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

THE IMPACT OF OBJECT DISCRIMINATION AND CHARACTERIZATION (ODC) APPLICATIONS USING ULTRA-WIDEBAND (UWB) TECHNOLOGY ON RADIO SERVICES

Vilnius, September 2008

0 EXECUTIVE SUMMARY

Although some ECC decisions address already specific UWB applications for imaging and probing applications ([1] and [2]) as well as generic UWB applications ([3] and [4]), this report considers an additional request from ETSI on Object Discrimination and Characterization (ODC) published in [5]. This report considers the possible impact of ODC on radio services/systems taking into account existing regulation for UWB by defining a spectrum emission mask, based on assumptions for the density and activity factor applicable for Europe[1]. Details are given in the referred sections of the report.

As result of these studies the limits of existing UWB regulations are applicable to ODC in some bands:
- below 1.73 GHz: the limits of ECC/DEC/(07)01 [2] are applicable to ODC, but not considering the LBT option.
- from 2.2 to 2.5 GHz, 3.8 to 4.8 GHz [2], 5 to 5.25 GHz, 5.35 to 5.6 GHz and 5.725 to 8.5 GHz: the limits of ECC/DEC/(07)01 [2] are applicable to ODC
- above 8.5 GHz: the limits of ECC/DEC/(06)04 [3] are applicable to ODC

Deviations from existing UWB regulations are needed in the other bands and these requirements are summarized in the table below.

	Application A: Limits and requirements for fixed installations with an antenna rejection in the horizontal plane (elevation angles from -20 to 30°)	**Application B**: Limits and requirements for non fixed installations with 10% Duty Cycle (DC) (Notes 1 and 4) and TRP (note 2)	**See Section**
IMT2000 Core band 1.73-2.2 GHz	Max -65 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -70 dBm/MHz e.i.r.p.	4.4 and 6.5
IMT2000 extension band 2.5-2.69 GHz Note 7	Max -50 dBm/MHz e.i.r.p. plus LBT from ECC/DEC/(07)01 and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -50 dBm/MHz e.i.r.p. plus LBT from ECC/DEC/(07)01 and a TRP limit of -60dBm/MHz	4.6, 5.2 and Annex 5
RAS 2.69-2.7 GHz, Note 3	Max -55 dBm/MHz e.i.r.p. -75 dBm/MHz e.i.r.p. in the horizontal plane	Max -70 dBm/MHz e.i.r.p. plus a DC limit of 10%	4.7, 6.1, Annexes1, 2 and 3
Radar S-Band, 2.7-2.9 GHz	Max -50 dBm/MHz e.i.r.p and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -70 dBm/MHz e.i.r.p.	4.8, 5.1.3 and 6.3
Radar S-Band, 2.9-3.4 GHz	Max -50 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -50 dBm/MHz e.i.r.p. with LBT from ECC/DEC/(07)01; Note 5	4.8, 5.1.2 and 6.3
BWA 3.4-3.8 GHz[3] Note 6	Max -50 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -50 dBm/MHz e.i.r.p., with a DC limit of 10% and a TRP limit of -55dBm/MHz	4.9 and 6.2

[1] The assumptions, used when developing the RAS SEAMCAT simulations, are specific to the Westerbork station in the Netherlands (see Annex 2 Simulation 8).
[2] Note: The Russian Federation is of the opinion that maximum mean e.i.r.p. spectral density level -70 dBm/MHz should be used for ODC applications in the frequency bands 3.8 – 4.2 and 4.5 – 4.8 GHz to protect stations of Fixed Satellite service (space-Earth).
[3] Note: The Russian Federation is of the opinion that maximum mean e.i.r.p. spectral density level -80 dBm/MHz should be used for ODC applications in the frequency band 3.4 – 3.8 GHz to protect stations of Fixed Satellite service (space-Earth).

RAS 4.8-5.0 GHz	Max -55 dBm/MHz e.i.r.p. and -75 dBm/MHz e.i.r.p. in the horizontal plane	Max -55 dBm/MHz e.i.r.p., plus a TRP limit of -65dBm plus a DC limit of 10%	4.11, 6.1, Annexes1, 2 and 3
Meteorological Radar 5.60-5.65 GHz	Max -50 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max limit -70 dBm/MHz e.i.r.p.	4.12, 5.1.3 and 6.3
Radar 5.25-5.35 GHz 5.65-5.725 GHz	Max -50 dBm/MHz e.i.r.p. and -60 dBm/MHz e.i.r.p. in the horizontal plane	Max limit -60 dBm/MHz e.i.r.p.	4.12, 5.1.3 and 6.4
Additional requirements	• Working sensor	• Proximity and working sensor	3.5
	• TPC with a dynamic range of 10 dB		3.7.3
	• Fixed installed in a saw table		2.1
		• Representative wall for the compliance measurements	3.6

Note 1: The Duty Cycle (DC) is defined in one second as described in section 3.7.1 of this report.
Note 2: TRP is defined in section 3.4 of this report.
Note 3: RR No. **5.340** states that "*all emissions are prohibited*".
Note 4: This limit is derived assuming that the DC limit of 10% gives a mitigation of 10dB.
Note 5: For protection of radiolocation services the test pattern for the DAA mechanism defined in ETSI EN 302 065 and ETSI TS 102 754 has to be taken into account for the measurement procedures for LBT in the ODC standard ETSI EN 302 498.
Note 6: Future mobile systems may require LBT for their protection.
Note 7: The efficiency of LBT may need to be further investigated for the protection of mobile terminals in idle mode (see Annex 5).

All limits in the table above are given in mean e.i.r.p. spectral density. Additionally the following peak limitation deviating from existing UWB regulations is proposed for ODC (existing UWB regulations having a peak limit about 40 dB above the average limit):

- the peak limit measured in a bandwidth of 50MHz is 25 dB higher than the average limit measured in a bandwidth of 1 MHz,

There are site specific mitigation factors that have not been considered. For example attenuation from walls and Non Line of Sight conditions. On the other side the assumptions on power or deployment densities in this Report may in some cases be exceeded and therefore may increase the risk of interference given the uncontrolled nature of the deployment and activity of these devices.

Band 2.69-2.7 GHz, the spectrum mask proposed in this report does not reflect, that according to RR 5.340, all emissions are prohibited in this band. Equipment operation must not cause any interference to radioastronomy.

For information, the SEAMCAT files used for the calculations for the study are available in a zip-file at the www.ero.dk (ERO Documentation Area) next to this Report.

Table of contents

0 EXECUTIVE SUMMARY 2

LIST OF ABBREVIATIONS 6

1 INTRODUCTION AND BACKGROUND 7

2 OVERVIEW OF ODC APPLICATIONS 8

2.1 APPLICATION A: PROXIMITY SENSING OF HUMAN TISSUE 8
2.2 APPLICATION B: "BREAK THROUGH" PROTECTION AND DIRECT CONTACT AVOIDANCE FOR BUILDING WORK 10

3 COMPARISON OF PARAMETERS AND ASSUMPTIONS OF EXISTING UWB REGULATIONS WITH ODC 10

3.1 LIMITS APPLICABLE TO UWB SYSTEMS 10
3.2 MEASUREMENT SCENARIO FOR THE STANDARD 11
3.3 DENSITY AND ACTIVITY FACTOR 12
3.3.1 Density 12
3.3.2 Average daily running time derived from the lifetime and the typical workflow 12
3.3.3 Summary of density and activity parameters 14
3.4 TOTAL RADIATED POWER 15
3.5 PROXIMITY AND WORKING SENSOR 16
3.6 WALL ATTENUATION FOR OUTDOOR RADIO SERVICES 17
3.7 ADDITIONAL MITIGATIONS (IN COMPARISON TO BMA) 18
3.7.1 Duty Cycle limitation 18
3.7.2 Transmit power control (TPC) 19
3.7.3 Antenna radiation pattern 20
3.8 SUMMARY 22

4 IDENTIFICATION OF BANDS AND RADIO SERVICES FOR FURTHER INVESTIGATIONS .. 23

4.1 FREQUENCY RANGE BELOW 1.215 GHZ 23
4.2 FREQUENCY RANGE 1.215-1.6 GHZ 23
4.3 FREQUENCY RANGE 1.6- 1.73 GHZ 24
4.4 FREQUENCY RANGE 1.73-2.2 GHZ 24
4.5 FREQUENCY RANGE 2.2-2.5 GHZ 25
4.6 FREQUENCY RANGE 2.5-2.655/2.69 GHZ 25
4.7 FREQUENCY RANGE 2.655/2.69-2.7 GHZ 25
4.8 FREQUENCY RANGE 2.7-3.4 GHZ 26
4.9 FREQUENCY RANGE 3.4-4.2 GHZ 26
4.10 FREQUENCY RANGE 4.2-4.8 GHZ 27
4.11 FREQUENCY RANGE 4.8-5 GHZ 27
4.12 FREQUENCY RANGE 5-6 GHZ 28
4.13 FREQUENCY RANGE 6-8 GHZ 28
4.14 FREQUENCY RANGE 8-8.5 GHZ 29
4.15 FREQUENCY RANGE 8.5-10.6GHZ 29
4.16 FREQUENCY RANGE ABOVE 10.6GHZ 29

5 LBT VERIFICATIONS 29

5.1 RADARS IN S-BAND AND C-BAND 29
5.1.1 Radar Threshold values 30
5.1.2 Specific requirements of radars in the Band 2.9 to 3.4 GHz 30
5.1.3 Specificities of Meteorological Radars in the 2.7 – 2.9 GHz band and 5 GHz range 31
5.2 IMT2000 2.5-2.69 GHZ 33

6 COMPLEMENTARY STUDIES 34

6.1 RAS 34
6.1.1 Operational characteristics of the RAS 34
6.1.2 Single entry scenario 35
6.1.3 Aggregation 35

6.1.4 Probability of exceeding the RAS protection criteria......37
6.1.5 Summary and conclusion RAS......39
6.2 BWA 3.4-3.8 GHz......40
6.3 Meteorological radars (S-Band and C-Band)......41
6.4 Radar C-band 5.25-5.35 GHz and 5.65-5.725 GHz......41
6.5 IMT2000 core band 1.73 - 2.2 GHz......42

7 CONCLUSIONS......42

ANNEX 1: RAS BANDS......45

ANNEX 2: SEAMCAT SIMULATIONS FOR RAS......46

ANNEX 3: RAS STUDIES PROVIDED BY CRAF......53

ANNEX 4: ADDITIONAL REMARKS ON THE MEASUREMENT OF UWB EMISSIONS......58

ANNEX 5: IMPACT ON THE UMTS MOBILE WITH RESPECT TO LBT......59

ANNEX 6: LIST OF REFERENCES......64

LIST OF ABBREVIATIONS

BMA	Building Material Analysis
BS	Building Structure
BWA	Broadband Wireless Access
CAC	Channel Availability Check
DAA	Detect and Avoid
DC	Duty Cycle
DFS	Dynamic Frequency Selection
DIY	Do It Yourself
ECC	Electronic Communications Committee
EESS	Earth Exploration Satellite Service
FS	Fixed Service
FSS	Fixed Satellite Service
FWA	Fixed Wireless Access
GPR	Ground Probing Radar
GSM	Global System for Mobile
LBT	Listen Before Talk
MCL	Minimum Coupling Loss
IMT2000	International Mobile Telecommunications-2000
iRSS	Interfering Signal Strength
MSS	Mobile Satellite Service
ODC	Object Discrimination and Characterization
PFD	Power Flux Density
PRF	Pulse Repetition Frequency
RAS	Radio Astronomy Service
RLAN	Radio Local Area Network
RNSS	Radionavigation Satellite Service
RR	Radio Regulations
SEAMCAT	Spectrum Engineering Advanced Monte Carlo Analysis Tool
SNR	Signal to Noise Ratio
SPFD	Spectral Power Flux Density
STF	Special Task Force
TPC	Transmit Power Control
TRP	Total Radiated Power
UWB	Ultra Wide Band
WLAN	Wireless Local Area Network
WPR	Wall Probing Radar

The impact of Object Discrimination and Characterization (ODC) applications Using Ultra-Wideband (UWB) technology on radio services

1 INTRODUCTION AND BACKGROUND

A number of difficulties of technical, regulatory and enforcement nature associated with the multiplication of specific UWB applications were raised during the development of relevant deliverables concerning UWB technology. It is concluded in particular that strong justification is needed for developing specific UWB regulations, which can be envisaged only for “niche applications”.

Requirements from the industry for specific UWB applications ought obviously to be considered for applications with clear benefits from using UWB technology that cannot fit under the generic Decision on UWB. The use of UWB technology in accurate imaging applications is expected to be the main application for which a specific UWB regulation could be developed because of physical reasons (e.g. lower frequencies with higher levels are needed due to reflections of clutter and the needed penetration depth).

Recognizing the benefits offered by UWB technology in providing "accuracy in imaging applications", ECC developed and approved the following Decisions for 3 kinds of applications:

- Ground- and Wall- Probing Radar (GPR/WPR): ECC Decision of 1 December 2006 on the conditions for use of the radio spectrum by Ground- and Wall- Probing Radar (GPR/WPR) imaging systems [1]
- Building Material Analysis (BMA) devices ECC Decision of 30 March 2007 on Building Material Analysis (BMA) devices using UWB technology [2]

All three basically aim to detect the location of objects contained within a structure or to determine the physical properties of a material, following the same physical principles. The differences between these three applications are in detail described in [13]. CEPT has considered predominantly the type of regulatory regime as key discriminating factor for the regulatory solutions of imaging applications.

*For **“Wall” imaging radar applications*** two different sets of regulations have been agreed:

- “*license exempt*”, for BMA, subject in some frequency bands to the implementation of adequate mitigation techniques;
- “*licensed*”, for WPR, allowing some higher radiated spectral power densities in certain frequency bands subject to adequate coordination procedures.

*For **Ground imaging radar applications*** An appropriate “*licensing*” regime has been agreed.

Although the aim of Object Discrimination and Characterisation (ODC) devices are in a similar scope then GPR/WPR devices, these rules ([1]) are not applicable for ODC because a licence exempt regime is necessary for ODC.

This report is structured in the following way:

1. **Chapter 2: Description of ODC**
2. **Chapter 3 and 4: Applicability of the existing limits**
    a. Applicability of the generic decisions ([3], [4]): Identify the frequency bands where the generic limits are applicable to ODC and compare in this bands the mitigations and assumed parameters of the generic UWB Regulations with the ODC values. If the ODC assumptions can be neglected in these bands compared to the generic assumptions (in principle this should be the case for all applications), then no additional investigation was done for these bands since ODC may be considered as "generic UWB".
    b. Applicability of the BMA decision ([2]):In bands where ODC can not be handled as “generic UWB” (-> the proposed limits and/or assumptions are higher then the generic limits/assumptions), the same methodology as in bullet 1 should be done with [2] (are ODC limits equal or below limits of [2] and are assumptions of ODC negligible compared to BMA?). If the ODC assumptions can be neglected in these bands compared to the BMA studies, then no additional investigation was done since ODC may be considered as BMA
3. **Chapter 5 and 6, Further studies:** In outstanding bands where the limits and/or the assumptions of ODC are higher than for BMA and generic devices, further studies are needed

2 OVERVIEW OF ODC APPLICATIONS

ODC systems and requirements in the frequency range 2.2 – 8.5 GHz are described in [5].

There are two types of applications which are expected for ODC:

- Application A for Proximity Sensing of Human tissue
- Application B for “Break through” protection and direct contact avoidance for building work

2.1 Application A: Proximity Sensing of Human tissue

Application A is intended for:

- detection of small objects like a finger or other extremities in the presence of obstacles (e.g. wood), positioned close to a hazard like a saw blade.
- applications typically for consumer market, like safety devices for power tools or dangerous machines.
- usage in close proximity to potentially hazard area (0 to 40 cm).

For this application A, two categories of saw devices are possible:

- Category 1: the bench table saw, (bench circular saw, combination saw)
- Category 2: the chop saw, panel saw or mitre saw

They are described in the following Figures.

Figure 1: Category 1, the bench table saw, (bench circular saw, combination saw)

Figure 2: Category 2, the chop saw, panel saw or mitre saw

The next pictures show the typical user scenarios for the different kind of saw categories.

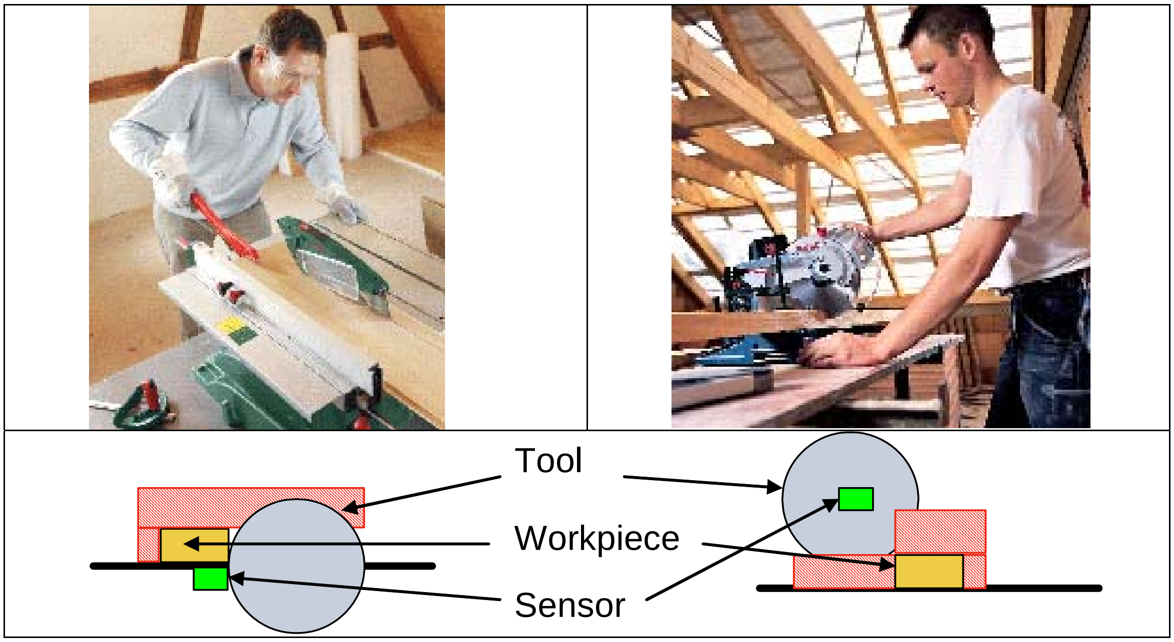

Figure 3: Saw Scenario

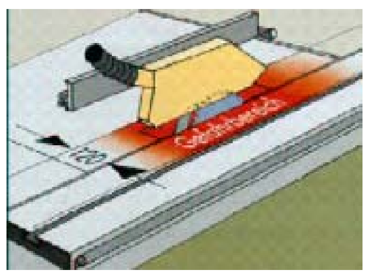

Figure 4: Table top saw blade

The following figure illustrates the number of injuries resulting from saw accident in Germany.

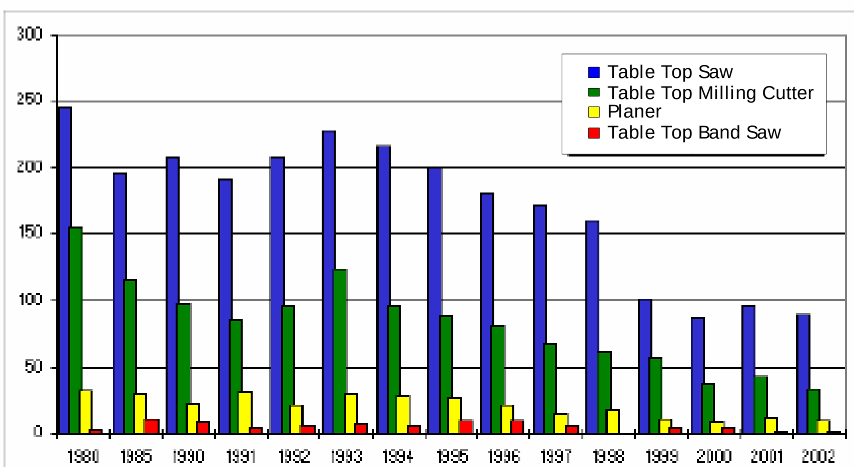

Figure 5: Injuries from accidents in Germany [11]

	2003	2004	2005	2006
Injuries caused by accidents	5232	4.428	3.940	3.524
New accident annuity	246	161	142	152

Table 1: Actual number of injuries from accidents in Germany [12]

New accident annuity: work accident or road accident with so difficult consequences that it has come in the current year for the first time to compensation in form of a pension, compensation or to the payment of death benefit.

2.2 Application B: "Break through" protection and direct contact avoidance for building work

Application B will be used for high end drilling and percussion drilling machines. It is planned to mount it directly to the tool. A parallel usage is possible. The UWB sensor application monitors the drilling process and controls the drilling machine also depending on the inhomogenities in the material. The user will be warned acoustically or optically in case of a collision with unexpected objects inside the material (e.g. gas- water pipes or electric cables) may happen.
The UWB application may be active synchronously to the operation of the drilling machine which will be supported by this application.

Figure 6: "Break through" situation

3 COMPARISON OF PARAMETERS AND ASSUMPTIONS OF EXISTING UWB REGULATIONS WITH ODC

Within this section of the parameters and assumptions of existing regulations ([2], [3] and [4]) are considered.

3.1 Limits applicable to UWB systems

Figure 7 provides an overview of the limits applicable to generic UWB.

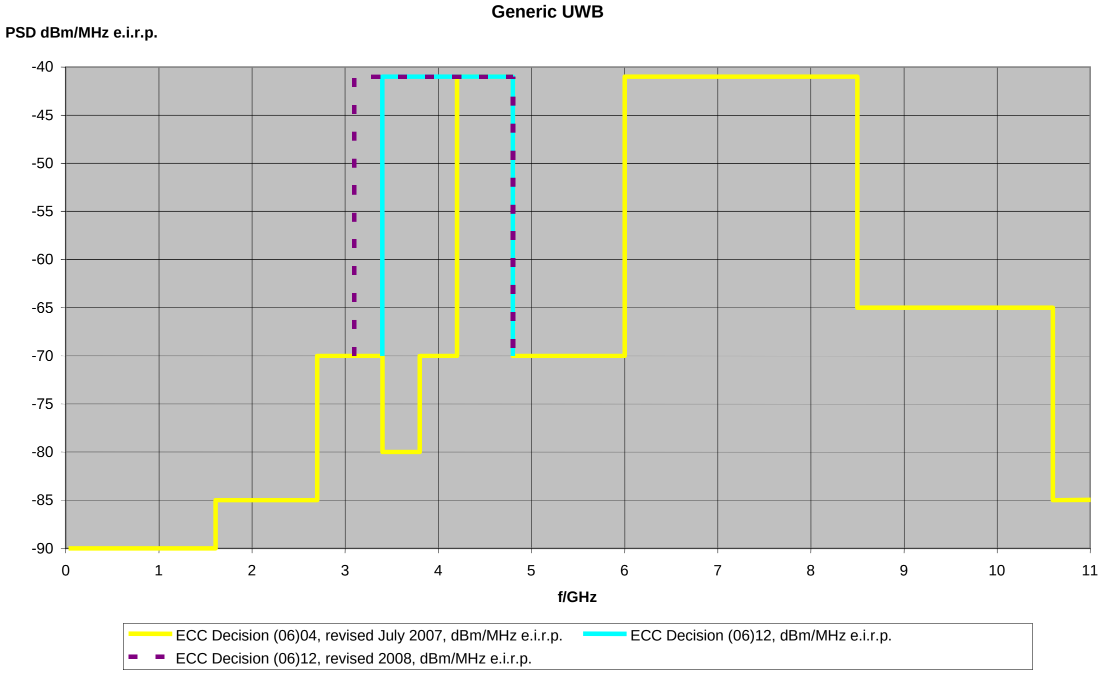

Figure 7: Generic UWB emission mask ([3], [4])

Figure 8 provides an overview of the limits applicable to BMA systems.

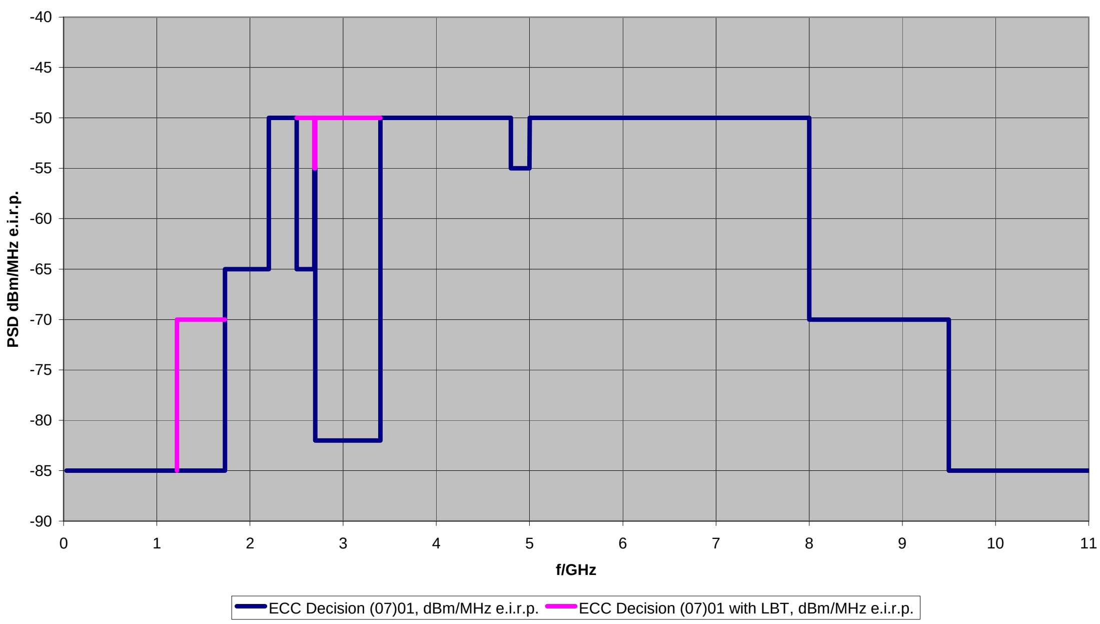

Figure 8: BMA emission mask ([2])

3.2 Measurement scenario for the standard

Fixed installations - Application A: Proximity Sensing of Human tissue
Radiated power over a sphere around the fixed ODC installation (e.g. a saw installed in a saw table with an ODC device).

Non fixed installations - Application B: "Break through" protection and direct contact avoidance for building work
Radiated power over a sphere around the ODC device on a representative wall in a non fixed installation (e.g. a drill hammer with ODC on a representative wall) [2].

3.3 Density and Activity factor

Actual market values and usage studies (from 2007) (i.e. updated information's compared to those contained in [5]).

3.3.1 Density

- ➔ Saw top: in Europe 2010 1.2 Mio Prof / 1,4 Mio DIY saw will be sold, 10% with ODC (260000/a) → Market saturation about 3 Mio/Europe in 2020
- ➔ Drilling machines: 2.5 Mio drilling machines/a will be sold, 10% with ODC (250000/a) → Market saturation about 800 T/Europe (with ODC sensor)
- ➔ Market share
  - Saw top: 3 Mio./ 250 Mio household in Europe → 1.2%
  - Drilling machines: 0.8/250Mio → 0.32%

3.3.2 Average daily running time derived from the lifetime and the typical workflow

Application A / saws

Lifetime of Saws derived from customer quality requirements:

- 5 years for professional users
- 10 to 15 years for DIY users

Integrated motor running time for such Device (This time is also depending on the usage e.g. thickness of the wood):

- 150 to 200h for DIY machines
- 300 to 350h for Professional machines,

Professional

- With an average usage working (motor running time of 15min / 12 h)
- 15min / 12h → 5 days per week leads to 1h 15min per week
- 52 weeks per year → 62,5 h / year
- For 5 Years this leads to: 312,5h usage time

DIY

- usage time 0,65h / month
- this leads to 7,8h / year
- for 10 years: 78h
- 15 years: 117h

Application B / drilling machines

Lifetime of drilling devices from customer quality requirements:

- 3 years for professional users
- 10 to 15 years for DIY users

Lifetime (integrated motor running time for such Device):

- 150 to 200h for DIY machines
- 400 to 500h for Prof machines,

Professional use

- 30 min to 45min / 12h → 5 Days per week → 2,5 to 3,75h / week
- 52 weeks per year → 125 to 187,5 h / year
- For 3 years this leads to: 375 to 562,5 h

DIY

- 1 min / 12h → 7 Days per week → 7 min / week
- 52 weeks per year → 6,1 h / year
- For 10 year : 61h
- For 15 year : 91,5h

<u>Based on these investigations the following numbers are used as average runtime per 12h:</u>

Application A/Saws

- Professional User (average machine runtime/12h): 15min / 12h = 2,08%
- DIYs : → for 0,65h / month → 0,18% in 12h

Application B/Drilling

- For all type of devices (Professional User):45min / 12h = 6,25%
- DIY : 0,1%

It can be noted that the peak activity factor to be used in single entry scenarios might be up to 100% on some days (note: for single case calculations).

3.3.3 Summary of density and activity parameters

	Application A: Proximity Sensing of Human tissue				Application B: "Break through" protection and direct contact avoidance for building work			
market saturation in 2010 in Europe (in thousand)	Urban	sub-urban	rural	sum	Urban	sub-urban	rural	sum
DIY	70	490	840	1400	53.33	53.33	53.33	160
Professional	360	600	240	1200	213.33	213.33	213.33	640
total	**430**	**1090**	**1080**	**2600**	**266.6667**	**266.6667**	**266.6667**	**800**
market share: devices per household in 2010 in Europe (based on 250 Mio. households in Europe)	Urban	sub-urban	rural		Urban	sub-urban	rural	
DIY	0.03%	0.20%	0.34%		0.02%	0.02%	0.02%	
Professional	0.14%	0.24%	0.10%		0.09%	0.09%	0.09%	
total	0.17%	0.44%	0.43%		0.11%	0.11%	0.11%	
households per km^2	6700	460	52		6700	460	52	
devices per km^2	Urban	sub-urban	rural		Urban	sub-urban	rural	
DIY	1.88	0.90	0.17		1.43	0.10	0.01	
Professional	9.65	1.10	0.05		5.72	0.39	0.04	
total	11.52	2.01	0.22		7.15	0.49	0.06	
average runtime per 12h	Urban	sub-urban	rural		Urban	sub-urban	rural	
DIY	0.18%	0.18%	0.18%		0.10%	0.10%	0.10%	
Professional	2.08%	2.08%	2.08%		6.25%	6.25%	6.25%	
mean	1.77%	1.23%	0.60%		5.02%	5.02%	5.02%	
Active device density /km^2	Urban	sub-urban	rural		Urban	sub-urban	rural	
DIY	3.38E-03	1.62E-03	3.14E-04		1.43E-03	9.81E-05	1.11E-05	
Professional	2.01E-01	2.30E-02	1.04E-03		3.57E-01	2.45E-02	2.77E-03	
Total	**0.204**	**0.025**	**0.001**		**0.359**	**0.025**	**0.003**	
	Urban	**sub-urban**	**rural**					
Total active ODC Density /km^2	**0.563**	**0.049**	**0.004**					
Average runtime in minutes	**21.70**	**14.20**	**10.63**					
Average runtime in seconds	1302.24	851.75	638.08					

Table 2: Summary of density and activity parameters

3.4 Total Radiated Power

The Total Radiated Power (TRP) is the integration of the power flux density of the radiated signal (e.g. e.i.r.p.) across the entire spherical surface enclosing the UWB sensor under test. From the measured e.i.r.p. values the TRP can be calculated as follows:

$$TRP = \int_{\Theta=0}^{\pi} \int_{\Phi=0}^{2\pi} \frac{e.i.r.p.(\Theta,\Phi)}{4\pi} \sin(\Theta)\, d\Theta\, d\Phi$$

with Θ and Φ being the two angles of the spherical coordinate system.

The measurement of the e.i.r.p. will be done (automatically) on the spherical surface enclosing the device at discrete measurement points. The measurement procedure and values will be implemented in the related ETSI standard.

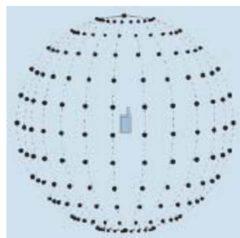

Figure 9: Measurement points across the spherical surface

To calculate the TRP from the measured e.i.r.p. values at the discrete measurement point, the following formula can be used:

$$TRP = \sum_{\Theta} \sum_{\Phi} \frac{e.i.r.p.(\Theta,\Phi)}{4\pi} \cdot \Delta A(\Theta,\Phi)$$

$$\text{with } \Delta A(\Theta,\Phi) = \int_{\Theta-\Delta\Theta/2}^{\Theta+\Delta\Theta/2} \int_{\Phi-\Delta\Phi/2}^{\Phi+\Delta\Phi/2} \sin(\Theta)\, d\Theta\, d\Phi = \Delta\Phi \cdot \left| -\cos(\Theta+\Delta\Theta/2) + \cos(\Theta-\Delta\Theta/2) \right|$$

being the surface element for which the measured e.i.r.p. value is valid and $\Delta\Theta$ respectively $\Delta\Phi$ the discrete step in angle.

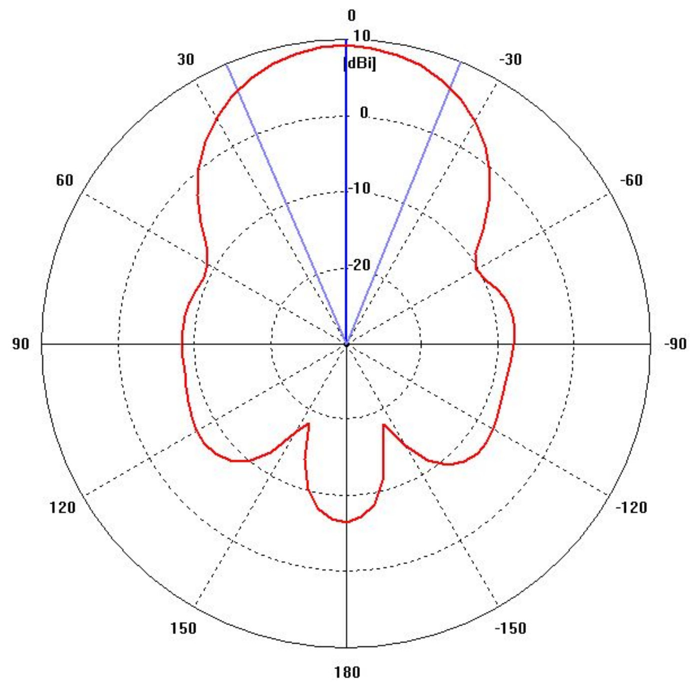

Figure 10*:* Example radiation pattern of an antenna in free-space with a directivity of D = 9.3 dBi

In case the directivity D of the transmit antenna including all surrounding parts is known, the TRP derives from the e.i.r.p. the following way:

$$TRP = \frac{e.i.r.p.}{D}$$

In figure 10 the directivity is 9.3 dBi and the 0 dBi circle represents the TRP. As an example for an e.i.r.p. of -55.7 dBm/MHz the TRP derives to -65 dBm/MHz. For a lossless antenna the gain G equals the directivity D. For real antennas the gain equals

$$G = \eta \cdot D$$

where η is the efficiency of the antenna.

The mitigating impact for aggregated scenarios of TRP may depend on the distribution of the pointing directions of application B (drill). For a uniform distribution the mitigation is exactly the TRP reduction (e.g. 10dB). For ODC devices just distributed in the horizontal plane the interference probability could rise by a factor of up to 4.

3.5 Proximity and working sensor

It has to be ensured that the UWB sensor is just switched on only if the tool is activated (e.g. saw, drill). It reduces the activity of the UWB sensor and is possible for both types of ODC applications.

Instead of the proximity sensor it is more appropriate to use a TPC mechanism for the saw (see chapter 3.7.2) while the proximity sensor concept is still be relevant for drilling equipments.

Proximity sensor and for misuse for application B

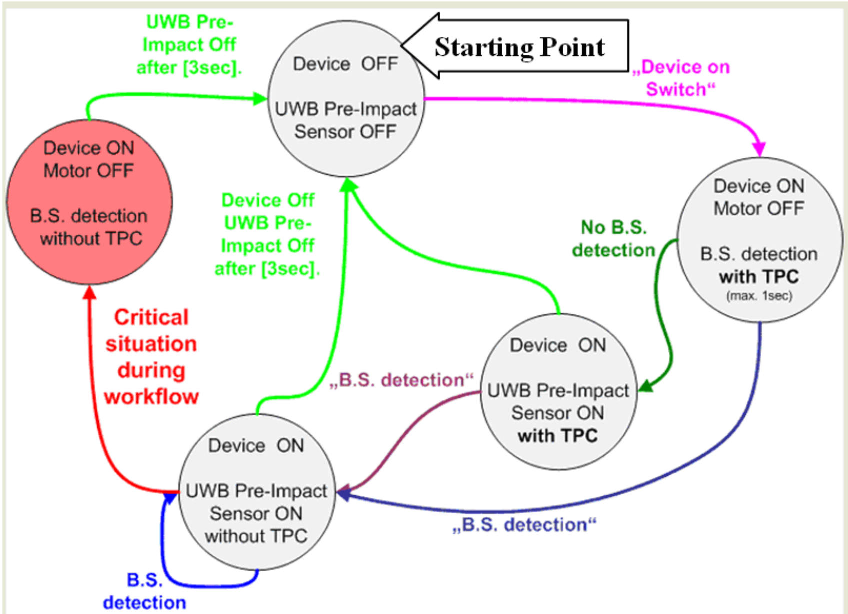

Figure 11: Proximity sensor

3.6 Wall attenuation for outdoor radio services

For the non fixed Application B (e.g. the drill) the same assumption as for BMA apply, as it is used definitely on a building material (a wall) and the limits are measured behind a representative wall: A typical house is here assumed to be represented in Figure 12:

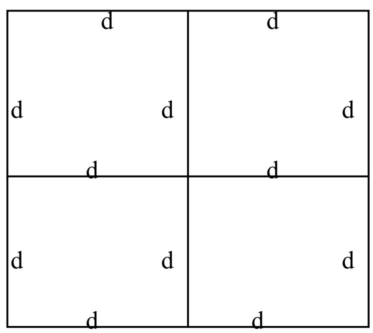

Figure 12*:* Typical house scenario

- All walls has an average wall attenuation of minimum 10dB (see [6]),
- The devices used on an inner wall can take into account 20dB building attenuation, and 10dB for the devices used on an outer wall
- Depending on the portion of devices on inner and outer walls the average building attenuation can be calculated following the formula:

10*log(Outer wall portion*10^(10dB/10)+inner wall portion*10^(20dB/10))

- Outer wall 100%, inner wall 0%: **10.0dB** = 0dB additional margin (assuming the representative wall has an attenuation of 10dB)
- Outer wall 75%, inner wall 25%: **15.7dB** = 5.7dB additional margin (assuming the representative wall has an attenuation of 10dB)
- Outer wall 50%, inner wall 50%: **17.4dB =** 7.4dB additional margin (assuming the representative wall has an attenuation of 10dB)
- Outer wall 25%, inner wall 75%: **18.9dB** = 8.9dB additional margin (assuming the representative wall has an attenuation of 10dB)

- Outer wall 0%, inner wall 100%: **20.0dB** = 10dB additional margin (assuming the representative wall has an attenuation of 10dB)

As average with the probability of 50% of having the ODC device on an outer wall the additional margin of **7.4 dB** is proposed to be used.

For application type A (e.g. the saw top) the scenario is a different one: here the UWB sensor is radiating into the air. The wall attenuation to be taken into account here depends on the percentage of indoor/outdoor usage; if we assume a percentage of 90% indoor usage with 10dB wall attenuation and a percentage of 10% outdoor usage with 0dB wall attenuation, then an average wall attenuation of 9.6 dB results; for a percentage of 50% indoor to 50% outdoor the result is a wall attenuation of 7.4 dB (10*log(Outdoor_usage*10^(0dB/10)+indoor_usage*10^(10dB/10)).

3.7 Additional mitigations (in comparison to BMA)

3.7.1 Duty Cycle limitation

Duty cycle (DC) limitation is not applicable for application A (saw)

DC is considered only for Application B (drill). Here a transmission time of 100ms per 1s is proposed, that means a DC of 10%.

The speed with which the drill of a drilling machine intrudes into the material is in average a few millimetres per second. This depends on the material in which a hole will be drilled. It needs less time in case of wood and more time in the case of concrete.

There are normally no obstacles or hidden objects expected in wood which is a homogeneous natural material in opposite to “stone like material” which are synthetic composed materials. For this kind of synthetic materials an ODC application is intended.

A synthetic material allows only a low intrusion speed of the drill of approximately few millimetres per second.

Therefore it is sufficient to apply a transmission time of 100 ms per second of drilling time.

The max power levels defined in chapter 7 have to be fulfilled during the 100ms.

This additional reduction of the transmitting time can be used as an additional mitigation factor.

This DC should not be confused with the ratio of the pulse length to the pulse repetition period of a pulsed system; this is often also used as Duty Cycle definition. But here it is meant as ratio of the transmitter-on time to the sum of transmitter-on and transmitter-off times (DC=Txon/(Txon+Txoff).

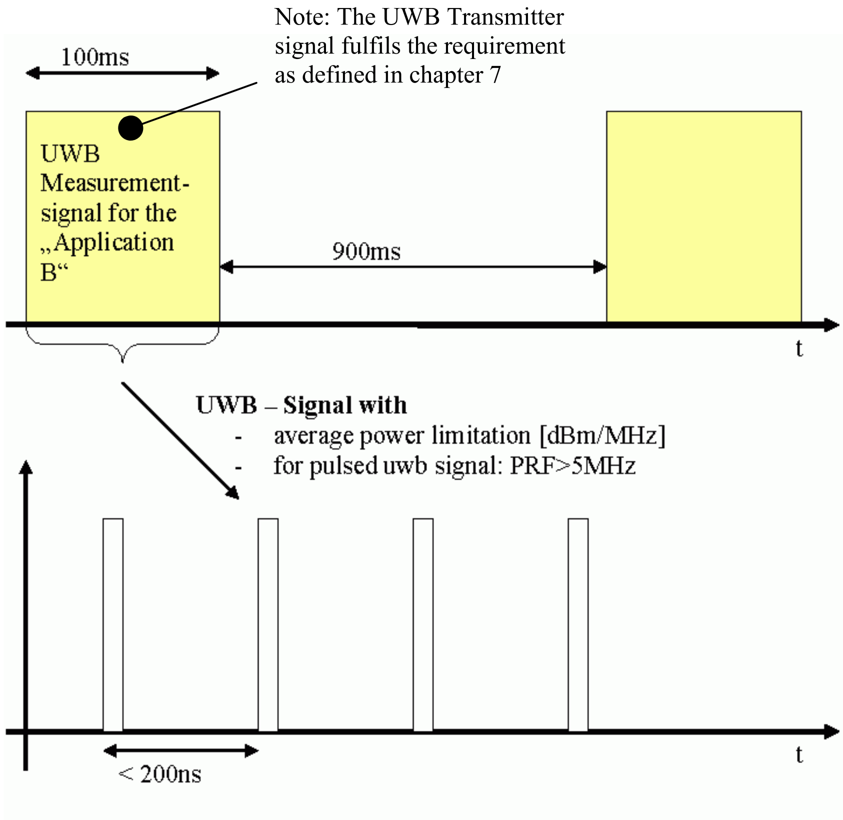

Figure 13: Duty cycle definition on the example of a pulsed UWB system (other possible measurement signals are described in [5])

For aggregated scenarios there is a mitigation of 10dB expected; for single entry scenarios there might be a mitigation dependent on the radio service (e.g. [14] on the impact of LDC on FWA).

For meteorological radars (as well as other radars), such duty cycle limitation would not provide any advantage since a 100 ms emission is well above the radar PRF period and that hence, such 100 ms duration corresponds to a potential of interference over about 1 to 4° azimuth of the radar coverage.

The impact of the Duty cycle limitation on RAS was taken into account in the calculations provided in the end of Annex 2.

3.7.2 Transmit power control (TPC)

For application A (saw application) a TPC mechanism is proposed in the following way: start with 10dB reduced power and use 10dB less power if no object is within the focus of the UWB antenna; the max power level is just allowed if an object is in the focus/ measurement area.

The impact of the TPC mechanism could provide advantage in the aggregate scenario but will not provide any mitigation for worst case single entry scenario.

The following is applicable to the running time of the saw:

- Table top saw: 40% reduced power, 60% full power
- Chop saw: 10% reduced power, 90% full power
- Average saw: 25% reduced power , 75% full power

Application	Saw
active device density rural	0.001
sensor activity to overall machine runtime	75%
Power during machine running	-60
Power during working	-50
resulting power	-51.11
TPC Mitigation dB	**1.1**

Table 3 : TPC impact

TPC only in case of <u>saw protection application (Application A)</u>

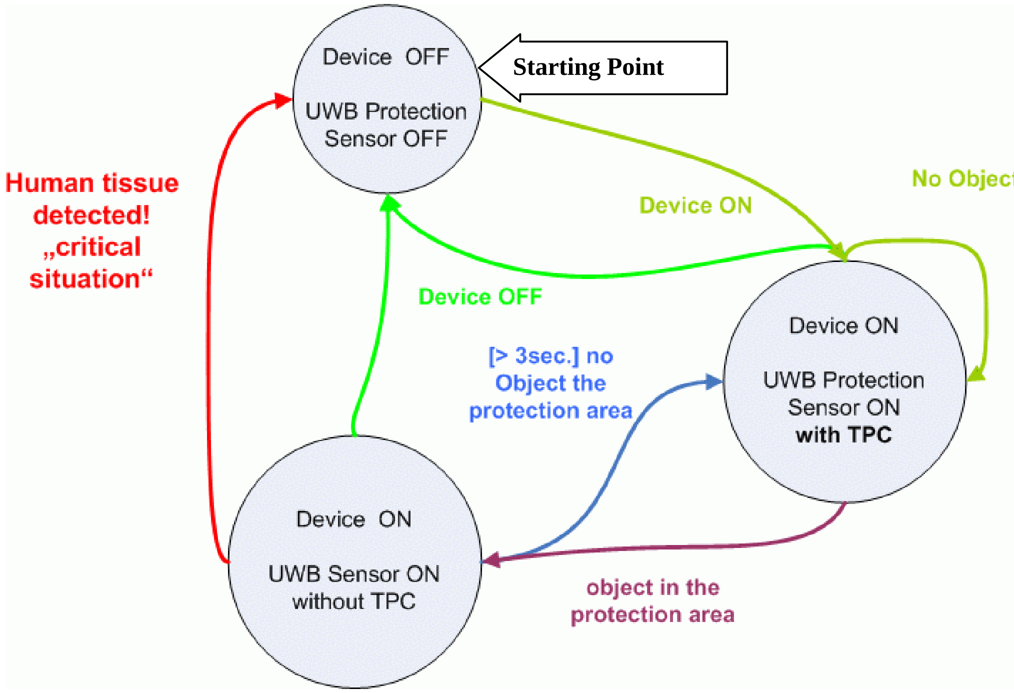

Figure 14

3.7.3 Antenna radiation pattern

For fixed installed ODC application A (Proximity Sensing of Human tissue applications e.g. a saw top), the wanted signal is limited to the vertical plane and hence, a limitation of the radiation in the horizontal plane could provide a mitigation with radio services for which the interference path is horizontal, such as RAS, Radar and Mobiles.

It has to be noted that this mitigation is not applicable for the quasi mobile application B (e.g. drill machine).

Example 1: the chop saw

- distance of the antenna (protective cover) to the work piece from ca. 100 mm to ca. 250 mm
- positioning of an antenna at the table is difficult to realize, because the saw blade is moveable lengthwise

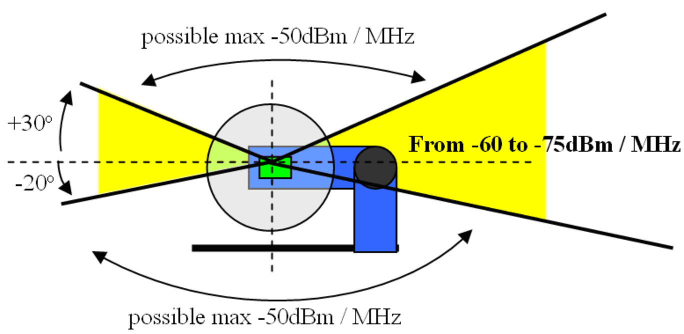

Figure 15: Radiation pattern for chop saw

Example 2: the bench table saw

- distance of the antenna (in protective cover) to the work piece about 100-150 mm (downview)
- distance of the antenna (embedded in table / topview) to the work piece max. 10 mm thickness of work piece up to 110 mm at panel saw
- adjustable in depth of the saw blade up to 80 mm, typical 40mm

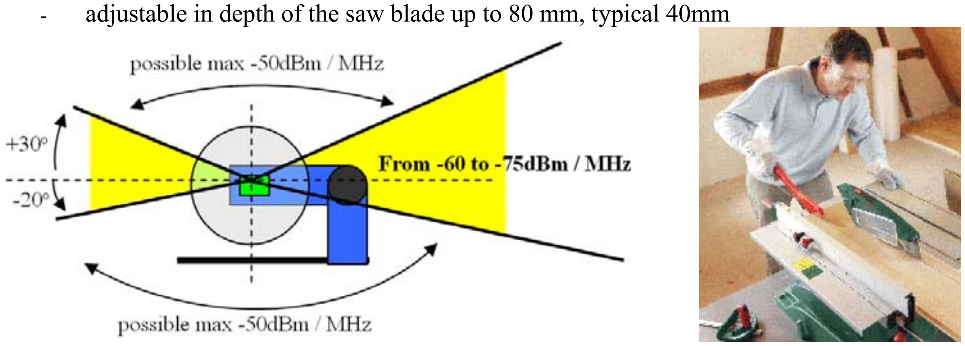

Figure 16: Radiation pattern for bench table saw

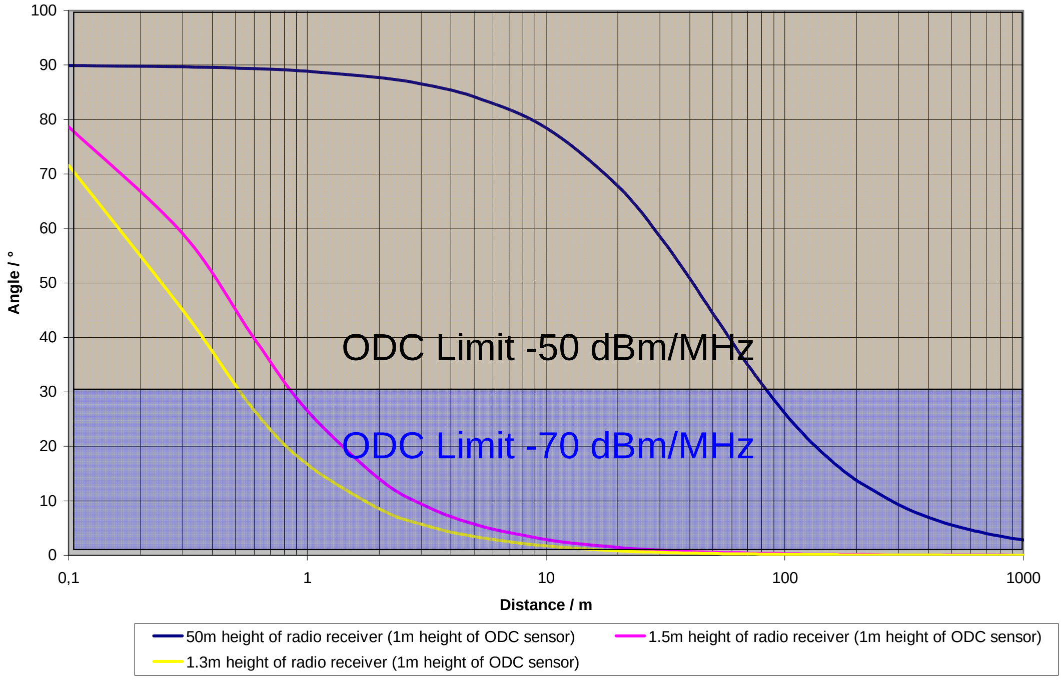

Figure 17: the effect of the elevation limitation on different radio receivers (50m=RAS, 1.3/1.5m=Mobile)

Therefore this limitation of the elevation antenna pattern in the range -20° to +30° should be used for the fixed installed ODC application A.

3.8 Summary

	Generic UWB ECC/DEC/(06)04	ECC/DEC/(07)01 on BMA	ODC	Impact on aggregation and probabilistic scenarios	Impact on single entry scenarios
Densities rural/ suburban/ dense urban per km^2	100/ 1000/ 10000	0.052/ 0.46/ 6.7	0.3/ 2.5/ 19	ODC neglect able compared to generic devices; ODC dominant compared to BMA	No impact
Aggregated Activity Factor per 12h	1%	0.28%	between 1.4% and 3%		No impact
Density of active devices rural/ suburban /dense urban per km^2	1/ 10/ 100	0.00015/ 0.0013/ 0.019	0.004 0.049 0.563	ODC neglect able compared to generic devices; ODC dominant compared to BMA	No impact
Total radiated power	NA	5dB below the max limits (especially 10dB within the RAS bands 2.69-2.7 and 4.8-5GHz)	For application A (saw) no TRP limit (see antenna rejection) For application B (drill) just TRP in RAS band 4.8-5 GHz	For application A 0dB mitigation For application B: 10dB for RAS 5dB for BWA 10dB for IMT2000 in the band 2.5-2.69 GHz	0dB Mitigation
Proximity sensor	NA	Yes	No for application A (saw (see TPC) Yes for the application B (drill)	Application B: Avoids incorrect usage	Application B: Avoids incorrect usage
Working sensor	NA	Movement	Running sensor	Decreases the activity	Decreases the activity
Acceptable protection distance around mobile services	0.36cm	3m due to the working area around	2m to mobiles and 3m to BWA/WLAN	No impact	Impacts the acceptable power level
Additional wall attenuation (for RAS studies)	10 dB	7.4 dB	7.4 dB	7.4 dB mitigation	0 dB mitigation
TPC	12dB in vehicles	NA		1.1dB for saw 0dB for application B (drill, see proximity sensor)	0 dB
Duty Cycle	NA	NA	Not for Application A; For Application B (drill) 10% DC (100ms/s)	0 dB for Application A/Saw 10 dB for Application B/Drill	0 dB for Application A/Saw 10 dB for Application B/Drill
Antenna radiation pattern (measured for ODC embedded in the machine)	NA	NA	For application A (saw, quasi fixed) installations: Rejection in the elevation from -20° to 30°	For application A (saw): 10-20 dB mitigation to RAS, Radar and Mobiles For application B (drill) : 0dB mitigation (see TRP)	For application A (saw): 10-20 dB mitigation to RAS, Radar and Mobiles For application B (drill) : 0dB mitigation (see TRP)
Measurement scenario for the standard d		Radiated power over a sphere around the BMA on a representative wall	Radiated power over a sphere around the ODC: • Application B (e.g. a drill) on a representative wall • Application A (e.g. a saw) installed in a saw table		

Table 4: Summary of the comparison of parameters and assumptions of existing UWB regulations with ODC

4 IDENTIFICATION OF BANDS AND RADIO SERVICES FOR FURTHER INVESTIGATIONS

Within this section, the limits and compatibility parameters of existing UWB regulations ([1], [2] and [3]) are compared with the proposed limits and parameters of ODC based on information contained in section 3. For cases, where it is found with this first assessment in this section hat the existing limits are not applicable, further investigations are presented in sections 5 and 6.

4.1 Frequency Range below 1.215 GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-90	-85	-85

Table 5

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
Broadcasting 0.17-0.23 GHz	Single entry: -97 dBm/MHz at 30cm	Compatible at 3m	Single entry: see BMA Aggregation: uncritical (lower density as generic UWB, just 5dB higher levels)
MSS S&R Downlink 0.406 GHz	Aggregated Rural 1(a) – 75 dBm/MHz	Compatible	compatible
Broadcasting 0.47-0.86 GHz	Single entry: -89 dBm/MHz at 30cm	Compatible at 3m	Single entry: see BMA Aggregation: uncritical (lower density as generic UWB, just 5dB higher levels)
RNSS 1.164-1.215 GHz	Single entry: -83.5 dBm/MHz at 1m	Compatible	compatible

Table 6

Conclusion: The limit of ECC/DEC/(07)01 applies for ODC: -85 dBm/MHz

4.2 Frequency Range 1.215-1.6 GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-90	-85 dBm/MHz; –70 dBm/MHz with LBT from 1.215-1.6 GHz (for Radar and Mobile applications)	-85 MHz dBm/

Table 7

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
RNSS 1.215-1.593 GHz	Single entry: -83.5 dBm/MHz at 1m	Compatible with -70 dBm/MHz at 3m together with TPR of -75 dBm/MHz	Compatible with -85 dBm/MHz
Radar 1.215-1.4 GHz	Single entry: -82.4 dBm/MHz at 400m	Compatible with –70 dBm/MHz and LBT	Compatible with -85 dBm/MHz
RAS 1.4-1.427 GHz	Aggregation suburban 1b: -110 dBm/MHz	Aggregation compatible with the BMA mitigations[1]; single entry compatible with a reliability of more than 99%	Compatible with -85 dBm/MHz
Broadcasting 1.45-1.49 GHz	Single entry: -85 dBm/MHz at 30cm	Compatible with –70 dBm/MHz at 3m	Compatible with -85 dBm/MHz
EESS 1.4 -1.427 GHz	Aggregated scenario	Compatible in the aggregated scenario with TRP of -75 dBm/MHz	Compatible with -85 dBm/MHz

[1] Density 0.46/km^2 / 10000/km^2 , activity 0.28% / 5%, 23.5dB additional mitigations

Table 8

Conclusion: It was agreed to apply the limit of ECC/DEC/ (07)01 (without LBT) for ODC: -85 dBm/MHz

4.3 Frequency Range 1.6- 1.73 GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-85	-85 ; –70 with LBT from 1.6-1.73 GHz (MSS)	-85 dBm/MHz

Table 9

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
MSS 1.52-1.66	Single entry: -98.4 dBm/MHz at 20m	Compatible with LBT for MSS uplink	Compatible with -85 dBm/MHz

Table 10

Conclusion: The limit of ECC/DEC/(07)01 (without LBT) applies for ODC: -85 dBm/MHz

4.4 Frequency Range 1.73-2.2 GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-85	-65	-65

Table 11

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
IMT/GSM1800	Single entry: -85 dBm/MHz at 36cm	Compatible with –65 at 3m	investigation of protection distance and other mitigations

Table 12

Conclusion: the applicability of the limit of ECC/DEC/(07)01 should be investigated in relation to the protection distance and other mitigations. This is addressed in section 6.5.

4.5 Frequency Range 2.2-2.5 GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-85	-50	-50

Table 13

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
Amateur 2.3-2.45 GHz	Single entry: -61.3 dBm/MHz at 10m	Compatible with –50 dBm/MHz at 30m	See BMA
SRD 2.4-2.485 GHz	Single entry: -75 dBm/MHz at 36cm	Compatible with –50 dBm/MHz at 3m	With a separation distance of 3m -50 dBm/MHz acceptable.,

Table 14

Conclusion: The limit of ECC/DEC/(07)01 applies for ODC: -50 dBm/MHz

4.6 Frequency Range 2.5-2.655/2.69 GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-85	-65; -50 with LBT (IMT2000)	-65 ; -50 with LBT (IMT2000)

Table 15

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
IMT2000	Single entry: -85 dBm/MHz at 36cm	Compatible with –65 at 3m and –50 together with LBT (IMT2000)	investigation of protection distance and LBT

Table 16

Conclusion: the applicability of the limit of ECC Dec (07)01 should be investigated in relation to the protection distance and LBT. This is addressed in section 5.2.

4.7 Frequency Range 2.655/2.69-2.7 GHz

	ECC/DEC/(06)04	Limit ECC/DEC(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-85	-55; TRP of -65	-55; TRP of -65

Table 17

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
RAS	Aggregation suburban 1b: -110 dBm/MHz	Aggregation compatible with the BMA mitigations[1]; single entry compatible with a reliability of more then 99%	investigation of mitigations and studies

1 Density 0.46/km^2 / 10000/km^2 , activity 0.28% / 5%, 23.5dB additional mitigations

Table 18

Conclusion: investigation of mitigations and studies on the impact on RAS. This is addressed in section 6.1.

4.8 Frequency Range 2.7-3.4 GHz

	ECC/DEC/(06)04 and ECC/DEC/(06)12	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-70 -41 with DAA and LDC	-82 ; -50 with LBT (Radar)	-82 ; -50 with LBT (Radar)

Table 19

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
Radar (e.g. meteorological radars 2.7-2.9 GHz)	Single entry: -82.6 dBm/MHz at 170m	Compatible with –50 and LBT	Possibility and/or practicability of LBT needs to be investigated, in particular with regards to meteorological radar. If LBT is not considered, other solutions would have to be determined

Table 20

Conclusion: Possibility and/or practicability of LBT needs to be investigated, in particular with regard to meteorological radar. If LBT is not considered, other solutions would have to be determined. This is addressed in section 5.1 and 6.3.

4.9 Frequency Range 3.4-4.2 GHz

	ECC/DEC/(06)04 and ECC/DEC/(06)12	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-80 -41 with DAA and LBT	-50	-50

Table 21

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
FS	Aggregation urban 1c: -71.5 dBm/MHz Complementary studies where resulting in an acceptable limit of -41 dBm/MHz for indoor applications with 1% AF	Aggregation compatible with the BMA mitigations[2]; Single entry compatible at 30m (antenna gain FS 0dBi)	Aggregation compatible with the ODC mitigations[3]; Single entry compatible at 30m (antenna gain FS 0dBi)
FSS Downlink	Aggregation urban 1c: -77 dBm/MHz Complementary studies where resulting in an acceptable limit of -41 dBm/MHz for indoor applications with 1% AF	Aggregation compatible with the BMA mitigations[2]; Single entry compatible at 50m (antenna gain FSS 0dBi)	Aggregation compatible with the ODC mitigations[3]; Single entry compatible at 50m (antenna gain FSS 0dBi)
BWA	Single entry: -68 dBm/MHz at 1m; later –80 dBm/MHz at 30cm	Compatible with –50 dBm/MHz at 3m and TRP of -55 dBm/MHz	LBT might be necessary

[2] Density 6.7/km^2 / 10000/km^2 , activity 0.28% / 5%
[3] Density 19/km^2 / 10000/km^2 , activity 1.3% / 5%

Table 22

Conclusion: investigation of the impact of ODC on BWA[4; 5]. This is addressed in section 6.2.

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[4] Note: The Russian Federation is of the opinion that maximum mean e.i.r.p. spectral density level -80 dBm/MHz should be used for ODC applications in the frequency band 3.4 – 3.8 GHz to protect stations of Fixed Satellite service (space-Earth).

4.10 Frequency Range 4.2-4.8 GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-70 (4.2-4.8GHz -41)	-50	-50

Table 23

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
FS 3.8-4.2 and 4.4-4.8 GHz	Aggregation urban 1c: -71.5 dBm/MHz Complementary studies where resulting in an acceptable limit of -41 dBm/MHz for indoor applications with 1% AF	Aggregation compatible with the BMA mitigations[3]; Single entry compatible at 30m (antenna gain FS 0dBi)	Aggregation compatible with the BMA mitigations[4]; Single entry compatible at 30m (antenna gain FS 0dBi)
FSS Downlink 4.5-4.8 GHz	Aggregation urban 1c: -77 dBm/MHz Complementary studies where resulting in an acceptable limit of -41 dBm/MHz for indoor applications with 1% AF	Aggregation compatible with the BMA mitigations[3]; Single entry compatible at 50m (antenna gain FSS 0dBi)	Aggregation compatible with the ODC mitigations[4]; Single entry compatible at 50m (antenna gain FSS 0dBi)
Radio Altimeter	Aggregation suburban 1b: -48.7 dBm/MHz	Compatible	See BMA

[3] Density 6.7/km^2 / 10000/km^2, activity 0.28% / 5%
[4] Density 19/km^2 / 10000/km^2, activity 1.3% / 5%

Table 24

Conclusion: ECC Dec (07)01 applies [6].

4.11 Frequency Range 4.8-5 GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-70	-55 ; TRP of -65	-55 ; TRP of -65

Table 25

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
RAS	Aggregation suburban 1b: -103.4 dBm/MHz	Aggregation compatible with the BMA mitigations[5]; single entry compatible with a reliability of more than 99%	investigation of mitigations and studies

[5] Density 0.46/km^2 / 1000/km^2, activity 0.28% / 1%, 23.5dB additional mitigations

Table 26

Conclusion: investigation of ODC mitigations and studies in relation to RAS. This is addressed in section 6.1.

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[5] Note: The Russian Federation is of the opinion that maximum mean e.i.r.p. spectral density level -70 dBm/MHz should be used for ODC applications in the frequency band 3.8 – 4.2 GHz to protect stations of Fixed Satellite service (space-Earth).

[6] Note: The Russian Federation is of the opinion that maximum mean e.i.r.p. spectral density level -70 dBm/MHz should be used for ODC applications in the frequency band 4.5 – 4.8 GHz to protect stations of Fixed Satellite service (space-Earth).

4.12 Frequency Range 5-6 GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-70	-50	-50

Table 27

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
MLS 5.03-5.17 GHz	Aggregation suburban 1b: -44.7 dBm/MHz	Compatible	See BMA
Meteorological Radar	Aggregation Suburban 1b: -65 dBm/MHz	Aggregation compatible with the BMA mitigations[6]	Possibility and/or practicability of LBT needs to be investigated, in particular with regards to meteorological radar. If LBT is not considered, other solutions would have to be determined
WLAN	Single entry: -68.2 dBm/MHz at 36cm	Compatible with –50 dBm/MHz at 3m	With a separation distance of 3m -50 dBm/MHz acceptable.
Radar 5.25-5.35 GHz and 5.65-5.725 GHz	Not investigated in ECC Report 64		To be further investigated

[6] Density 0.46/km^2 / 1000/km^2 , activity 0.28% / 5%

Table 28

Conclusion: meteorological radar studies are needed in particular to consider the possibility of LBT. This is addressed in sections 5.1 and 6.3. Other radars in C-band will be further investigated in chapter 6.4.

4.13 Frequency Range 6-8 GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-41 quasi indoor and in vehicles with 12dB TPC or -53	-50	-50

Table 29

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
FS 6-8 GHz	Aggregation urban 1c: -71.5 dBm/MHz; Complementary studies where resulting in an acceptable limit of -41 dBm/MHz for indoor applications with 1% AF	Aggregation compatible with the BMA mitigations[7]; Single entry compatible at 30m (antenna gain FS 0dBi)	Aggregation compatible with the ODC mitigations[8]; Single entry compatible at 30m (antenna gain FS 0dBi)
FSS Downlink 7.25-7.75 GHz	Aggregation urban 1c: -77 dBm/MHz; Complementary studies where resulting in an acceptable limit of -41 dBm/MHz for indoor applications with 1% AF	Aggregation compatible with the BMA mitigations[7]; Single entry compatible at 30m (antenna gain FSS 0dBi)	Aggregation compatible with the ODC mitigations[8]; Single entry compatible at 30m (antenna gain FS 0dBi)

[7] Density 6.7/km^2 / 10000/km^2 , activity 0.28% / 5%
[8] Density 19/km^2 / 10000/km^2 , activity 1.3% / 5%

Table 30

Conclusion: limit of ECC/DEC/(07)01 applies for ODC: -50 dBm/MHz

4.14 Frequency Range 8-8.5 GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-41 quasi indoor and in vehicles with 12dB TPC or -53	-70	-50

Table 31

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
FS 8-8.5 GHz	Aggregation urban 1c: -69 dBm/MHz; Complementary studies where resulting in an acceptable limit of -41 dBm/MHz for indoor applications with 1% AF	Aggregation compatible with the BMA mitigations[9]; Single entry compatible at 3m (antenna gain FS 0dBi)	Aggregation compatible with the ODC mitigations[10]; Single entry compatible at 30m (antenna gain FS 0dBi)

[9] Density 6.7/km^2 / 10000/km^2 , activity 0.28% / 5%
[10] Density 19/km^2 / 10000/km^2 , activity 1.3% / 5%

Table 32

Conclusion: limit of -50 dBm/MHz applies for ODC.

4.15 Frequency Range 8.5-10.6GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-65	-85	-65

Table 33

Dominant radio services	ECC Report 64	Evaluation BMA	Evaluation ODC
Radar 9-9.5 GHz	Single entry: -90.2 dBm/MHz at 20m	Compatible	See BMA

Table 34

Conclusion: generic limit of ECC/DEC/(06)04 applies for ODC : -65 dBm/MHz

4.16 Frequency Range above 10.6GHz

	ECC/DEC/(06)04	Limit ECC/DEC/(07)01	Proposal ODC
Average power limit dBm/MHz e.i.r.p.	-85	-85	-85

Table 35

Conclusion: generic limit of ECC/DEC/(06)04 applies for ODC : -85 dBm/MHz

5 LBT VERIFICATIONS

5.1 Radars in S-band and C-Band

Summary for the S-Band:

- A max average limit of about –82 dBm/MHz e.i.r.p. would be necessary considering the results of ECC Report 64; within this limitation a safety margin of 6dB and a multiple interferer margin of 6 dB are included.
- ECC/DEC/(06)04 revised 2007 permits a limit of -70 dBm/MHz from 2.7 - 3.4 GHz
- For application A (saw), the antenna rejection to -70 dBm/MHz EIRP in elevation range from -20 to + 30° is sufficient for protection of S- band radar.

- o For application B (drill), the antenna rejection is not applicable and hence another solution needs to be considered. Due to the meteorological radars specificities, LBT is not practicable in the 2.7-2.9 GHz band and a -70 dBm/MHz limit applies to ODC type B in the 2.7-2.9 GHz band. For the band 2.9 to 3.4 GHz the LBT mechanism as defined in ECC/DEC/(07)01 (Annex 2) can be used but test pattern for the DAA mechanism defined in ETSI EN 302 065 and ETSI TS 102 754 has to be taken into account for the measurement procedures for LBT in the ODC standard ETSI EN 302 498..

Summary for the C-Band (meteorological radars):

- o ECC/DEC/(06)04 permits a limit of -70 dBm/MHz from 5-6 GHz, level confirmed as necessary for ODC by technical studies for meteorological radars
- o For application A (saw), the antenna rejection to -70 dBm/MHz e.i.r.p in elevation range from -20 to + 30° is sufficient for protection of C- band radar
- o For application B (drill), the antenna rejection is not applicable and hence another solution need to be considered. Due to the meteorological radars specificities, LBT is not practicable in the band 5.6 to 5.65 GHz band and a -70 dBm/MHz limit applies to ODC type B in this band.

5.1.1 Radar Threshold values

Assuming free space propagation, then the Radar signal received in the BMA device can be easily determined (see Table 36). The minimum Radar power levels are used for calculating the threshold levels for the LBT mechanism.
It has to be noted that the table below in based on characteristics of military or aeronautical radars but is not consistent with meteorological radars characteristics.

	Radar --> ODC
	Mainlobe
	S-Band
f/GHz	2,70
Bandwidth MHz	5,00
peak power dBm e.i.r.p.	70,00
max antenna gain dBi	33,50
p_eirp_Radar dBm	103,50
p_eirp max W	2,24E+07
Radar thermal noise dBm/MHz	-110,00
I/N dB	-10,00
Imax/Radar dBm/MHz	-120,00
P_uwb dBm/MHz e.i.r.p.	-50,00
protection distance/m Free space	1314,12
Power flux density at the BMA at the protection distance W/m^2	1,03E+00
Antenna Gain BMA dBi	0
Received power at the BMA at the protection distance dBm/Bandwidth	0,00
Received power at the BMA at the protection distance dBm/BW	**-6,99**

Table 36

The following explains how the protection distance is derived:

- Imax=Peirp+Ge-L ;
- L=32,5dB+20log(r/m)+20log(f/GHz)
- L=Peirp+Ge-Imax
- R=10^((L-32,5-20log(f/GHz))/20))

5.1.2 Specific requirements of radars in the Band 2.9 to 3.4 GHz

Additional to the threshold value, the following has to be defined for the LBT mechanism within the ECC Decision:

- Simultaneously listening and automatic switch-off feasible every 10ms if the threshold value is exceeded. If the detector has detected and switched off the transmitter, a silent time of at least 12s while listening is necessary
- The rationale behind this LBT requirement is:

- o Radar device emits its PSD with a certain PRF. A PRF of 1100 Hz and a rotational speed of 0.25 Hz (1 rotation per 4 sec) is assumed as worst case. The shortest pulse duration is 1 us. The radar main beam width is 1.5°. Every 0.9 us the radar device emits 1 impulse. A BMA beam width of 20° is assumed (with a directivity/gain of 5 dB it is approximately 60°).
- o The criterion to switch off the sensor is to receive 5 times the main beam of the radar (5x 1/PRF), for the worst case scenario 5 x 1/1100Hz= 5ms during 1 dish rotation. That means after 4ms the sensor switches off (display will show a hint, eg: "interference signal"). Now a latency time of 12 sec has to be introduced during which the UWB sensor device only receives (no transmitting, that is to cover the window for the slowest rotation rate of radar device with 0.08Hz). If during this 12 s period the main beam is detected again, the display hint will continue. If not, the measurement procedure can start again, because the interferer does not belong to a radar service.
- o The following parameters will be defined and have to be implemented into the harmonized ETSI standard: The radar pulse train has to be detected after max 10 ms. Then, the transmitter has to be switched off. After detecting the radar signal a waiting time of >12 sec has to be implemented in which the UWB sensor is only receiving. If a next radar signal is detected, then the timer (12 sec) will be triggered again. The silent time during which the LBT receiver is active has to be ensured even after the device is switched off by the functions described in Annex 1, 2i (proximity sensor) and 2ii (manual operation).

5.1.3 Specificities of Meteorological Radars in the 2.7 – 2.9 GHz band and 5 GHz range

Following detection deficiencies of RLAN 5 GHz that led to interference to meteorological radars, a recent enquiry at a request of the EC TCAM has allowed showing that there is no typical scheme, nor characteristics for meteorological radars. However, the following figure ranges can be considered for meteorological radars in both the S and C-Bands:

- operational elevation ranging from 0° to 90°
- Pulse width ranging from 0.5 to 2.5 µs (for operational radars). Existing radars are capable of pulse width up to 3.3 µs for uncompressed pulses whereas some radars use pulse compression with pulse width of about 40 µs and expected 100 µs in the future.
- Pulse repetition Frequency (PRF) ranging from 250 to 1200 Hz (for operational radars). Existing radars are capable of PRF up to 2400 Hz
- Rotation speed ranging from 1 to 6 rpm
- Maximum number of detectable pulses, depending on low PRF and high rotation speed of about 6 to 10
- Use on a given radar of different emission schemes at different elevations mixing different pulse width and PRF, and in particular the use of fixed, staggered or interleaved PRF (i.e. different PRF during a single scheme)

Some example of such different emission schemes are provided below:

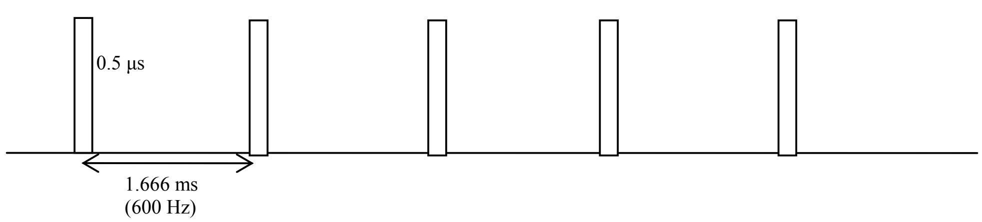

Figure 18 : Fixed PRF

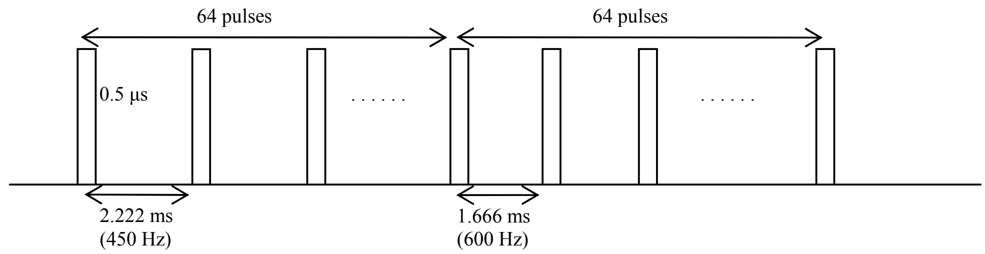

Figure 19 : Staggered PRF

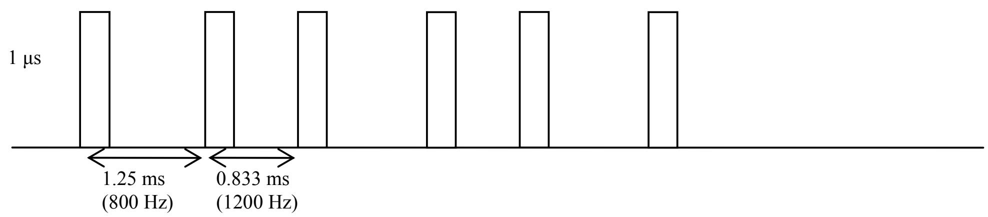

Figure 20 : Double interleaved PRF

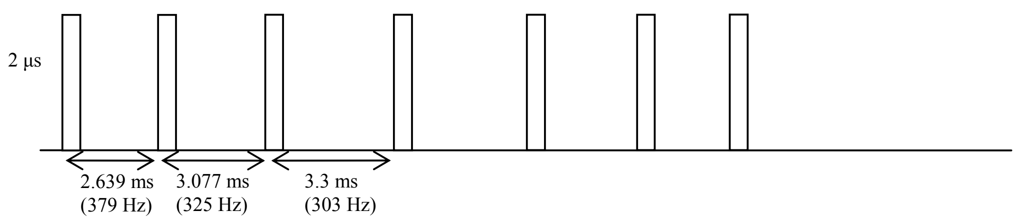

Figure 21 : Triple interleaved PRF

These different emission schemes are used on a number of radar in their emission strategy, during which, at different elevations and rotation speeds, one emission scheme is transmitted.

Finally, and more important, it has been shown that a number of meteorological radars perform **noise calibration ("Zero Check")** during their scanning phase, during which no emission is made but noise measurements are still performed.

This means that if no radar emission is detected (either by the RLAN DFS, the BMA DAA or the ODC LBT), it can reflect the following situations that will have to be discriminated:

- No radar around the RLAN,
- Radar is transmitting at high elevation
- Radar is performing noise calibration

At the end, it has been shown and agreed that, to discriminate among these 3 above situations and hence ensure detection of meteorological radars, the DFS mechanism of RLAN shall implement a Channel Availability Check (CAC) of 10 minutes, during which radar detection is to be performed and no emissions are authorized in the meteorological radar channels.

To this regards, one can note in particular that such 10 minutes CAC requirement in included in Annex 1 of Recommendation ITU-R M.1652 (in its section 2.3) states that:

"Additionally, in the band 5 600-5 650 MHz, if a channel has been flagged as containing a radar, a 10 min continuous monitoring of the flagged channel is required prior to use of that channel. Otherwise, other appropriate methods such as channel exclusion would be required."

It is important to highlight that this Annex 1 is included by reference in the Radio Regulations and is hence a mandatory requirement.

The same principle and hence 10 min CAC shall apply to any LBT feature with regards to meteorological radars. However, in the case of ODC (as well as for BMA) one can seriously doubt about the applicability of such CAC of 10 minutes, since it would mean that before using any apparatus equipped with ODC, users would have to wait 10 minutes before switching it on. (the Case of RLAN is different since they can operate on different channels).

To this respect, it obviously appears that LBT is neither applicable nor practicable to meteorological radars.

5.2 IMT2000 2.5-2.69 GHz

For application A with a limit of -70dBm/MHz in the horizontal plane the LBT mechanism from [2] is proposed as an additional mitigation technique. For application B the LBT mechanism from [2] is needed in addition to the TRP mitigation (see section 3.4).

Assuming free space propagation, then, the IMT signal received in the ODC device at the needed protection distance can easily be determined:

	MS->ODC	
f/GHz	2,70	
power dBm/3.84MHz	21,00	
max antenna gain dBi	0,00	
p_eirp dBm	21,00	
p_eirp W	1,26E-01	
Imax dBm/MHz	-115,00	
P_uwb dBm/MHz e.i.r.p.	-50,00	
protection distance/m Free space loss	15,62	
Power flux density at the BMA at the protection distance W/m^2	4,11E-05	
Power flux density at the BMA at the protection distance dBm/m^2	-13,86	PFD Threshold
Antenna Gain BMA dBi	0	
Received power at the BMA at the protection distance dBm/3.84MHz	-44,00	Power Threshold

Table 37

The LBT threshold is therefore -44 dBm/3.84 MHz, based on an emission level of 21dBm/3.84MHz from the mobile phone.

It must be noted that the LBT proposed for this band may be inefficient on mobiles in idle mode since a static IMT mobile in idle mode may transmit signaling information only once every hour, in accordance with the procedures described in the document 3 GPP TS 24.008.

Noting that an emission level of -50 dBm/MHz is compatible with a distance of 15m in a worst case scenario, this means that mobile phones having the lowest possible SNR (e.g. at the cell edge or in deep indoor scenarios) located at a distance less than 15m from ODC may loose incoming calls and may suffer from interference in this band (see details in Annex 5).

The specification of reduction of the antenna gain in the horizontal plan (Application A) or Total Radiated Power (Application B) will allow reducing the separation distances in the horizontal plan for Application A (separation distance of 2 m) and in the side lobes for Application B.

6 COMPLEMENTARY STUDIES

6.1 RAS

The protection criteria for the RAS frequency bands in the range below10 GHz are given in Table 41 in terms of spectral power flux density at receiver input detrimental to radio astronomy, for both spectral line (narrow band) and continuum (broadband) observations made in single-dish mode, as all radio telescopes operating in this range are used for this kind of observations – the most stringent levels should always be used. These threshold levels have been determined using the methodology of [9]. This assumed that the probability to receive interference from the main lobe of the antenna is low, and that interference is mainly received through the side lobes of the antenna pattern, i.e. at a level of 0 dBi at 19º from boresight (see also [8]). For the assumptions considered in [9], it is irrelevant whether the interferer is located in the near field or in the far field of a radio telescope.

Above the threshold levels of interference detrimental to radio astronomy observations given in [9], radio astronomical data are degraded. In principle, under rather idealized circumstances, if these levels are very slightly exceeded, it may be possible to compensate at the radio astronomy observatory by increased observing time. In doing so, the channel capacity of the telescope is reduced, with a corresponding reduction in scientific throughput. If the interference exceeds the detrimental interference threshold levels given in [9] by 10 dB or more, then increased observing time will no longer be effective in ensuring that valid scientific data are provided to the scientist. The radio astronomy station will be unable to operate in the affected frequency band and its ability to provide service will be lost.

6.1.1 Operational characteristics of the RAS

The RAS bands in the 1-10 GHz range are used for a wide variety of scientific programs, using both spectral line (narrow-band) and continuum (broadband) observations, with radio telescopes used in single-dish or Very Long Baseline Interferometry (VLBI) mode. In general, observations are made differentially.

In the case of continuous emissions, a map may be made of the area of sky containing the wanted source and the background emission subtracted; measurements are made of the power coming from the direction from the source (on-source) and at one or more nearby positions in the sky (off-source).
In the case of spectral line observations, spectra are recorded in frequency ranges including the line emissions of interest (the line spectra), and then at a frequency that is offset from the line emissions, or at the same frequency but at a nearby position in the sky (the reference spectra). Multichannel spectrometers are used that can integrate simultaneously the power in many (typically 256 to 4096) narrow reference frequency channels distributed across the band.

VLBI observations are made by digitizing the data without rectification, recording them along with precise timing signals, and synchronizing and correlating them later in a VLBI data processing centre. Consequently, the full impact of interference might not be known until the observing period is over and the data has been processed.

Table 38 shows the max permissible RAS interference power levels of [9] based on a Antenna gain of the RAS of 0 dBi.

continuum

Fc (MHz)	611	1413.5	2695	4995
BW (MHz)	6	27	10	10
P dBW	-202	-205	-207	-207
P dBm/MHz	**-179.8**	**-189.3**	**-187**	**-187**

spectral lines

Fc (MHz)	327	1420	1612	1665	4830
BW (kHz)	10	20	20	20	50
P dBW	-215	-250	-220	-220	-218
P dBm/MHz	**-165**	**-203**	**-173**	**-173**	**-175**

Table 38

6.1.2 Single entry scenario

Table 39 shows mitigation factors to be taken into account in the single entry scenario calculations.

Mitigations	**Application B: non fixed**	**Application A: fixed**
Additional wall attenuation	0 dB	0 dB
Duty Cycle 10%	10 dB	0 dB
TPC (not always activated)	0 dB	1.1 dB
ODC Elevation pattern from -20 to +30°	0dB	20 dB
sum of mitigations	**10 dB**	**21.1 dB**

Table 39: Mitigations for RAS worst-case single entry studies (for details of the mitigations see chapter 3)

The protection distances shown in Table 40 and Table 41 are resulting when fulfilling the requirements of [9] based on free space propagation for the single entry case.

	Continuum observation		Spectral line observation	
Frequency / GHz	2,7	4,8	2,7	4,8
average power level dBm/MHz e.i.r.p.	**-70**	**-70**	**-70**	**-70**
mitigations dB	**10**	**10**	**10**	**10**
threshold power level RA.769 dBm/MHz	-187	-187	-175	-175
MCL dB	107	107	95	95
Protection distance free space loss m	**1966**	**1106**	**494**	**278**

Table 40: protection distance for non-fixed installations (the Table is inserted as Excel-Sheet, input fields are yellow coloured)

	Continuum observation		Spectral line observation	
Frequency / GHz	2,7	4,8	2,7	4,8
average power level dBm/MHz e.i.r.p.	**-55**	**-55**	**-55**	**-55**
mitigations dB	**21,1**	**21,1**	**21,1**	**21,1**
threshold power level RA.769 dBm/MHz	-187	-187	-175	-175
MCL dB	110,9	110,9	98,9	98,9
Protection distance free space loss m	**3081**	**1733**	**774**	**435**

Table 41: protection distance for fixed installations (the Table is inserted as Excel-Sheet, input fields are yellow coloured)

6.1.3 Aggregation

Table 42 shows mitigation factors to be taken into account in the aggregated scenario calculations.

Mitigations	**Application B: non fixed**	**Application A: fixed**
Additional TRP limitation	10 dB	0 dB
Additional wall attenuation	7.4 dB	7.4 dB
TPC	0 dB	1.1 dB
Duty Cycle 10%	10 dB	0 dB
ODC Elevation pattern from -10 to +30°	0dB	20 dB
sum of mitigations	**27.4 dB**	**28.5 dB**

Table 42: Mitigations for RAS aggregated studies (for details of the mitigations see chapter 3)

The protection distances shown in Table 43 and Table 44 are resulting when fulfilling the requirements of [9] based on the integral methodology described in [10].

f/MHz	2690.00	2690.00	2690.00	2690.00
Lambda/m	0.11	0.11	0.11	0.11
Ps dBm/MHz	-40.00	-45.00	-50.00	-55.00
Mitigations	**27.40**	**27.40**	**27.40**	**27.40**
UWB Ps/dBm/MHz incl. Mitigations	-67.40	-72.40	-77.40	-82.40
UWB Ps W/MHz	1.82E-10	5.75E-11	1.82E-11	5.75E-12
UWB Gs/dBi	0.00	0.00	0.00	0.00
UWB Gs abs	1.00	1.00	1.00	1.00
active Density/km^2	0.004	0.004	0.004	0.004
active Density/m^2	4.00E-09	4.00E-09	4.00E-09	4.00E-09
Outer radius R1 in m	30000.00	30000.00	30000.00	30000.00
RAS Ge/dBi	0	0	0	0
RAS Ge abs	1.00	1.00	1.00	1.00
Alpha	1.43E-14	4.53E-15	1.43E-15	4.53E-16
Imax dBm/MHz	-187.00	-187.00	-187.00	-187.00
Imax W/MHz	2.00E-22	2.00E-22	2.00E-22	2.00E-22
minimum inner protection radius m	**17240.89**	**5204.74**	**117.90**	**0.00**

Table 43: Protection distance for non-fixed installations
(the Table is inserted as Excel-Sheet; input fields are yellow coloured)

f/MHz	2690,00	2690,00	2690,00	2690,00
Lambda/m	0,11	0,11	0,11	0,11
Ps dBm/MHz	-41,00	-45,00	-50,00	-55,00
Mitigations	**28,50**	**28,50**	**28,50**	**28,50**
UWB Ps/dBm/MHz incl. Mitigations	-69,50	-73,50	-78,50	-83,50
UWB Ps W/MHz	1,12E-10	4,47E-11	1,41E-11	4,47E-12
UWB Gs/dBi	0,00	0,00	0,00	0,00
UWB Gs abs	1,00	1,00	1,00	1,00
active Density/km^2	0,004	0,004	0,004	0,004
active Density/m^2	4,00E-09	4,00E-09	4,00E-09	4,00E-09
Outer radius R1 in m	30000,00	30000,00	30000,00	30000,00
RAS Ge/dBi	0	0	0	0
RAS Ge abs	1,00	1,00	1,00	1,00
Alpha	8,84E-15	3,52E-15	1,11E-15	3,52E-16
Imax dBm/MHz	-187,00	-187,00	-187,00	-187,00
Imax W/MHz	2,00E-22	2,00E-22	2,00E-22	2,00E-22
minimum inner protection radius m	**12217,32**	**3141,38**	**23,88**	**0,00**

Table 44: Protection distance for fixed installations
(the Table is inserted as Excel-Sheet; input fields are yellow coloured)

The comparison of the aggregated impact of ODC with existing UWB applications is shown in table 45.

	Generic	BMA	Saw	Drill
f/MHz	2690,00	2690,00	2690,00	2690,00
Lambda/m	0,11	0,11	0,11	0,11
Ps dBm/MHz	-85,00	-55,00	-55,00	-55,00
Mitigations	**10,00**	**28,50**	**28,50**	**27,40**
UWB Ps/dBm/MHz incl. Mitigations	-95,00	-83,50	-83,50	-82,40
UWB Ps W/MHz	3,16E-13	4,47E-12	4,47E-12	5,75E-12
UWB Gs/dBi	0,00	0,00	0,00	0,00
UWB Gs abs	1,00	1,00	1,00	1,00
active Density/km^2	1,00E+00	1,46E-04	1,32E-03	3,00E-03
active Density/m^2	1,00E-06	1,46E-10	1,32E-09	3,00E-09
Outer radius R1 in m	30000,00	30000,00	30000,00	30000,00
RAS Ge/dBi	0	0	0	0
RAS Ge_abs	1,00	1,00	1,00	1,00
Alpha	2,49E-17	3,52E-16	3,52E-16	4,53E-16
Imax dBm/MHz	-187,00	-187,00	-187,00	-187,00
Imax W/MHz	2,00E-22	2,00E-22	2,00E-22	2,00E-22
minimum inner protection radius m (single UWB applications)	**8383,13**	**0,00**	**0,00**	**0,00**
		Generic+BMA	**Generic+BMA+ Saw**	**Generic+BMA+ Saw+Drill**
minimum inner protection radius m (Aggregation of UWB applications)		**8405,10**	**8602,74**	**9165,96**

Table 45: Aggregated impact of all UWB applications

6.1.4 Probability of exceeding the RAS protection criteria

In this section the input parameters and results of the SEAMCAT simulations are presented.

Table 46 shows mitigation factors to be taken into account in the simulations.

Mitigations	**Application B: non fixed**	**Application A: fixed**
Additional TRP limitation	10 dB	0 dB
Additional wall attenuation	7.4 dB	7.4 dB
Duty Cycle 10%	10 dB	0 dB
TPC	0 dB	1.1 dB
ODC Elevation pattern from -20 to +30°	0dB	20 dB
sum of mitigations	**27.4 dB**	**28.5 dB**

Table 46: Mitigations for RAS aggregated studies (for details of the mitigations see chapter 4)

Table 47 shows the SEAMCAT parameters for the simulations (the parameters are calculated for a simulation radius of about 30 km).

	Interfering Links	IF Link1	IF Link2	IF Link3	IF Link4
		ODC Saw	ODC drill	generic	BMA
		rural	rural	rural	rural
	2,7 GHz Limit dBm/MHz	-55	-55	-85	-55
	4,8 GHz Limit dBm/MHz	-55	-55	-70	-55
	Mitigation dB	28,5	27,4	10	28,5
SEAMCAT Input	2,7 GHz Power dBm/MHz	-83,5	-82,4	-95	-83,5
SEAMCAT Input	4,8 GHz Power dBm/MHz	-83,5	-82,4	-80	-83,5
SEAMCAT Input	density/km^2	0,22	0,06	100	0,052
SEAMCAT Input	activity factor	0,006	0,05	0,01	0,0028
SEAMCAT Input	prob	1	1	1	1
SEAMCAT Input	active devices	4	9	2827	1
	simu radius km	31,06	30,90	30,00	46,76
	area/km^2	3030,3	3000,0	2827,0	6868,1

Table 47 : parameters used for SEAMCAT simulations

The details of SEAMCAT simulations are reported in Annex 2.

Table 48 below gives the summary of the simulations (the first result corresponds to a RAS antenna taken from [8] (70dBi mainbeam) and the second one to a 0 dBi antenna gain)

Limit Saw application	Max -50 dBm/MHz Horizontal -70 dBm/MHz	Max -55 dBm/MHz Horizontal -75 dBm/MHz
Limit Drill application	Max -50 + 10dB TRP +10% DC	Max -55 + 10dB TRP +10% DC
Generic	22.9 - 100%	
BMA	0.02 - 0.1%	
ODC saw	0.7 - 2.6 %	0.3 – 0.8%
ODC Drill	0.8 - 2.3 %	0.28 – 0.7%
ODC Saw+Drill	1.5 – 5.7%	0.6 – 1.7%
BMA + ODC Saw/Drill	1.5 - 5.9%	0.6 – 1.7%
Generic + BMA + ODC Saw/Drill	25.6 - 100%	24 – 100%

Table 48*: Summary of SEAMCAT simulations*

6.1.4.1 Applicability of data loss limits

This section aims to verify and clarify the interference probability issue which is related to the acceptable percentage of Radio Astronomy data loss of 2% contained in [7].

Within [7] it is recommended:

1. *that, for evaluation of interference, a criterion of 5% be used for the aggregate data loss to the RAS due to interference from all networks, in any frequency band allocated to the RAS on a primary basis, noting that further studies of the apportionment between different networks are required;*
2. ***that, for evaluation of interference, a criterion of 2% be used for data loss to the RAS due to interference from any one network, in any frequency band which is allocated to the RAS on a primary basis;*** *and*
3. *that* ***the percentage of data loss, in frequency bands allocated to the RAS on a primary basis, be determined as the percentage of integration periods of 2 000 s in which the average spectral power flux-density (pfd) at the radio telescope exceeds the levels defined (assuming 0 dBi antenna gain) in [9].*** *The effect of interference that is periodic on time scales of the order of seconds or less, such as radar pulses, requires further study.*

Due to the lack of specific criteria in ITU-R recommendation for interference due to UWB devices, the recommended percentage of data loss[7] of 2% from this Recommendation was used as the percentage of lost observation packets each 2000 s period over one day.

In the SEAMCAT scenario the main beam direction of a RAS antenna accordant to [8] is randomly distributed over the entire sky, including very unlikely elevations down to 0°, wherefore the results of the SEAMCAT simulations shows a

[7] Note from the Netherlands and CRAF: When strictly interpreting ITU-R Rec RA.1513-1 and taking into account the history of drafting this recommendation, only mitigable data loss from networks is allowed. These networks are for example GSM networks with a more or less stable geographical layout. The proposed UWB devices cause unmitigable data loss in addition to that of the already existing networks to their uncontrolled geographical layout and modulation scheme.

worst-case percentage of "blocked sky". Therefore the probability of interference results of the SEAMCAT simulation seems to be applicable to the allowed data loss due to interference given in [7].

6.1.5 Summary and conclusion RAS

Considering the worst-case scenario and the limits of the continuum observation from [9], then the results are:

Worst Case Single entry scenario (Free space loss)

- For non-fixed installations (e.g. a drill) a max limit of -70 dBm/MHz at 2.7 GHz with a 10 % Duty Cycle Limitation would result in a needed protection distance between 500 m and 2 km
- For fixed installations (e.g. a saw top) a max limit of -55 dBm/MHz at 2.7 GHz with a horizontal limit of -75 dBm/MHz would result in a needed protection distance between 770 m and 3 km
- This scenario does not take into account mitigation factors like for example wall attenuation (up to 20 dB), TPC (up to 10 dB), Non Line of Sight propagation.

Aggregated scenario (Free space loss)

- For non-fixed installations (e.g. a drill) a max limit of -50 dBm/MHz at 2.7 GHz with a TRP 10 dB below max e.i.r.p and a 10% Duty Cycle Limitation (-60 dBm/MHz) would be acceptable (separation distances slightly above 100m)
- For fixed installations (e.g. a saw top) a max limit of -50 dBm/MHz at 2.7 GHz with a horizontal limit of -75 dBm/MHz would be acceptable (separation distances less than 100m)

Probability of interference (Exceeding the limits of [9])

- For non-fixed installations (e.g. a drill) a max limit of -55 dBm/MHz at 2.7 GHz with a TRP 10 dB below max e.i.r.p (see Section 3.4) and a 10 % Duty Cycle Limitation would result in a probability of interference of less than 1 %
- For fixed installations (e.g. a saw top) a max limit of -55 dBm/MHz at 2.7 GHz with a horizontal limit of -75 dBm/MHz would result in a probability of interference of less than 1 %
- Both ODC applications with a max limit of -55 dBm/MHz at 2.7 GHz would result in a probability of interference of less than 2 %

Aggregation of all UWB applications

- Integral methodology:
  - The protection radius for RAS for current UWB applications (Generic -85, BMA -55) at 2.7 GHz is 8.4 km; assuming a Generic Limit of -90 the protection distance would be about 500m);
  - The protection radius for RAS for all UWB applications (Generic -85, BMA and ODC -55) at 2.7 GHz would be 8.8km; assuming a Generic Limit of -90 the protection distance would be about 800m)
  - -> About 5% bigger protection distance with ODC
- SEAMCAT:
  - The probability of interference of the current UWB devices (Generic UWB plus BMA) is at 2.7 GHz in the range between 23% (Antenna pattern of [8]) and 100% (isotropic pattern);
  - The overall probability of interference of current UWB devices plus ODC (with max -55 dBm/MHz) is between 24% (Antenna pattern of [8]) and 100% (isotropic pattern)
  - The probability of interference of ODC (-55) plus BMA without generic UWB is below 2%
- The impact of ODC compared to generic UWB is neglect able

In Table 49 the acceptable power levels of the different studies are presented. The limits at 1.4 GHz is extrapolated from the results at 2.7 GHz by about 5dB less Free Space Loss, and the limit at 4.8 GHz by 5dB more Free Space loss.

	Non fixed installation, Application B			Fixed installation, Application A		
	1.4 GHz	**2.7GHz**	**4.8GHz**	**1.4 GHz**	**2.7GHz**	**4.8GHz**
Single entry dBm/MHz	-75	-70	-65	-60 horizontal - 80	-55 horizontal - 75	-50 horizontal - 70
Aggregation dBm/MHz	-55 + TRP -65 + 10% DC	-50 + TRP -60 + 10% DC	-45 +TRP -55 +10% DC	-55 horizontal - 75	-50 horizontal - 70	-45 horizontal - 65
ODC Power level dBm/MHz for a Probability of interference <1%	-60	-55	-50	-60	-55	-50
Requested Levels by CRAF dBm/MHz (see Annex 3)	-90	-81	-70	-90	-81	-70
Conclusion dBm/MHz	**Max -85**	**Max -70 + 10% DC → -80**	**Max -55 + TRP -65 + 10% DC → -75 Note**	**Max -85**	**Max -55 → horizontal - 75**	**Max -55 → horizontal - 75**

Table 49: Summary

Note: this limit is derived assuming that the DC limit of 10% gives a mitigation of 10dB.

6.2 BWA 3.4-3.8 GHz

ECC/DEC/(06)04 revised in July 2007 permits a power level of -80 dBm/MHz e.i.r.p. based on an extrapolation of the acceptable power level of -85 dBm/MHz e.i.r.p. for IMT2000 at 2.1 GHz to 3.4 GHz (about 5dB more free space loss, see TG3#18_26_Annex3). This result assumes a max permissible power level of -115 dBm/MHz at a distance of 36 cm.

Single entry scenario

Frequency / GHz	3,4	3,4	3,4	3,4
average power level dBm/MHz e.i.r.p.	**-50**	**-60**	**-50**	**-60**
mitigations dB	**0**	**0**	**10**	**10**
max interference power dBm/MHz	-115	-115	-115	-115
MCL dB	65	55	55	45
Protection distance free space loss m	**12,40**	**3,92**	**3,92**	**1,24**

Table 50: protection distance for Application B/non-fixed installations
(the Table is inserted as Excel-Sheet, input fields are yellow coloured)

Frequency / GHz	3,4	3,4	3,4	3,4
average power level dBm/MHz e.i.r.p.	**-50**	**-55**	**-60**	**-65**
mitigations dB	**20**	**20**	**20**	**20**
max interference power dBm/MHz	-115	-115	-115	-115
MCL dB	45	40	35	30
Protection distance free space loss m	**1,24**	**0,70**	**0,39**	**0,22**

Table 51: protection distance for Application A/fixed installations
(the Table is inserted as Excel-Sheet, input fields are yellow coloured)

Conclusion based on worst case single entry scenario with an acceptable separation distance of 3m:

- Application B/ Non fixed: Max -50 dBm/MHz with a DC limit of 10% and a TRP limit of -55dBm/MHz
- Application A/ Fixed: Max -50 dBm/MHz with an antenna rejection to -70 dBm/MHz from -20 to +30°

6.3 Meteorological radars (S-Band and C-Band)

It has been considered that the single entry scenario was dominant, acknowledging that according to ODC operational modes, activity factor on the long-term have to be taken into account and that in such single entry scenarios, no mitigation techniques neither average activity factor can be applied.
Interference calculations have been made in both S-Band and C-Band with a maximum ODC power density of -50 dBm/MHz and with consistent meteorological radars characteristics as in [6], using a 0° minimum elevation and the average and minimum radar antenna heights.

These calculations show that with ODC systems operating at -50 dBm/MHz, even without considering any additional apportionment factor of 8.7 dB as used in studies given in [6]:

For S-Band radars (2700-2900 MHz) :

- interference criterion of -10 dB I/N ([15]) is exceeded between 13 (average radar height 16m) and 28 dB (minimum radar height 7m and UWB at 5m)
- interference criterion of -10 dB I/N is exceeded over a distance ranging up to more than 5 km

On this basis, it appears that current maximum level to be applied as applied to BMA in this band (-82 dBm/MHz) has also to apply to ODC devices.

For C-Band radars (5600-5650 MHz) :

- interference criterion of -10 dB I/N is exceeded between 5 (average radar height 16m) and 22 dB (minimum radar height 7m and UWB at 5m)
- interference criterion of -10 dB I/N is exceeded over a distance ranging up to 4.5 km

On this basis, it appears that current maximum level as applied to generic UWB in this band (-70 dBm/MHz) has to be applied to ODC devices.

Conclusions
Based on the above, in order to ensure protection of meteorological radars operating in the 2700-2900 MHz and 5600-5650 MHz bands, following maximum power density levels should be applied to ODC devices:

- -82 dBm/MHz in the 2700-2900 MHz band (consistent with [2])
- -70 dBm/MHz in the 5600-5650 MHz band (consistent with [3])

After discussions, with regards to applications A (saw), an antenna rejection to -70 dBm/MHz in the elevation angle from -20 to +30° could allow the coexistence with meteorological radars in both bands.
For application B, no mitigation technique has been found to potentially improve the situation and hence, a -70 dBm/MHz maximum eirp density has to be applied in both bands.

6.4 Radar C-band 5.25-5.35 GHz and 5.65-5.725 GHz

Table 52 shows the needed separation distance within the main beam of a radar antenna under line of sight conditions.

f/GHz	5,25	5,25	5,25	5,25	5,25	5,25
Imax dBm/MHz	-115	-115	-115	-115	-115	-115
Ge dBi	47	47	47	47	47	47
Peirp dBm/MHz	-50	-50	-60	-60	-70	-70
Wall attenuation/dB	10	20	10	20	10	20
r/m	568,64	179,82	179,82	56,86	56,86	17,98

Table 52

With regard to application A (saw), an antenna rejection to –60 dBm/MHz e.i.r.p. in the elevation angle from -20 to +30° would allow the coexistence with radars in the C- band.

For application B a generic limit of -60 dBm/MHz e.i.r.p. would be sufficient for the protection of those radars.

6.5 IMT2000 core band 1.73 - 2.2 GHz

The limit of [2] for BMA in this frequency range is -65 dBm/MHz and is based on an accepted separation distance of 3m. This value was derived from the accepted level for generic UWB ([3]) of -85 dBm/MHz at 2.1 GHz based on a 36cm separation distance.

For a separation distance of 3m, -65dBm/MHz would be needed, for 2m, -70 dBm/MHz, for 1m, -75 dBm/MHz and for 36cm, -85 dBm/MHz.

The question here is the appropriate number for a separation distance. 36cm might be a separation distance to avoid worst case scenario next to an ODC device (e.g. for IMT2000 an incoming call might be lost if the mobile operates in a low SNR regime).
But considering the very low probability of such situations (1. a worker is sawing, 2. he has a mobile in a distance of 36cm to the saw, 3. the mobile has a very low SNR and 4. an incoming call arrives) it seems to be more realistic to consider a separation distance of 2 m.
Additionally the following Table 53 shows the power which may be already produced by emc radiations of a saw at a mobile receiver in a distance of 50cm. This power level of -77 dBm/MHz already exceeds the protection level of -115 dBm/MHz by more than 40dB.

	EMC Limit EN 55022 Class B >1GHz	
E/dBµV/mMHz	50	50
E/V/mMHz	0,00032	0,00032
r/m	3	3
ZF/Ohm	377	377
Peirp W/MHz	2,99993E-08	3E-08
Peirp dBm/MHz	**-45,23**	**-45,23**
distance /m	0,50	3,00
f/GHz	1,80	1,80
Free space loss	31,6	47,1
P mobile dBm/MHz	**-76,81**	**-92,38**

Table 53

Taken this into account, a power level of -70 dBm/MHz at 2 m would be acceptable in the band 1.73 to 2.2 GHz.

7 CONCLUSIONS

As result of the studies in this report the existing UWB limits are applicable to ODC in the following bands:

- Below 1.73 GHz: the limits of ECC/DEC/(07)01 [1] are applicable to ODC, but not considering the LBT option.
- from 2.2 to 2.5 GHz, 3.8 to 4.8 GHz, 5 to 5.25 GHz, 5.35 to 5.6 GHz and 5.725 to 8.5 GHz: the limits of ECC/DEC/(07)01 are applicable to ODC
- above 8.5 GHz: the limits of ECC/DEC/(06)04 are applicable to ODC

Deviations from the existing UWB regulations are needed in the other bands and these requirements are summarized in table 54.

	Application A: Limits and requirements for fixed installations with an antenna rejection in the horizontal plane (elevation angles from -20 to 30°)	**Application B**: Limits and requirements for non fixed installations with 10% Duty Cycle (Note 1 and 4) and TRP (Note 2)
IMT2000 Core band 1.73-2.2 GHz	Max -65 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -70 dBm/MHz e.i.r.p.
IMT2000 extension band 2.5-2.69 GHz Note 7	Max -50 dBm/MHz e.i.r.p. plus LBT and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -50 dBm/MHz e.i.r.p. plus LBT from ECC/DEC/(07)01 and TRP limit of -60dBm/MHz
RAS 2.69-2.7 GHz, Note 3	Max -55 dBm/MHz e.i.r.p. and -75 dBm/MHz e.i.r.p. in the horizontal plane	Max -70 dBm/MHz e.i.r.p. plus a DC limit of 10%
Radar S-Band, 2.7-2.9 GHz	Max -50 dBm/MHz e.i.r.p and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -70 dBm/MHz e.i.r.p.
Radar S-Band, 2.9-3.4 GHz	Max -50 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -50 dBm/MHz e.i.r.p. with LBT from ECC/DEC/(07)01; Note 5
BWA 3.4-3.8 GHz Note 6	Max -50 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -50 dBm/MHz e.i.r.p. plus a TRP limit of -55 dBm/MHz and a DC limit of 10%
RAS 4.8-5 GHz	Max -55 dBm/MHz e.i.r.p. and -75 dBm/MHz e.i.r.p. in the horizontal plane	Max -55 dBm/MHz e.i.r.p. plus a TRP limit of -65dBM/MHz and a DC limit of 10%
Meteorological Radar 5.6-5.65 GHz	Max -50 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max limit -70 dBm/MHz e.i.r.p.
Radar 5.25-5.35 GHz 5.65-5.725 GHz	Max -50 dBm/MHz e.i.r.p. and -60 dBm/MHz e.i.r.p. in the horizontal plane	Max limit -60 dBm/MHz e.i.r.p.
Additional requirements	• Working sensor • TPC with a dynamic range of 10 dB • Fixed installed in a saw table	• Working sensor • Proximity sensor • Representative wall for the compliance measurements

Note 1: The Duty Cycle is defined in one second as described in section 3.7.1 of this report.
Note 2: TRP is defined in section 3.4 of this report.
Note 3: RR No. **5.340** states that "*all emissions are prohibited*".
Note 4: This limit is derived assuming that the DC limit of 10% gives a mitigation of 10dB.
Note 5: For protection of radiolocation services the test pattern for the DAA mechanism defined in ETSI EN 302 065 and ETSI TS 102 754 has to be taken into account for the measurement procedures for LBT in the ODC standard ETSI EN 302 498.
Note 6: Future mobile systems may require LBT for their protection.
Note 7: The efficiency of LBT may need to be further investigated for the protection of mobile terminals in idle mode (see Annex 5).

Table 54

This leads to consider the following limits for ODC:

F/GHz	Limits for **fixed installations (Application A)** with an antenna rejection in the horizontal plane (-20 to 30°)	Limits for **non fixed installations (Application B)**
<1.73	Max -85 dBm/MHz e.i.r.p.	
1.73-2.2	Max -65 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -70 dBm/MHz
2.2-2.5	Max -50 dBm/MHz e.i.r.p.	
2.5-2.69	Max -50 dBm/MHz e.i.r.p. with LBT and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -50 dBm/MHz e.i.r.p. with LBT from ECC/DEC/(07)01 and a TRP limit of -60 dBm/MHz
2.69-2.7	Max -55dBm/MHz e.i.r.p. and -75 dBm/MHz e.i.r.p. in the horizontal plane	Max -70 dBm/MHz e.i.r.p. with a DC limit of 10%
2.7-2.9	Max -50 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -70 dBm/MHz e.i.r.p.
2.9-3.4	Max -50 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -50 dBm/MHz e.i.r.p. with LBT from ECC/DEC/(07)01
3.4-3.8[1]	Max -50 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -50 dBm/MHz e.i.r.p. plus a DC limit of 10% and a TRP limit of -55 dBm/MHz
3.8-4.8[2]	Max -50 dBm/MHz e.i.r.p.	
4.8-5	Max -55 dBm/MHz e.i.r.p. and -75 dBm/MHz e.i.r.p. in the horizontal plane	Max -55 dBm/MHz e.i.r.p. plus a TRP limit of -65 dBm/MHz and a DC limit of 10%
5-5.25	Max -50 dBm/MHz e.i.r.p.	
5.25-5.35	Max -50 dBm/MHz e.i.r.p. and -60 dBm/MHz e.i.r.p. in the horizontal plane	Max -60 dBm/MHz e.i.r.p.
5.35-5.6	Max -50 dBm/MHz e.i.r.p.	
5.6-5.65	Max -50 dBm/MHz e.i.r.p. and -70 dBm/MHz e.i.r.p. in the horizontal plane	Max -70 dBm/MHz e.i.r.p.
5.65-5.725	Max -50 dBm/MHz e.i.r.p. and -60 dBm/MHz e.i.r.p. in the horizontal plane	Max -60 dBm/MHz e.i.r.p.
5.725-8.5	Max -50 dBm/MHz e.i.r.p.	
8.5-10.6	Max -65 dBm/MHz e.i.r.p.	
>10.6	Max -85 dBm/MHz e.i.r.p.	

Table 55

All limits in table 54 and 55 are given in mean e.i.r.p. spectral density. Additionally the following peak limitation deviating from existing UWB regulations is proposed for ODC (existing UWB regulations having a peak limit about 40 dB above the average limit):

- the peak limit measured in a bandwidth of 50MHz is 25 dB higher than the average limit measured in a bandwidth of 1 MHz

On one side, there are site specific mitigation factors that have not been considered for example attenuation from walls and Non Line of Sight. On the other side, the assumptions on power or deployment densities in this Report may in some cases be exceeded and therefore this would increase the risk of interference given the uncontrolled nature of the deployment and activity of these devices.

[1)] Note: The Russian Federation is of the opinion that maximum mean e.i.r.p. spectral density level -80 dBm/MHz should be used for ODC applications in the frequency band 3.4 – 3.8 GHz to protect stations of Fixed Satellite service (space-Earth).

[2)] Note: The Russian Federation is of the opinion that maximum mean e.i.r.p. spectral density level -70 dBm/MHz should be used for ODC applications in the frequency bands 3.8 – 4.2 and 4.5 – 4.8 GHz to protect stations of Fixed Satellite service (space-Earth).

ANNEX 1: RAS BANDS

Bands allocated to RAS

Table 58 lists the frequency bands allocated to, and used by, the RAS in the range below10 GHz.

Frequency band (MHz)	**Relevant RR footnote**	**Detrimental spfd (from [9]) (dB(W/(m^2.Hz)))**
608-614	RR No 5.149 (in Regions 1 and 3)	-253[2]
1 330.0-1 400.0	RR No. 5.149	-239[1], -255[2]
1 400.0-1 427.0	RR No. 5.340	-239[1], -255[2]
1 610.6-1 613.8	RR No. 5.149	-238[1]
1 660.0-1 670.0	RR No. 5.149	-237[1], -251[2]
1 718.8-1 722.2	RR No. 5.149	-237[1]
2 655.0-2 690.0	RR No. 5.149	-247[2]
2 690.0-2 700.0	RR No. 5.340	-247[2]
3 260.0-3 267.0	RR No. 5.149	-230[1]
3 332.0-3 339.0	RR No. 5.149	-230[1]
3 345.8-3 352.5	RR No. 5.149	-230[1]
4 800.0-4 990.0	RR No. 5.149	-230[1], -241[2]
4 990.0-5 000.0	RR No. 5.149	-241[2]
6 650.0-6 675.2	RR No. 5.149	-230[1]

[1] Spectral line observations (narrow band).
[2] Continuum observations (broadband).

- RR No. **5.149** states that "*administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference*".
- RR No. **5.340** states that "*all emissions are prohibited*" in given frequency bands.

Table 56 : Frequency bands used by the RAS in the range below 10.6 GHz and their protection criteria

ANNEX 2: SEAMCAT SIMULATIONS FOR RAS

The following Table 59 shows the SEAMCAT parameters for the simulations (the parameters are calculated for a simulation radius of about 30 km).

	Interfering Links	IF Link1	IF Link2	IF Link3	IF Link4
		ODC Saw	ODC drill	generic	BMA
		rural	rural	rural	rural
	2,7 GHz Limit dBm/MHz	-55	-55	-85	-55
	4,8 GHz Limit dBm/MHz	-55	-55	-70	-55
	Mitigation dB	28,5	32,4	10	28,5
SEAMCAT Input	2,7 GHz Power dBm/MHz	-83,5	-87,4	-95	-83,5
SEAMCAT Input	4,8 GHz Power dBm/MHz	-83,5	-87,4	-80	-83,5
SEAMCAT Input	density/km^2	0,22	0,06	100	0,052
SEAMCAT Input	activity factor	0,006	0,05	0,01	0,0028
SEAMCAT Input	prob	1	1	1	1
SEAMCAT Input	active devices	4	9	2827	0,4
	simu radius km	31,06	30,90	30,00	29,57
	area/km^2	3030,3	3000,0	2827,0	2747,3

Table A2.1

SEAMCAT simulation 1: Application A/Saw (Interfering Link1)

Assumptions for the Interfering Link

- Simulated interfering power — Application A -78.5 dBm/MHz e.i.r.p. (-50 minus 28.5dB mitigation)
- Antenna gain ODC — 0dBi
- ODC height — 1.5m
- Path loss model — Free space / Other propagation models to be also considered
- Distribution of interferer — Uniform density
- Density of active transmitter — 0.22/km^2
  - o This number represents the average over Europe
- Activity factor — 0.6%
- Probability of transmission — 1
- Time (hours) — 12
- Protection distance — 0 km
- Numbers of active transmitters — 4
- Simulation radius — 30km

Assumptions for the Victim Link

- RAS height — 50m
- RAS antenna gain — **0dBi** and a high directive antenna from [8] (70dBi in the main beam)
- Antenna azimuth range 0 - 360°
- Antenna elevation range 0 - 90°
- Noise floor — -167 dBm
- Reception bandwidth — 10.000 kHz
- I/N — -10 dB
  - o the other interference criteria are not used and can be ignored
- Sensitivity — -167 dBm
  - o not used in the simulations

Frequency		2.7 GHz			
Density of transmitters		Application A/Saw, Rural 0.22/km^2			
Number of active transmitters		4			
Protection criteria		–177 dBm/10MHz according to [9]			
Antenna gain RAS		0dBi		[8], Mainbeam 70 dBi	
Propagation model		Free Space Loss			
Simulated ODC power dBm/MHz	equivalent max ODC power level dBm/MHz e.i.r.p.	iRSS mean dBm/10MHz (StdDev)	Probability of interference	iRSS mean dBm/10MHz (StdDev)	Probability of interference
-78.5	Max -50, -70 in horizontal plane	-187 (4dB)	2.6%	-196 (5dB)	0.7%
-83.5	Max -55, -75 in horizontal plane	-192 (4dB)	0.8%	-201 (5dB)	0.2%
Propagation model		Extended Hata (Rural, Victim receiver and Interfering transmitter outdoor)			
-78.5	Max -50, -70 in horizontal plane	-202 (10dB)	1.7%	-210 (10dB)	0.5%
-83.5	Max -55, -75 in horizontal plane	-207 (10dB)	0.8%	-215 (10dB)	0.3%

TableA2.2: Summary of Results of SEAMCAT simulation at 2.7 GHz (Free Space Loss and Hata)

Simulation 2: Application B, Interfering Link 2

Assumptions for the Interfering Link

- Simulated interfering power Application B -82.4 dBm/MHz e.i.r.p. (-50 minus 32.4 dB mitigation)
- Antenna gain ODC 0dBi
- ODC height 1.5m
- Path loss model Free space / Other propagation models to be also considered
- Distribution of interferer Uniform density
- Density of active transmitter 0.06/km^2
  - This number represents the average over Europe
- Activity factor 5%
- Probability of transmission 1
- Time (hours) 12
- Protection distance 0 km
- Numbers of active transmitters 9
- Simulation radius 30km

Assumptions for the Victim Link

- RAS height 50m
- RAS antenna gain **0dBi** and a high directive antenna of [8] (70dBi in the main beam)
- Antenna azimuthrange 0 - 360°
- Antenna elevation range 0 - 90°
- Noise floor -167 dBm
- Reception bandwidth 10.000 kHz
- I/N -10 dB
  - the other interference criteria are not used and can be ignored
- Sensitivity -167 dBm
  - not used in the simulations

Frequency		2.7 GHz			
Density of transmitters		Application B/Drill, Rural 0.06/km^2			
Number of active transmitters		9			
Protection criteria		–177 dBm/10MHz according to [9]			
Antenna gain RAS		0dBi		[8], Mainbeam 70 dBi	
Propagation model		Free Space Loss			
Simulated ODC power dBm/MHz	equivalent max ODC power level dBm/MHz e.i.r.p.	iRSS mean dBm/10MHz (StdDev)	Probability of interference	iRSS mean dBm/10MHz (StdDev)	Probability of interference
-82.4	Max -50 +10dB less TRP, +10%DC	-187 (4dB)	2.3%	-195 (5dB)	0.76%
-87.4	Max -55 +10dB less TRP, +10%DC	-192 (4dB)	0.7%	-200 (5dB)	0.28%
Propagation model		Extended Hata (Rural, Victim receiver and Interfering transmitter outdoor)			
-82.4	Max -50 +10dB less TRP, +10%DC	-199 (9dB)	2.5%	-207 (9dB)	0.8%
-87.4	Max -55 +10dB less TRP, +10%DC	-204 (9dB)	1.1%	-212 (9dB)	0.38%

TableA2.3: Summary of Results of SEAMCAT simulation at 2.7 GHz (Free Space Loss and Hata)

Simulation 3: Generic UWB, Interfering Link 3

Assumptions for the Interfering Link

- Simulated interfering power — Generic UWB -95 dBm/MHz e.i.r.p. (-85 minus 10 dB mitigation)
- Antenna gain ODC — 0dBi
- ODC height — 1.5m
- Path loss model — Free space / Other propagation models to be also considered
- Distribution of interferer — Uniform density
- Density of active transmitter — 100/km^2
  - This number represents the average over Europe
- Activity factor — 1%
- Probability of transmission — 1
- Time (hours) — 12
- Protection distance — 0 km
- Numbers of active transmitters — 2827
- Simulation radius — 30km

Assumptions for the Victim Link

- RAS height — 50m
- RAS antenna gain — **0dBi** and a high directive antenna from [8]/ ITU-R SA.509 (70dBi in the main beam)
- Antenna azimuth range 0 - 360°
- Antenna elevation range 0 - 90°
- Noise floor — -167 dBm
- Reception bandwidth — 10.000 kHz
- I/N — -10 dB
  - the other interference criteria are not used and can be ignored
- Sensitivity — -167 dBm
  - not used in the simulations

Frequency		2.7 GHz			
Density of transmitters		Generic UWB, Rural 100/km^2			
Number of active transmitters		2827			
Propagation model		Free Space Loss			
Protection criteria		–177 dBm/10MHz according to [9]			
Antenna gain RAS		0dBi		[8], Mainbeam 70 dBi	
Simulated ODC power dBm/MHz	equivalent max ODC power level dBm/MHz e.i.r.p.	iRSS mean dBm/10MHz (StdDev)	Probability of interference	iRSS mean dBm/10MHz (StdDev)	Probability of interference
-95	Max -85 +10dB Wall attenuation	-170 (2dB)	100%	-178 (4dB)	22.9%
-100	Max -90 +10dB Wall attenuation	-175 (2dB)	79%	-183 (4dB)	6.7%

TableA2.4: Summary of Results of SEAMCAT simulation at 2.7 GHz (Free Space Loss)

Simulation 4: BMA, Interfering Link 4

Assumptions for the Interfering Link
- Simulated interfering power BMA -83.5 dBm/MHz e.i.r.p. (-55 minus 28.5 dB mitigation)
- Antenna gain ODC 0dBi
- ODC height 1.5m
- Path loss model Free space / Other propagation models to be also considered
- Distribution of interferer Uniform density
- Density of active transmitter 0.052/km^2
  - This number represents the average over Europe
- Activity factor 0.28%
- Probability of transmission 1
- Time (hours) 12
- Protection distance 0 km
- Numbers of active transmitters 1
- Simulation radius 30km

Assumptions for the Victim Link
- RAS height 50m
- RAS antenna gain **0dBi** and a hight directive antenna from [8](70dBi in the main beam)
- Antenna azimuth distribution 0 - 360°
- Antenna elevation distribution 0 - 90°
- Noise floor -167 dBm
- Reception bandwidth 10.000 kHz
- I/N -10 dB
  - the other interference criteria are not used and can be ignored
- Sensitivity -167 dBm
  - not used in the simulations

Frequency		2.7 GHz			
Density of transmitters		BMA, Rural 0.052/km^2			
Number of active transmitters		1			
Propagation model		Free Space Loss			
Protection criteria		–177 dBm/10MHz according to [9]			
Antenna gain RAS		0dBi		[8], Mainbeam 70 dBi	
Simulated ODC power dBm/MHz	equivalent max ODC power level dBm/MHz e.i.r.p.	iRSS mean dBm/10MHz (StdDev)	Probability of interference	iRSS mean dBm/10MHz (StdDev)	Probability of interference
-83.5	Max -55 +10dB less TRP	-203 (4dB)	0.1%	-212 (5dB)	0.02%

TableA2.5: Summary of Results of SEAMCAT simulation at 2.7 GHz (Free Space Loss)

Simulation 5: ODC Saw + Drill, Interfering Link 1+2

Frequency		2.7 GHz			
Propagation model		Free Space Loss			
Protection criteria		–177 dBm/10MHz according to [9]			
Antenna gain RAS		0dBi		[8], Mainbeam 70 dBi	
Simulated power dBm/MHz	equivalent max power level dBm/MHz e.i.r.p.	iRSS mean dBm/10MHz (StdDev)	Probability of interference	iRSS mean dBm/10MHz (StdDev)	Probability of interference
Saw -78.5 Drill -82.4	Saw -50 horizontal -70 Drill -50 + 10dB TRP +10% DC	-183 (4dB)	5.7%	-192 (4.7dB)	1.5%
Saw -83.5 Drill -87.4	Saw -55 horizontal -75 Drill -55 + 10dB TRP +10% DC	-188 (4dB)	1.7%	-197 (4.7dB)	0.6%

TableA2.6: Summary of Results of SEAMCAT simulation at 2.7 GHz (Free Space Loss)

Simulation 6: BMA+ ODC Saw+Drill, Interfering Link 1+2+4

Frequency		2.7 GHz			
Propagation model		Free Space Loss			
Protection criteria		–177 dBm/10MHz according to [9]			
Antenna gain RAS		0dBi		[8], Mainbeam 70 dBi	
Simulated power dBm/MHz	equivalent max power level dBm/MHz e.i.r.p.	iRSS mean dBm/10MHz (StdDev)	Probability of interference	iRSS mean dBm/10MHz (StdDev)	Probability of interference
Saw -78.5 Drill -82.4 BMA -83.5	Saw -50 horizontal -70 Drill -50 + 10dB TRP +10% DC BMA -55	-183 (3.7)	5.9%	-192 (4.7dB)	1.5%
Saw -83.5 Drill -87.4 BMA -83.5	Saw -55 horizontal -70 Drill -55 + 10dB TRP +10% DC BMA -55	-188 (3.7)	1.7%	-197 (4.7dB)	0.6%

TableA2.7: Summary of Results of SEAMCAT simulation at 2.7 GHz (Free Space Loss)

Simulation 7: generic+ BMA+ ODC Saw+Drill, Interfering Link 1+2+3+4

Frequency		2.7 GHz			
Propagation model		Free Space Loss			
Protection criteria		–177 dBm/10MHz according to [9]			
Antenna gain RAS		0dBi		[8], Mainbeam 70 dBi	
Simulated power dBm/MHz	equivalent max power level dBm/MHz e.i.r.p.	iRSS mean dBm/10MHz (StdDev)	Probability of interference	iRSS mean dBm/10MHz (StdDev)	Probability of interference
Saw -78.5 Drill -82.4 Generic -95 BMA -83.5	Saw -50 horizontal -70 Drill -50 + 10dB TRP +10% DC Generic -85 BMA -55	-170 (2dB)	100%	-178 (4dB)	25.6%
Saw -83.5 Drill -87.4 Generic -95 BMA -83.5	Saw -55 horizontal -75 Drill -55 + 10dB TRP +10% DC Generic -85 BMA -55	-170 (2dB)	100%	-178 (4dB)	24%

Table A2.8: Summary of Results of SEAMCAT simulation at 2.7 GHz (Free Space Loss)

Simulation 8: Complementary RAS simulations for Application B (drills)

DIY drills
Density of transmitters: Westerbork is situated in the province Drenthe in the Netherlands. The area which could affect Westerbork (a circle with diameter of 30 km) contains the cities Assen, Emmen and Hoogeveen. We took the population density of the whole province of Drenthe as representative for the area surrounding Westerbork. According to our information the density is 183 inhabitants / km2 . When using an estimate of 4 persons per household this translates to roughly 45 households per km2. We estimate 1 drill for every 4 households and the assumption that 10% of all drills will eventually be equipped with ODC, we arrive at an estimate of the density of 1 ODC drill/ km2.

- f=4.8GHz
- RAS antenna gain 0dBi
- Uniform Density ODC: 1 drill /km2
- Activity factor: 1 minute per 12 hour : 0.14% , 50% of this is in walls: 0.07%
- 10 active devices
- Probability 10%
- ODC antenna (see Figure A2.1): Max -55 dBm/MHz eirp beamwidth 30°, Min -66 dBm/MHz eirp for the rest of the sphere, TRP -65 dBm/MHz eirp

Professional drills
Approx 500 companies involved in construction and related work such as plumbing are active in Drenthe With an estimate of 3 drills per company and again a market penetration of 10% for ODC, 150 ODC drills in the total of Drenthe. Remark: 10% penetration for professional use is extremely low. Especially for professionals this is a must-have in a later phase which can be near in time due to higher replacement rates in this sector.

- f=4.8GHz
- RAS antenna gain 0dBi
- Uniform Density: 150/ 2670 km2= 0.06 drills /km2
- Activity: 45 min / 12 hour. = 6.25% ->50% in walls: 3.13%
- 10 active devices
- Probability 10%
- ODC antenna (see Figure A2.1): Max -55 dBm/MHz eirp beamwidth 30°, Min -66 dBm/MHz eirp for the rest of the sphere, TRP -65 dBm/MHz eirp

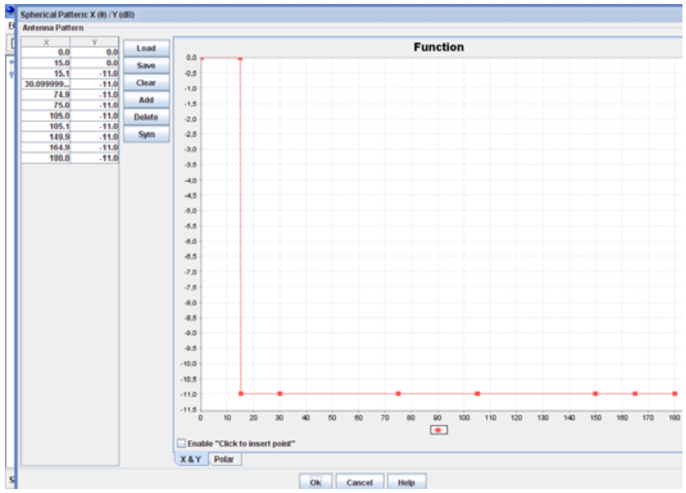

Figure A2.1

	Probability of interference (interfering power >-187 dBm/MHz)	
ODC Antenna pointing	DIY-Scenario	Professional Scenario
elevation 0-90°, azimuth 0-360°	0.8%	1.2%
Elevation used defined (see figure A2.2)	0.9%	2%
elevation 0°, azimuth 0-360°	1.6%	4.3%

Table A2.9

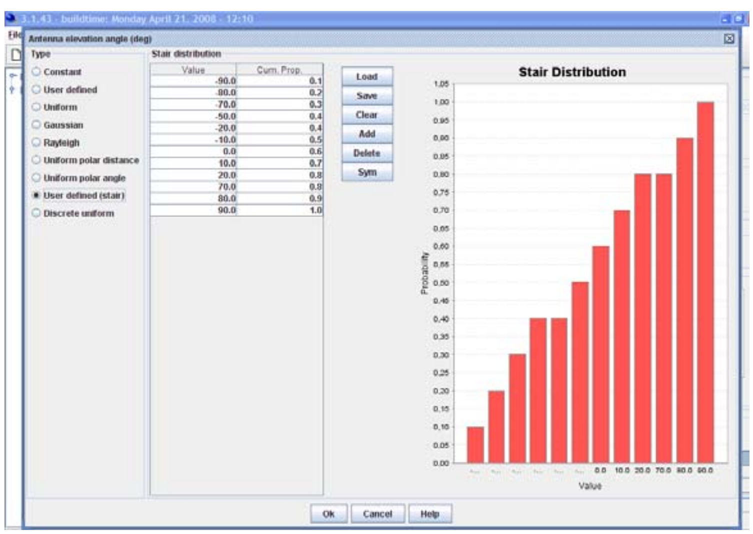

Figure A2.2

ANNEX 3: RAS STUDIES PROVIDED BY CRAF

1. BACKGROUND

The ECC Report 64 states:

> **"7.4.2 *Conclusions***
> *The calculated maximum tolerable e.i.r.p. per UWB device is several tens of dBs below the levels of the spectrum masks considered in this report. It is noted that this difference depends strongly on the aggregated impact of UWB devices emitting towards a RAS antenna. At this moment no accurate estimate of a realistic density of UWB devices is available.*
> *For any significant deployment of UWB devices, it is shown that significant separation distances must be needed for the protection of RAS stations. In any protection strategy, a major difficulty will be that outside the territory of a RAS station, the enforcement of such a condition is not practical.*
> *From these results, it can be concluded that there is currently significant incompatibility between UWB emissions and the RAS, for any practical scenario. Whether dedicated mitigation techniques capable of bridging the calculated gap of several orders of magnitude between expected and tolerable e.i.r.p. levels can be implemented is uncertain.*
> *As for the maximum allowable generic UWB PSD, it is proposed to use the limits derived from the sub-urban (1b) deployment scenario.*
> ……………
>
> ***8. OVERALL CONCLUSIONS OF THE REPORT***
> *The majority of the considered radiocommunications services require up to 20-30 dB more stringent Generic UWB PSD limits than defined in the FCC masks, indoor as well as outdoor. Only a few EESS applications are sufficiently protected by FCC mask, whereas some RAS bands require 50-80 dB more stringent limits"*
> *Similar to the BMA study, the proposed spectrum mask for UWB ODC devices does not fulfil the requirements of the ITU-R Footnote 5.340 for the bands 1400-1427 MHz and 2690-2700 MHZ allocated to RAS."*
>
> In the band 2.69-2.7, RR 5.340 states that "*all emissions are prohibited*", but this has not been reflected in the ODC proposed masks developed in the document.

2. INTERFERENCE ASSESSMENT FOR THE RADIO ASTRONOMY SERVICE

The compatibility analysis of ODC applications with Radio Astronomy Service depend mainly by the following input parameters:
- UWB emission levels
- density of devices
- activity factor
- separation distance between interferer and victim receiver.

The appropriate choice of these parameters will expose the actual protection levels for RA stations.

2.1. Single interferer scenario

In this section, CRAF would like to consider two practical interferer situations that are relevant to RAS-ODC analysis.

Case 1. For the given RA detrimental threshold levels and the given proposed ODC emission levels, the following minimum distances are required for protection of the radioastronomy station:

For **-65dBm/MHz**
- 11.7 Km, at 1.4 GHz
- 6.9 Km, at 1.6 GHz
- 4 Km, at 2.7 GHz
- 1.9 Km, at 4.9 GHz

For **-55dBm/MHz**
- 15.3 Km, at 2.7 GHz
- 3.2 Km, at 4.9 GHz

Case 2. For the given fixed separation distance of 500m and given RA detrimental thresholds levels, the required limits for the ODC emissions are:

- -90dBm/MHz at 1.4GHz
- -86 dBm/MHz at 1.6 GHz
- -81dBm/MHz, at 2.7 GHz
- -70dBm/MHz, at 4.9 GHz

Note: The wall attenuation of 7.4 dB is not applicable in the case of saw stop applications, as circular saws are often operated outside buildings.

The limits given here are therefore without inclusion of wall attenuation. We have used e.i.r.p. levels with –10dB allowance (conversion to TRP) for the gain of the TX antenna.

2.2. Aggregate interference scenario

Used parameters are 2.7 GHz, -65 dBm/MHz e.i.r.p. This includes –10dB conversion for radiation and an allowance of –25.5 dB for 0.28% activity.

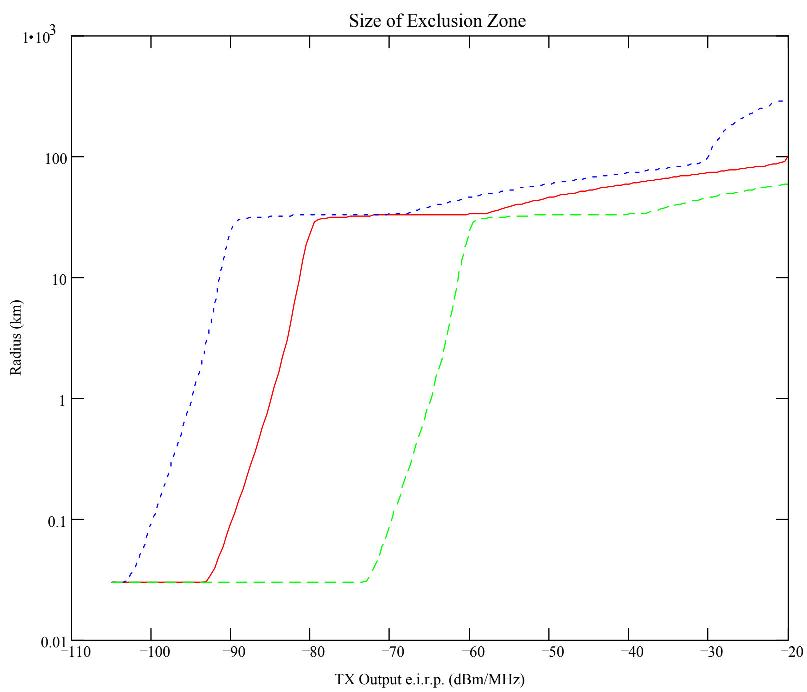

Figure A3.1: Size of exclusion zones for different average device densities

blue: $\rho_1 = 10 \cdot km^{-2}$ red: $\rho_0 = 1 \cdot km^{-2}$ green: $\rho_2 = 0.01 \cdot km^{-2}$

Radii of exclusion zones for different average device densities:

$\rho_1 = 10 \cdot km^{-2}$ => $d_{min}(L_{prot}, \rho_1) = 38.668 \cdot km$

$\rho_0 = 1 \cdot km^{-2}$ => $d_{min}(L_{prot}, \rho_0) = 33.22 \cdot km$

$\rho_2 = 0.01 \cdot km^{-2}$ => $d_{min}(L_{prot}, \rho_2) = 0.964 \cdot km$

These densities are effective averages over total daily activity, assuming a homogeneous spatial deployment.
It is easy to see how the emissions level scales with density of devices and activity factor resulting in a shift of an equivalent number of dBs. A SEAMCAT simulation using equivalent parameters should yield the same results.

3. REDUCTION OF RAS CHANNEL CAPACITY CAUSED BY INTERFERENCE

The Relative Channel Capacity is defined as the reciprocal of the factor by which observing time of an observation has to be increased in order to reach the same level of sensitivity as would have been obtained in the absence of interference.

It is assumed that the unwanted emission has statistics that approximate Gaussian noise within an integration period of 2000 seconds.

In the *Figure 24*, below, the Relative Channel Capacity is plotted as a function of interfering signal. The figure uses values of system noise, integration time and receiver bandwidth as defined in [9]. Many astronomical observations are made today with systems having significantly lower system noise and using longer integration times than assumed in [9].

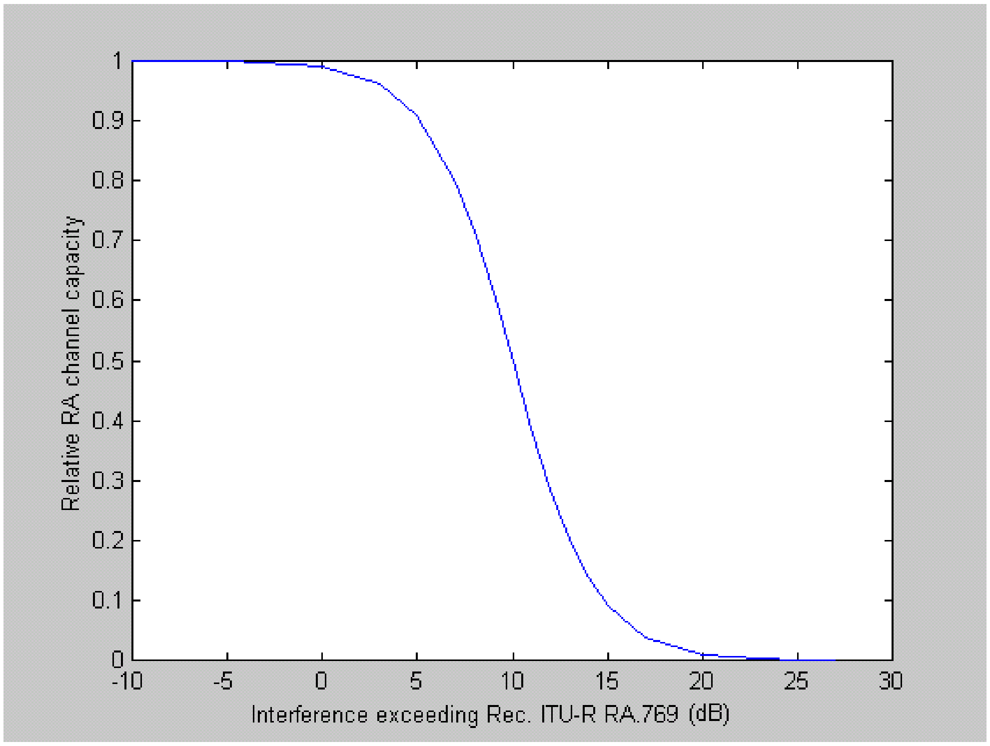

Figure A3.2: Reduction in RAS Channel capacity caused by interference

The 0 dB level then corresponds to the [9] threshold for detrimental interference to the RAS.

A 5 dB excess above [9] gives a reduction in capacity of 10%, meaning that 10% data is lost.

At a level of 10 dB above [9], the Channel Capacity is halved (50% data useless data).

The real situation is likely to be even worse than the above scenario. In practice, interference will never have the statistical characteristics assumed above, so when the level of received interference reaches a level of 10 dB above levels of [9], useful observations become impossible, with total loss of service.

4. CONSIDERATIONS ABOUT SEAMCAT SIMULATIONS

4.1 Input parameters to SEAMCAT

The results of SEAMCAT simulations (as well, the results of summation methodology) depend crucially of the input parameters, such as density of devices and activity factor. These parameters are provided as average values, without any specified error margin. A large deviation of these parameters is possible. It appears that these parameters have been obtained from marketing studies, which themselves may be considered extremely dubious and certainly can not be called rigorous.

Such large deviation from the proposed value of density is presented in the following example.

Example case: Effelsberg radiotelecope

In Effelsberg, Germany, is located the biggest radiotelescope in Europe with a diameter of the dish antenna of 100m. The neighbourhood includes Effelsberg, Lethert and Holzem villages, having about 150 households each. During low elevation observations there is even direct line of sight visibility between radiotelescope antenna and these villages, as they are located on higher ground than the telescope. Per village, there are about 6 households owning woodland and making fuel wood. About half of the households own saws for cutting wood and for DIY purposes. In this area, with only very few distractions and high prices of services by professional builders, DIY is a very popular pastime, especially on weekends (when the telescope is observing around the clock).

So, in this rural area, within 4 km radius there are at least 450*0.5/pi*(4km)^2= 4.5 devices per sq. km, which is far more than the estimates considered in ODC proposed scenario. Seasonal activity (after wood harvest in winter) makes it likely, that say one in ten of the land owners will use their saw continuously on a given Saturday, (of course with lunch breaks and so on) meaning an activity factor of 90% for say a ten hour period. The DIY enthusiasts will perhaps use their equipment less frequently, say once every three months, but also for an extended period, eight hours, with an activity factor of 33%, to build new floorboards, wall panelling etc.

By traditional means (binomial probability distribution) one can estimate the probability of interference from one or more of these sources and for a given length of time, resulting in an activity that clearly has a very high probability of interference.

Note: it will be practically impossible to control the deployment around radio telescope sites (within required protection zone) for mass-produced, unlicensed type of devices. CRAF sees a formal restriction printed on the instruction sheet (as the solution proposed in BMA case) only as a token gesture, but certainly not as an effective method of protecting the radio astronomical operations.

Statistically, the density of ODC devices is close bonded by the density of population. The biggest deviations from the proposed values occur for the countries having high density of population, like Netherlands, UK, Germany, Italy, etc (see Appendix 1).

Appendix 1 to Annex 3: Density of population per square Km in some European countries

Country	**Pop/km2**
Netherlands	392
Belgium	341
UK	246
Germany	232
Italy	193
Switzerland	176
Czech Republic	130
Poland	123
Portugal	114
France	110
Hungary	109
Austria	98
Turkey	93
Spain	89
Greece	84
Latvia	36
Sweden	20
Finland	15,6
Russia	8,4

Table: Density of population per square Km in some European countries *(source: http://en.wikipedia.org/wiki/List_of_countries_by_population_density)*

ANNEX 4: ADDITIONAL REMARKS ON THE MEASUREMENT OF UWB EMISSIONS

Current definition of TRP needs a measurement method based on an intensive spherical scan of the device. This method is very suitable for verification purposes by industry especially where additional information such as an antenna pattern measurement is desired.

For enforcement purposes this method is not practical. A simplified method measuring the e.i.r.p in the main beam and some chosen directions can be used to identify if a device is suspected not to be compliant. As a result a manufacturer could be forced to provide a detailed measurement report. This should be noted in a future HS.

In the case of ultra wideband devices it is in most cases impossible to distinguish between emissions generated by the transmitter and the clock and intentional transmissions.
To avoid the application of an unsuitable measurement method all emissions should be measured with a method reflecting a true e.i.r.p. measurement. Standard methods for EMC are not applicable in this case.

ANNEX 5: IMPACT ON THE UMTS MOBILE WITH RESPECT TO LBT

ODC devices are proposed to operate between 2.5 and 2.69 GHz with an e.i.r.p. limit of about –50 dBm/MHz. That is about 35 dB more than the limit in the ECC Decision for generic UWB application. Or with other words, the separation distance would be increased from 36 cm to about 15.6 m.

This limit is based on the BMA decision, the text below is extracted from the report on BMA:

Recognizing that BMA will be not such a mass market as UWB communication applications, that because of the usage scenarios a protection distance of more than 36 cm was considered as acceptable (e.g. 3 m) and the probability of interference is much smaller, but there is still a potential risk for UMTS, particularly in the extension band. In order to protect UMTS, therefore, a listen-before-talk (LBT) mitigation technique is indented to be included, the main requirements will be defined within the ECC Decision and the whole mechanism will be described in the harmonised ETSI standard.

The proposed estimation of the required threshold for LBT is based on the max PSD limit of –83 dBm/MHz e.i.r.p. resulting from studies ([6], based on 36cm separation distance) and leading to 15.6 m separation distance.

The specification of reduction of the antenna gain in the horizontal plan (Application A) or Total Radiated Power (Application B) will allow reducing the separation distances in the horizontal plan for Application A (separation distance of 2 m) and in the side lobes for Application B.

Identification of critical UMTS operational modes

There are 3 different interference scenarios to be considered for UWB interfering on 3G mobile systems being deployed in the UMTS extension band with respect to LBT where interference can be expected:

- A UE communicating with a BTS
- A UE in idle mode waiting to become paged (MTC).
- A UE in idle mode, which would like to establish a connection (MOC).

These are based on the assumption that an IMT-2000 FDD WCDMA UE will be operated in the UMTS extension band.

A UE communicating with a BTS

The required Tx power is controlled by the Node B. To avoid interference the algorithm always reduces power to the minimum value that is needed for transmission.

The dynamic range is from +24 dBm to –50 dBm or below, the UE Tx power can change rapidly. If a transmitter enters the power control headroom of about 3 dB below the maximum output power it can be expected to loose the connection completely because the UE is in the range of its sensitivity level. Thus, values in the range of more than +20 dBm are just necessary for high data transmissions within the Uplink if the mobile is working at its sensitivity level.

The required UE Tx power depends on BER and the data rate of the service, which could be between 12.2 kbps and 384kbps . Also cases like a data connection with 384 kbps on the downlink (DL) and only 12.2 kbps on the uplink (UL) have to be considered. In any case the UE receiver (DL) might be at the edge of performance and cannot live with any additional interference. But the UL runs on low load and low power.

Figure A5.1 visualises a **typical** UE Tx power behaviour during a 64 kbps video call at an indoor location (derived from the standard 3GPP TS 25.101 for the UMTS core band since it can be assumed that the standard extension for the Extension Band will look the same).

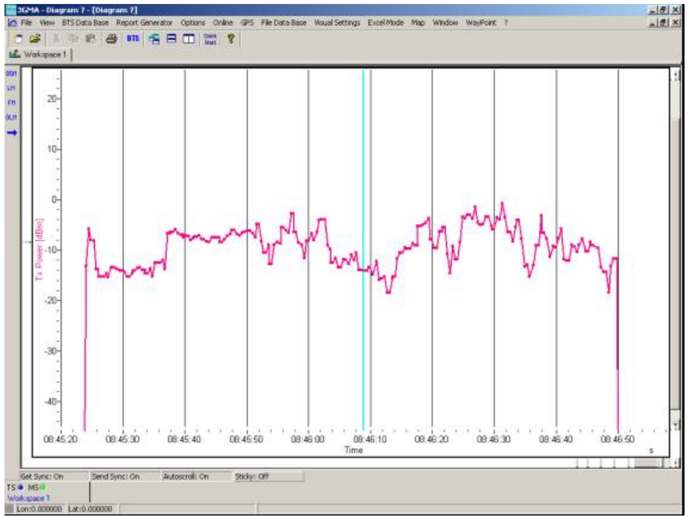

Figure A5.1

As can be seen, the Tx power was about 30 dB below max for typical situations, but the max power is used in some situations, mainly if the propagation loss between BS and MS is very high.

Tables A5.1 and A5.2 are clarifying the most critical situation for link levels at MS and BS.

In the link budget for DL and UL a log normal fading margin is considered with σ = 8 dB and 90% edge confidence which corresponds to 97% area coverage. In addition, a soft handover 3 dB gain is assumed (2 equal links).

Geometry for DL is assumed to be -3 dB which represents the cell edge. This configuration is an interference limited scenario and the sensitivity (Row w, Table A5.1) is 3.3 dB higher compared to the sensitivity for an isolated cell (Row s, Table A5.1) which represents a noise limited scenario.

		WCDMA 12.2 kbps Speech		WCDMA 384 kbps Data		Comments
		Value	Unit		Unit	
a	BS HPA max transmit power (Ior)	43.0	dBm	43.0	dBm	input
b	BS Maximum traffic channel fraction of total power (Ec/Ior)	-12.5	dB	-6.0	dB	input (depending on target BLER)
c	BS Maximum traffic channel transmit power	30.5	dBm	37.0	dBm	=a+b
d	BS losses (cable, connector, combiner)	-3.0	dB	-3.0	dB	input
e	BS Transmit Antenna gain	17.0	dBi	17.0	dBi	input
f	BS Maximum per traffic channel ERP	44.5	dBm	51.0	dBm	=c+d+e
g	BS max ERP	57.0	dBm	57.0	dBm	=a+d+e
h	Thermal noise density = kT	-174.0	dBm/Hz	-174.0	dBm/Hz	k=1.38*10^(-23), T = 290K
i	Information rate	40.9	dB-Hz	55.8	dB-Hz	= 10*log10(data rate)
j	Receiver noise figure	9.0	dB	9.0	dB	input
k	UE Receiver antenna gain	0.0	dBi	0.0	dBi	input

l	UE Losses (cable, connector, combiner)	0.0	dB	0.0	dB	input
m	UE Rx antenna gain – losses	0.0	dB	0.0	dB	=k+l
n	I^or/Ioc	-3.0	dB	-3.0	dB	input (Geometry at cell edge)
o	Soft-handover combining gain	3.0	dB	3.0	dB	input (2-way soft HO)
p	Required Eb/Nt	5.0	dB	1.5	dB	input (5% target BLER)
q1	Log-normal fading	-10.3	dB	-10.3	dB	input resulting from σ = 8 dB and 90% edge confidence
q2	Handover gain	4.1	dB	4.1	dB	input due to soft handover
q3	Diversity gain	0.0	dB	0.0	dB	input
q4	Building penetration losses	-20.0	dB	-20.0	dB	input
q5	Body loss	0.0	dB	0.0	dB	input
r	Propagation components	-26.2	dB	-26.2	dB	=q1+q2+q3+q4+q5
s	Required sensitivity, discounting interference and propagation component	-119.1	dBm	-107.7	dBm	=h+i+j+p
t	Max path loss, without other cells interference	163.6	dB	158.7	dB	=f-s+m
u	Received power from target cell	-106.6	dBm	-101.7	dBm	=g-t
v	Other cells interference power spectral density, Ioc	169.48	dBm/Hz	-164.5	dBm/Hz	=u-n-10*log10(3840000)
w	Sensitivity counting other cells interference	-117.8	dBm	-104.4	dBm	=10*log10(10^((h+j)/10)+ 10^(v/10) +i+p
x	Maximum path loss	136.1	dB	129.2	dB	=f-w+m+r

Table A5.1: Downlink Budget for WCDMA Downlink

Parameter Description		WCDMA 12.2 kbps Speech		Comments
		Value	Unit	
a	Thermal noise density = kT	-174.0	dBm/Hz	k=1.38*10^(-23), T = 290K
b	Information rate	40.9	dB-Hz	= 10*log10(12200)
c	Receiver noise figure	5.0	dB	Input
d	Load	50%		Input
e	Noise rise over thermal	-3	dB	=10*log10(1-d)
f	Required Eb/Nt	5	dB	input (1% target BLER)
g	Sensitivity	-120.1	dBm	=a+b+c-e+f
h	BS receiver antenna gain	17.0	dBi	Input
i	BS losses (cable, connector, combiner)	-3.0	dB	Input
j	BS Rx antenna gain – losses	14.0	dB	=h+i
k	UE Receiver antenna gain	0.0	dBi	Input
l	UE Losses (cable, connector, combiner)	0.0	dB	Input
m	UE Rx antenna gain – losses	0.0	dB	=k+l
n1	Log-normal fading	-10.3	dB	resulting from σ = 8 dB and 90% edge confidence
n2	Handover gain	4.1	dB	due to soft handover
n3	Diversity gain	0.0	dB	included in f
n4	Building penetration losses	-20.0	dB	Input
n5	Body loss	0.0	dB	Input
n6	Propagation components	-26.2	dB	=n1+n2+n3+n4+n5
o	Path loss	129.2	dB	input from DL
p	Required UE EIRP	21.3	dBm	=o+g-j-n6
q	Required UE transmit power	21.3	dBm	=p-m

TableA5.2: Uplink Budget for WCDMA Uplink

Consequences for the detection of UMTS mobiles at the edge of the cell with LBT:

- For the worst case channel of 12.2kbps the power of the MS to be taken into account for deriving the threshold level for LBT is 21dBm/3.84MHz.

A UE in idle mode waiting to become paged (MTC)

The LBT proposed for this band may be inefficient on mobiles in idle mode since a static IMT mobile in idle mode may transmit signalization only once every hour, in accordance with the procedures described in the document 3 GPP TS 24.008.

Noting that an emission level of -50 dBm/MHz is compatible with a distance of 15m in a worst case scenario (maximum antenna gain directions), this means that a mobile station working at its sensitivity level (e.g. at the cell edge or in deep indoor scenarios) located at a distance less than 15m from ODC may loose incoming calls, SMS, etc. and may suffer from interference in this band.

If interference occurs for a longer period of time that might cause the UE to reselect to GSM where it is not capable to perform higher data rate multimedia services. This is again a QoS restriction for the affected customers.

A UE in idle mode, which would like to establish a connection (MOC).

Before the link establishment between BS and UE, both parties have to know what kind of service the uplink and downlink will be able to provide. The UE is not just receiving but exchanging information with the BS about the QoS of Up- and

Downlink and the UE is expected to be active receiving any paging information and can be detected by the LBT mechanism.

A MOC would cause the UE to send a number of short Access Bursts with a Tx power increasing by up to 20 dB until acknowledgement from NodeB is received. If not receiving an answer due to the interference from UWB the call establishment will fail.
To avoid such malfunction it has to be required that the LBT algorithm detects the access bursts and switches off the ODC device immediately. That requires the ODC device to listen constantly which will be ensured by the LBT mechanism.

ANNEX 6: LIST OF REFERENCES

[1] ECC/DEC/(06)08: ECC Decision of 1 December 2006 on the conditions for use of the radio spectrum by Ground- and Wall- Probing Radar (GPR/WPR) imaging systems
[2] ECC/DEC/(07)01: ECC Decision of 30 March 2007 on Building Material Analysis (BMA) devices using UWB technology
[3] ECC/DEC/(06)04: ECC Decision of 24 March 2006 amended 6 July 2007 at Constanta on the Harmonized conditions for devices using UWB technology in bands below 10.6 GHz
[4] ECC/DEC/(06)12: ECC Decision of 1 December 2006 on the harmonised conditions for devices using Ultra-Wideband (UWB) technology with Low Duty Cycle (LDC) in the frequency band 3.4-4.8 GHz
[5] ETSI TR 102 495-2: Technical characteristics for SRD equipment using Ultra Wide Band Sensor technology (UWB), Part 2: Object Discrimination and Characterization applications (ODC) for power tool devices operating in the frequency band 2.2 GHz to 8.5 GHz
[6] ECC Report 64: The protection requirements of radiocommunications systems below 10.6 GHz from generic UWB applications.
[7] Recommendation ITU-R RA.1513: Levels of data loss to radio astronomy observations and percentage-of-time criteria resulting from degradation by interference for frequency bands allocated to the radio astronomy on a primary basis
[8] Recommendation ITU-R SA.509: Space research earth station and radio astronomy reference antenna radiation pattern for use in interference calculations, including coordination procedures
[9] Recommendation ITU-R RA.769: Protection criteria used for radio astronomical measurements
[10] Recommendation ITU-R SM.1757: Impact of devices using ultra-wideband technology on systems operating within radiocommunication services; integral methodology in Annex 2, Chapter 2.3.1;
[11] Holzberufsgenossenschaft Deutschland; Employers liability insurance association Germany, Munich
[12] Source: "Statistik - Arbeitsunfälle, Prävention", Deutsche Gesetzliche Unfallversicherung (DGUV)
[13] CEPT Report 010 and TG3#21_05R1; CEPT Report to EC on specific UWB applications
[14] ECC Report 94: Technical requirements for UWB LDC devices to ensure the protection of FWA systems
[15] ECC Report 120: Technical requirements for UWB DAA (Detect And Avoid) devices to ensure the protection of radiolocation in the bands 3.1-3.4 GHz and 8.5-9 GHz and BWA terminals in the band 3.4-4.2 GHz
[16] Recommendation ITU-R M.1464 : Characteristics of radiolocation radars, and characteristics and protection criteria for sharing studies for aeronautical radionavigation and meteorological radars in the radiodetermination service operating in the frequency band 2 700-2 900 MHz