
Minimum Narrowband Signal Detection Threshold (dBm) in a bandwidth ranging from 1-20 MHz D_{thresh}	[*XXX* dBm]
Silent Period T_{silent} ms every T_{tot} ms	[*XXX* ms *off* every *YYY* ms (*ZZ*% duty cycle)]
Detection Reliability	[99% detection probability of any transmission received at Minimum Detection Threshold lasting *XXX* µsec in duration located in the *XXX* ms *off* period]
Initial Channel availability check time	*[XXX ms]*
Narrowband Signal Protection Level	[*XX* dBm/MHz]
Implementation Time T_{impl}	[*XX* ms]
Mitigation Time Period T_{mit}	*[XX minutes]*

TABLE 2

Summary of performance requirements for dynamic DAA mitigation techniques based upon Downlink detection

Parameter	**Value**
Minimum Narrowband Signal Detection Threshold (dBm) in a bandwidth ranging from 1-20 MHz D_{thresh}	[*XX* dBm]
Detection Reliability	[99% detection probability of any transmission received at Minimum Detection Threshold lasting *XXX* μsec in duration located in initial channel availability check time]
Initial Channel availability check time	[*XX ms*]
Channel availability Check Period (repetition period of channel availability check)	[XX hour]
Narrowband Signal Protection Level	[*XX* dBm/MHz]
Implementation Time T_{impl}	[*XX* ms]

When technical studies for the definition of these parameters will be mature, the DAA performance will have to be demonstrated by measurement campaigns based on real victim service deployment scenario.

Typical impact analysis of UWB with DAA on FWA system will be considered for different realistic services and applications, in addition to different modes for the WiMAX client.

- Network entry mode
- Sleep mode
- Idle mode
- Active mode, with different services considered:
  - Video streaming
  - Video conferencing
  - VoIP
  - FTP

ECCTG3 expected to complete the technical requirement and validation of the efficiency of DAA to protect FWA at 3.4 to 3.8 GHz band by March 2008.

4 Conclusions and recommendations

Decision ECC/DEC/(06)04 on the harmonised conditions for devices using UWB technology in bands below 10.6 GHz shall remain the cornerstone of European regulatory package on UWB which is subject to future reviews like the other ECC Decisions on UWB.

ECC has developed separate Decision ECC/DEC/(06)12 on UWB devices with low duty cycle which complements ECC/DEC/(06)04. When ECCTG3 complete the work to define technical requirement for DAA, ECCTG3 recommends to update ECC/DEC/(06)12 with the technical requirement for DAA.

Technical requirements, including those applicable to mitigation techniques, may evolve based on new evidences.

Annex 2: Report on the technical requirements for UWB Devices installed in Road and Rail Vehicles

1 Introduction

A number of technical studies have been performed within CEPT in support of the development of generic regulatory solutions for devices using UWB technology.

Following the adoption of ECC Report 64, further analysis has been performed within the frame of the second EC Mandate on UWB issued by the European Commission to CEPT in June 2005, including in particular:

- complementary technical studies focused on three selected coexistence scenarios (Fixed Satellite Services, outdoor Fixed Services and indoor FWA scenarios);
- an impact analysis, structured per frequency range, initially considering an e.i.r.p. density limit of -55 dBm/MHz in the 3.1 – 10.6 GHz frequency range, taking into account possible mitigation factors in particular restriction to indoor UWB applications.

The complementary technical studies provided a sufficient level of confidence regarding protection of the outdoor stations of the Fixed Service and the Fixed Satellite Service in the bands 3.4 – 4.8 GHz and 6 – 8.5 GHz. For those investigations different propagation models and 100% of UWB devices operating indoor with an average 1% activity factor and with a maximum mean e.i.r.p. density of –41.3 dBm/MHz were assumed. The results of these aggregate interference studies depend on the UWB deployment scenarios.

At the time of concluding the complementary technical studies no data was available of the attenuation of the UWB signal from within a car. Therefore devices installed in road and rail vehicles have not been considered in the investigations which resulted in the development of the Decision ECC/DEC/(06)04.

Based on measurements undertaken by the EC Joint Research Centre on the attenuation of the UWB signal from within a car, the results of these measurements concluded that the attenuation of the UWB signal from within a car is equivalent to that of the indoor/outdoor attenuation. Therefore this should lead to the conclusion that the in-vehicle usage should be permitted within the scope of Decision ECC/DEC/(06)04.

In order to address the third EC Mandate on UWB issued to CEPT in July 2006, CEPT identified that necessary complementary work should focus on the following activities:

- *See complementary technical studies on FS/FSS: how can the conclusions applicable to outdoor victim services in the band 3.4 – 4.8 GHz and 6 – 8.5 GHz be extrapolated when assuming UWB deployment in vehicles and taking into account car attenuation measurements? Identify the differences in the density assumptions for the applications in vehicles compare to "indoor" devices.*
- *Consider the possible need for additional study addressing specific deployment scenarios taking into account the above consideration*
- *Consider the requirements for UWB transmission in vehicles based on TG3 previous studies*

2 Review of complementary technical studies on FS/FSS

The results of the complementary technical studies have been detailed in the Final CEPT Report in response to the Second EC Mandate to CEPT to Harmonise radio spectrum use for Ultra-wideband Systems (see Doc. ECC(05)139rev2 Annex 10).

These studies provided a range of values for the maximum UWB mean e.i.r.p. density required to ensure the protection of outdoor stations from the Fixed Service and the Fixed Satellite Service in the bands 3.4 – 4.8 GHz and 6 – 8.5 GHz, pending various assumptions on the propagation models and deployment scenarios.

- Density: 100, 1000, 10000 / km2
- Activity factor: 1%
- 100% indoor deployment

As an illustration, the maximum UWB mean e.i.r.p. density resulting from the complementary technical studies on FS in frequency band 3.4 – 5 GHz are shown in the table below for the urban scenario:

TABLE 1

Results of complementary technical studies on FS

Average AF	1 %		5 %		17 %	
Simulation method	Intel	Siemens	Intel	Siemens	Intel	Siemens
Contribution of additional 20% UWB outdoor handheld devices (AF 1% Siemens) (AF 0.01% Intel)	0.5 at most	3	None	1	none	None
UWB PSD level (dBm/MHz) for 95% confidence of matching with power control (dB)	**–37.8**	**–45.3**	**–42.8**	**–49.8**	**–47.3**	**–54.7**
UWB PSD level (dBm/MHz) for 99% confidence of matching	**–40.8**	**–48.3**	**–46.3**	**–53.3**	**–50.3**	**–57.7**

When considering the above results on FS, it should be noted that the contribution from the additional 20% of hand-held outdoor UWB devices had been evaluated to be between 0,5 dB and 3 dB increase in the noise assuming a 1% activity factor.

In an attempt to extrapolate the results of the aggregate interference studies on FS/FSS to the broader UWB deployment including installations inside road and rail vehicles, the main factors which are relevant are the attenuation, the density and activity of UWB devices installed in vehicles and the use scenarios of UWB devices inside vehicles.

2.1 Assumptions of car density

The maximum density of vehicles is expected in urban areas. The density of 330 vehicles / km^2 taken from ECC Report 23 is used for this assessment.

TABLE 2

Device densities

	Rural	Suburban	Urban
Density "indoor"/ km^2	100	1000	10000
Density "vehicles" / km^2	-	-	330

This value is generally considered to be conservative as other studies have shown even significant less typical values for Paris for example pointing on a maximum of 224/km² as a total maximum for Europe.

It should be noted that the relevance of such parameter depends on the dimensions of the area over which the number of vehicles is averaged. The relevance of assumptions used for car density is closely related to that of the interference model considered.

2.2 UWB activity factors

Cable replacement is certainly a significant market that can be anticipated for UWB installations in vehicles. The industry has various incentives (cost, fuel consumption…) to reduce the weight of a car. The replacement of cables by wireless UWB transmission used for various command/control electrical transmissions or for some multimedia transmissions (including video streaming) would serve this purpose. An individual UWB *piconet* structure would expectedly enable to achieve these various communications within an individual modern vehicle.

Therefore in general the 1% activity factor value used in the complementary technical studies is expected to be applicable also for UWB devices installed in vehicles as a basis. Due to the specific use pattern of vehicles communication applications, it was furthermore argued that a number of mitigation factors could in practice significantly reduce the average activity factor for such applications:

a) the main influencing scenario on the activity factor is the home-scenario with the video-streaming with a very high probability of simultaneously usage at the same time of 62% in peak hours, which is not the case in the ,,vehicle,, scenario
b) the communication distances in vehicles are smaller then assumed for generic indoor devices (vehicles 0.5-2m, indoor 1-10m) and for smaller distances the expected data rate is higher and therefore the resulting physical-activity time as well as needed power will be lower (depending on the number of persons in the vehicle providing absorption close to the antennas) → this can result in activity factor reduction by a factor of 0.5
c) the vehicle is occupied/used only by a fraction of the time as a typical home or office is (1h compared to 8-10h → this results in a significant activity factor reduction by a factor of RF_time = 0.1
d) the typical use case of entertainment equipment (which was identified as the most driving factor in activity factor calculation) is only active, if there are at least 3 persons in the car (the back seats populated), which is only true in a fractional

number of use cases → this results in a significant activity factor reduction by a factor of RF_#user = 0.1

e) not all cars will use wireless UWB systems to the same extend, it will be possibly one out of several options of extras to be chosen by the customer (like high quality entertainment equipment) at the moment of purchase → this results in an activity factor reduction by a factor of 0.1 - 0.5, which will decrease over the next 10 years

It was emphasized that generic UWB devices, which by nature are low cost radio devices, could become commercially viable for any kind of modern car. Several UWB devices could communicate within a single car *piconet* structure, including possible audio/video streaming transmission.

Following a conservative approach and not considering a), b) and e) it was argued that an activity factor average value as low as 0.01%[1] could be relevant in case of UWB installations in cars.

2.3 Screening attenuation

The results of the ISPRA measurements campaign performed in August 2006 indicate that, in most cases, there is in the frequency range from 3-6 GHz and 6-9 GHz a mean attenuation which is comparable to the indoor/outdoor attenuation. In some exceptional cases, where the UWB antennas were placed directly behind the car windows pointing through the window outside there was less attenuation reported. Besides the fact, that such positions are not relevant for the envisaged applications this is the same behaviour as in typical buildings. So there is a lot of commonality between car screening attenuation measured and indoor/outdoor attenuation model agreed in ECC TG3 to have as a mean value of 10 dB (Report 64). It should be noted, that cars with metallized windows provide a mean attenuation of about 15dB and cars without any metallized windows provide a mean attenuation of about 8dB. Cars with one window being metallized (front window) provide a mean attenuation of 12 dB. For the details please see Table 3.

TABLE 3

Relevant lines of table 5-1 Attenuation values for compartment illumination positions of the antenna

Frequency range (GHz)	BMW-2 (with all windows metallized)	BMW-1 (with metallised front window)	MB (w/o metal, positions 1,8)
3-6	13-16 dB	9-14 dB	7-8 dB
6-9	12-19 dB	9-14 dB	7-9 dB

It is important to note, that in addition to the screening attenuation there is an absorption loss due to the effect of the human body being close to the UWB antenna in a car. This loss could be as high as 10-20dB. In particular the use case of entertainment of the back seats contributing mainly to the activity is characterised by having at least 3 passengers in the vehicle.

[1] AF_vehicles = AF_ECC_indoor * RF_time * RF_#user = 1% * 0.1 *0.1 = 0.01%

2.4 Preliminary conclusion

As indicated previously, the objective of this first analysis was to consider whether the assumptions of the complementary studies on FS and FSS can be fulfilled with a high confidence taking into account UWB deployment in vehicles.

The table below gives an indication of the additional aggregated power evaluation resulting from the deployment of UWB installations in vehicles.

TABLE 4

Resulting additional aggregated power evaluation

	ECC/DEC/(06)04	"vehicles"	Impact of ECC/DEC/(06)04 + vehicles
Density urban / km^2	10.000	330	0.14dB additional aggregated power
Activity factor	1%	0.01%	Reducing time of influence by factor of 100, as vehicle is a moving UWB source
Active device density / km^2	100	0.033	0.0014dB additional aggregated power
Building / car screening attenuation (mean value)	10 dB	10 dB from 3 to 9 GHz	0 dB weight of additional aggregated power
Absorption loss due to close proximity of human body to UWB antenna	-	10-20 dB	10-20 dB additional attenuation due to absorption

Table 4 shows that the deployment of UWB devices installed in vehicles operating under the existing generic UWB rules would have no significant impact on FS/FSS.

In the previous sections related to the assessment of the main factors of the interference studies it was mentioned, that the relevance of assumptions used for car density is closely related to that of the interference model considered. It is proposed in the following section to consider specific studies, some of them assuming a linear deployment of UWB transmitters along a road.

3 Additional specific studies

3.1 Impact on RTTT/DSRC

One administration and one RTTT/DSRC manufacturer presented results on the assessment of the impact of UWB devices installed in road and rail vehicles on RTTT/DSRC performance. After an initial discussion of the topic a comprehensive analysis was presented concluding, that there are –72 dBm/0.5MHz peak power allowed in 0.5 MHz bandwidth to protect DSRC services compared to the –70 dBm/0.5 MHz calculated from the ECC decision (06)04. Additionally taking into account, that the screening attenuation of a car would be sufficient even in worst case to provide the required additional 2 dB and to provide an additional margin of several dB in most cases, it was agreed, that the generic limits can be applied to UWB installed in vehicles as well and would be compatible with the DSRC services.

3.2 Impact on civil Mobile Services

Investigations on the impact of UWB devices installed in road and rail vehicles on the civil Mobile Services are provided by a mobile service operator (see Doc. TG3#17_11R0). Some initial considerations on the impact of UWB applications in "road and rail vehicles" on mobile radio systems as considered in ECC Report 64 and/or ITU-R Report SM.2057 are provided in this document; in particular on UMTS in the core and extension bands around 2 GHz and WLANs at 2.4 and 5 GHz. The critical case reported is the single interference case. It is stated, that further studies may be required when the parameters and frequency bands of the future broadband mobile systems are defined after WRC-07. This holds for the generic decision as well. Further it is argued that the limits defined in ECC Dec (06)04 and the corresponding limits for LDC and DAA mitigation techniques (currently developed) provide sufficient protection of the "civil" mobile user.

3.3 Extrapolation from 24 GHz SRR deployment scenarios

One administration proposed to apply different values for activity factor and screening attenuation as well as density. The main concern with the model used so far is that it would not sufficiently account for the cumulative LOS UWB interference into a victim radio FS/FSS station located in the vicinity of a large road. It is argued that the resulting noise increase at the victim receiver level during peak hour road traffic should not be underestimated.

An alternative extrapolation of the SRR/FS compatibility study detailed in ECC Report 23 was thus proposed, assuming in particular the following worst case assumptions different from the assumptions in section 2:

- 100% of vehicles within visibility of the victim service are equipped with UWB
- each individual road vehicle is assimilated as one individual UWB transmitter 10% active
- an average screening attenuation of 5 dB

Based on such alternative assumptions, one administration supported for "UWB installations in road vehicles" a maximum mean e.i.r.p. density in order of -55 dBm/MHz.

3.4 Extrapolation of the conclusion of Fixed outdoor installations to the case of vehicles

The importance of avoiding outdoor UWB on fixed location or connected to outdoor fixed antenna was emphasised within the frame of the complementary technical studies on FS/FSS.

In the single entry scenario "outdoor UWB / outdoor FS station" detailed in ECC Report 64 (see section 4.2 of Annex 2-01 on FS), the UWB device is assumed to be at ground level. The attenuation associated with path loss increases with distance, although this may be partially overcome by the antenna gain as a result of the angular variation (i.e. towards main beam). The technical study concluded that a single UWB device, with ~-41 dBm/MHz e.i.r.p. density, fixed placed in LOS of a FS receiver and without any indoor-outdoor additional attenuation, would exceed the objective significantly.

If one would assume no clutter loss between the side of a road and a victim FS receiver and further one would assume zero distance between cars having each 100% UWB device activity factor, a regular flow of UWB-equipped road vehicles could imply a continuous LOS exposure of the victim FS receiver to UWB interference. It is obvious that this extreme situation is not the case in practice, but it illustrates that the results of the "Single entry outdoor UWB emission r.m.s. interference" detailed in ECC Report 64 should invite to a cautious approach.

3.5 Impact on outdoor stations from the Mobile Service in the band 4400-4800 MHz

During the course of the discussions relating to the "phased approach", a contribution was submitted by one administration on the potential impact of mass UWB deployment on outdoor Defence stations from the Mobile Service (see Doc. TG3#13_05R0), suggesting in particular that a limit of –50 dBm/MHz mean e.i.r.p. density would be required to ensure the protection of Unmanned Aircraft Vehicles (UAV).

It appeared however that the coexistence would be feasible when considering the deployment scenarios used in the complementary technical studies on FS/FSS; i.e. that the conditions of coexistence of UWB devices with UAVs would be similar to that with FS and FSS outdoor receivers.

The uncontrolled nature of the deployment of UWB devices and the related impact on outdoor victim systems, in particular UAVs which are already using this frequency band for survey and public security missions should however invite administration to caution.

The extrapolation analysis of the additional aggregated power resulting from the deployment of UWB installations in vehicles presented in section 2 of this report could assumed to be applicable as well to the case of outdoor stations from the Mobile Service.

3.6 Impact on radio astronomy service in the band of 4800-5000 MHz

The radio astronomy service has no concerns for the single interferer case but has raised some concerns for the aggregate interference scenarios. In case of a very high density of vehicles it is suggested to adopt an appropriate protection zone or other mitigation techniques.

4 Requirements for UWB transmission in vehicles

A report on UWB requirements and communications link budget has been developed within ECC TG3 (see Doc. TG3#10_42-A5R0).

Some consideration was given to the Link budget calculations detailed in this report and more specifically to the case of STB/Speaker Systems application. In this application a STB (Set Top Box) is connected to a set of speakers distributed in the living room. The relative position of the two systems should be as flexible as possible.

The STB is a High End device. The speakers are medium complex devices with an RX antenna gain of 0dBi. The possible range is 4.0m which would be sufficient for the typical living room setups. With a TX power of -55 dBm/MHz the range would be limited to 1.6m. While this range would definitely put severe restrictions to the choice of the relative positions of the devices in a living room, it was argued that such range would be sufficient within a car.

It was however underlined that such analysis does not account for an absorption loss due to the effect of the human body being close to the UWB antenna in a car, which could be as high as 10-20dB. In particular the use case of entertainment of the back seats contributing mainly to the activity is characterised by having at least 3 passengers in the vehicle.

Given the need to limit the aggregate UWB interference into outdoor victim receivers, the emissions from UWB installations in vehicles should be kept a minimum necessary taking into account the propagation conditions. This suggests the implementation of some kind of Transmit Power Control mitigation.

5 Conclusion

Based on the various considerations detailed in this report, it can be concluded that the activity factor of UWB devices installed in vehicles is less than the indoor activity factor and that the average screening attenuation is comparable with typical indoor/outdoor attenuation. In addition there is a strong absorption loss due to human passengers providing an additional mitigation.

The density of UWB devices installed in vehicles is also expected to be significantly less than the indoor density assumed in previous compatibility studies. Therefore it can be recommended to consider the additional impact of UWB devices installed in vehicles as negligible and to remove the prohibition to install UWB devices in vehicles from Decision ECC/DEC/(06)04.

However taking into account the alternative scenario extrapolation considerations in this report and that the transmit power can be reduced in a majority of the cases without significantly degrading performance of the in car applications due to smaller communication ranges, it is recommended to make a transmit power control (TPC) mandatory for UWB devices installed in road and rail vehicles, which are not LDC.

This precautionary mitigation factor will ensure the efficiency of the spectrum management as well as a safety margin recognizing the need of appropriate monitoring measures and to minimize outdoor activity of UWB as underlined in Decision ECC/DEC/(06)04.

Annex 3: UWB operation in the frequency band 8.5 – 9 GHz

1 Introduction

This is the final Report developed by the European Conference of Postal and Telecommunications Administrations (CEPT) in response to the European Commission (EC) under the Mandate dealing with the harmonised technical conditions for the use in the European Union of UWB applications in the frequency range between 8.5 and 9 GHz.

Based on the latest ECCTG3 compatibility study and measurement campaign results conducted for UWB impact analysis on surveillance radars deployed in 8.5 to 9 GHz band, this report confirms the protection limit of a maximum average PSD of -65 dBm/MHz (referenced to 25 m protection distance) for these radiolocation systems.

Additionally, this report provides recommendations on further work to be carried in order to define and validate adequate mitigation techniques to allow UWB operation with higher emission levels in this frequency band without causing any harmful interference to radiolocation systems. The performance verification of these mitigation techniques applied to radars, may be performed by measurement campaigns which will require the availability of radar systems and UWB equipments operating with these mitigation techniques.

2 Technical approach for protection limits definition and validation

ECCTG3 mandated an ad-hoc radar WG to conduct this work.
The radar WG has set up a technical approach based on a technical analysis between compatibility studies currently submitted, which are based on ITU- Recommendation protection criteria (I/N) and measurement results providing realistic deployment scenario and real UWB interferer impact. A measurement campaign has been completed, and these test results have been used for this technical study.

For both technical studies and measurement campaigns similar assumptions have been considered, the table below provides these revised assumptions:

TABLE 1

Revised Assumptions

Assumptions	Criteria
Indoor attenuation	**10 dB**
UWB interference link	**Main beam**
Safety margin	**No**
Multiple System/Technology Allowance	**No**
Protection distance	**25 m**
Path loss model	**Free space model**

3 Measurement campaign

This measurement campaign has been performed at the EMC test centre at Greding, Germany in collaboration with the Federal Office of the Bundeswehr for Information Management and Information Technology.

The objective of this measurement was to conduct the UWB impact analysis on X-Band radio location systems using different UWB devices (MBOFDM based UWB and Pulse based UWB)

The general measurement configuration is shown in Figure 1.
The measurements have been conducted in a hall (length of 40m and a width of 16m).
The transmitting antenna and instrumentation trailer were located at a distance of 25 m from the Radar antenna. The target generator and UWB antennas were located in the same orientation from the radars.

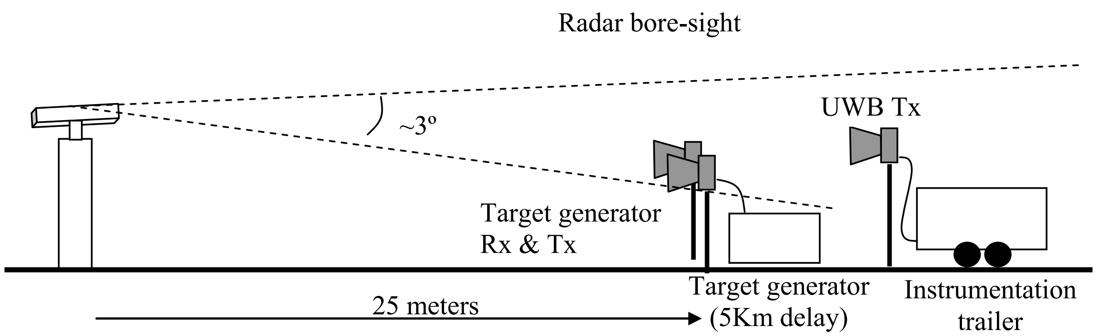

Figure 1: Measurement set-up with target generators and UWB interferers

The target generator used was a device developed by the Thales group for the test of X-Band radio location devices.
The target generator consists of a combined receiver and transmitter antenna. The received radar signal is transferred via an internal optical cable in order to emulate a target distance of 5km. Then the delayed signal is retransmitted using the same antenna.

For generating UWB interferers, two UWB sources have been used, one based on MBOFDM, representative of current product developments, and one based on Pulsed UWB. As these devices were built for operating in frequency bands below 5GHz, for the measurements in the X-Band, the base band signals have been up-converted, and then the signal has been filtered using an X-Band band pass filter.

In addition of the UWB sources, two reference interference sources have been used, a CW generator and a broadband noise generator.

The measurement campaign consisted of two different UWB interference measurements;

- UWB impact analysis on X-band radars in passive mode (No target sources), and the UWB sources were:
    - Noise source signal
    - WIMEDIA like UWB signal, 100% activity factor and 0.7% activity factor
    - Pulse based signal

- UWB impact analysis on X-band radars in active mode (with target sources), and the UWB sources were:
  - Noise source signal
  - WIMEDIA like UWB signal
  - CW signal

4 Protection limits recommendation

The measurements have been performed with a distance of 25m (isolation between UWB source and victim: 80dB) between the victim X-band radio location device and the UWB interfering source. The transmission conditions between the victim and the UWB sources are Line-of-Sight without any addition attenuation. No additional mitigation techniques have been used in the UWB systems. The measured values for the interference are the average power of the UWB sources.

Under these conditions, the onset of a degradation of the radar sensitivity was at a level of -65dBm/MHz UWB interference power for a 100% active UWB system. At this level a range reduction of 5% can be noticed. For a lower activity factor of 0.7% the onset of degradation has been at a interference level of around 20dB above the 100% value, thus at -45dBm/MHz.

The internal signal processing operations of the x-band radio location device has no significant influence on the behaviour under interference conditions.
The theoretical calculation of the worst case situations have been confirmed by the measurements.

Under these operational conditions, a maximum average PSD of -65dBm/MHz (referenced to 25meters protection distance) is allowed for UWB emission power limit, if no additional mitigation technique is used.

5 Further work recommendation on 8.5 to 9 GHz band

ECCTG3 proposes further work for studying and defining regulatory requirements for mitigation techniques allowing UWB devices coexistence with surveillance radars deployed in 8.5 to 9GHz band.

Two main activities would be required:

- A theoretical study, for the definition of adequate mitigation techniques for radio location systems, such as:
  - Listen Before Talk “LBT”
  - Low Duty Cycle “LDC”
  - Flexible Detect And Avoid “DAA”
- The implementation of a test bed for validation of these mitigation techniques.

As an initial minimum isolation between UWB devices and X-band radio location devices a isolation of 105dB (80dB at -65dBm/MHz → 105dB at -41.3dBm/MHz) could be envisaged. This isolation corresponds to a LOS mitigation distance of 500m and a NLOS mitigation distance of 35m.