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

COMPATIBILITY STUDY FOR GENERIC LIMITS FOR THE EMISSION LEVELS OF INDUCTIVE SRDs BELOW 30 MHz

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EXECUTIVE SUMMARY

Inductive systems are increasingly being used for Very Short Range Device (VSRD) applications. The operating ranges for these applications are from one tenth to a few metres with frequencies in the range of a few kHz up to 30 MHz.

Today these applications are not fully covered by ECC/Rec. 70-03 [1] for Short Range Devices (SRD), therefore, ECC/SRDMG has proposed to a establish a new generic limit of –5 dBµA/m @ 10 m measured in a 10 kHz bandwidth to fulfil these market needs.

Some CEPT administrations raised objections against a generic limit for a magnetic field strength of -5 dBµA/m @ 10 m for inductive SRDs over the whole frequency range from 148.5 kHz to 30 MHz. To investigate and respond to these objections, this compatibility study has been conducted.

It is noted that the bands below 148.5 kHz are already covered by the ERC Recommendation 70-03.

This report uses 2 methods to evaluate the interference potential:

1. The methodology used in ERC Report 69 [2] has been used to determine the interference level to enable comparison with the received environment noise. The protection distances are calculated for a single interferer for different receiver sensitivity degradations between 3dB and 0.5dB.
2. To calculate the cumulative interference probability SEAMCAT simulations are used for fixed services and broadcast services in residential areas for mass volume products. The density of the devices and activity factor of the devices is taken into account. However, it should be noted that the skywave cumulative interference has not been taken into account. The used built-in propagation models used in the SEAMCAT simulation are extrapolated from those used for frequencies above 30 MHz. The free space propagation model may be subject to validation.

The proposal from the SRD/MG has been considered in this report and compatibility studies were conducted to assess its impact.

Based on the results of these studies the following generic limit is proposed in the frequency range 148.5 kHz – 30 MHz:

- a maximum field strength of -15 dBµA/m @ 10m in a bandwidth of 10 kHz allowing
- a total field strength up to -5 dBµA/m @ 10m for systems with an operating bandwidth larger than 10 kHz whilst keeping the density limit above.

However, it should be noted that this generic limit may not provide adequate protection to some of existing services.

In particular, in the band 3 MHz - 30 MHz, this generic limit does not guarantee adequate protection to the broadcast services and additional measures such as more stringent limits (e.g. -25 dBµA/m) may be needed on a national basis.

Additional measures may also be needed in military bands on a national basis.

Such measures may be implemented by including specific limits in Appendix 3 of Rec. 70-03 [1].

For the RAS case, since there are a limited number of radio astronomy sites operating in the 13 MHz and 25 MHz bands any site specific scenario can be handled by the Administrations concerned.

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1 INTRODUCTION

Inductive systems are one of the technologies used by SRDs. Inductive systems are used for an increasing number of applications. The ranges for these applications are from one tenth to a few metres with frequencies in the range of a few kHz up to 30 MHz.

Currently the applications for inductive SRDs are not fully covered by ERC Rec. 70-03 [1] for Short Range Devices (SRD), therefore, ECC/SRDMG has proposed to a establish a new generic limit of –5 dBµA/m @ 10 m measured in a 10 kHz bandwidth to fulfil the existing and future market needs.

It should be noted that some CEPT administrations have raised concerns against a general generic limit for a magnetic field strength of –5 dBµA/m @ 10m for inductive SRDs since a single SRD application devices will not require to use the whole 135 kHz - 30 MHz band. To understand the reason for these objections, this compatibility study has been conducted in order to define a generic limit with preferably one or a few parameter sets. This report considered the complexity of the protection requirements as well as balancing it with the needs of the existing and future applications. It is very difficult if not impossible that a single field strength limit will take care of the needs of a huge number of applications and to be valid over more than three frequency decades in view of the need of protection of primary services.

It is noted that the bands below 148.5 kHz are already covered by the ERC Recommendation 70-03 [1].

The existing compatibility reports and studies in the inductive field for particular applications are outside the scope and conclusions of this report.

2 CHARACTERISTICS OF INDUCTIVE SRDS

The Market and Application Descriptions for inductive SRDs can be found in the informative Annex 2.

In the frequency range 148.5 kHz to 30 MHz, the SRDs operating bandwidth is defined at the level of 15 dB below the maximum level of the emission.

ETSI ERM-RM has approved a System Reference Document (SRDoc TR 102 378 [3]) for inductive RFIDs operating in the frequency range from 400 kHz to 600 kHz. The SRDoc describes a generic application which has been used in the industry in a number of countries and is an essential part in the chain of industrial manufacturing logistics and production control of manufacturing and distribution goods. For instance, in the automotive car assembly and the semiconductor industry, the system provides in addition to identification and data handling also location and object positioning information for tracing purposes. This application is not covered by the limit defined in this report however calculations conducted in section 3 have shown that the limit given in the TR will not cause harmful interference to existing services in the 400 – 600 kHz frequency range.

EN 300 330 [4] provides characteristics of inductive loop systems operating in the frequency range 9 kHz to 30 MHz systems. It is understood that the part of SRD spectrum falling below 150 kHz (i.e. from 148.5 – 150 kHz), if any, will be measured using the same measurement bandwidth as the SRD spectrum falling above 150 kHz since the center frequency falls above 150 kHz.

3 PROTECTION REQUIREMENTS FOR PRIMARY AND SECONDARY SERVICES

Various types of primary and secondary services are defined in the ITU **R**adio **R**egulations. The services are grouped into generic types having similar protection needs. In Chapter 3.2 the protection distances are calculated based on the propagation model given in ERC Report 69 [2]. In Annex 5 the cumulative effects are calculated based on SEAMCAT simulations for mass volume services against fixed services and broadcast.

3.1 Interference criteria for victim receivers

Degradations are given in Table 1 and the permissible interference levels are given in Table 2 depending on the receiving bandwidth.

The protection criteria for the Radio Astronomy Service are given in Recommendation ITU-R RA.769 [5]. According to Recommendation ITU-R RA.769 [5] the maximum permissible interference levels equal 10% of the system noise and the assumption that the interference is received through the antenna sidelobes, i.e. for the radio telescope an antenna gain of 0 dBi is used.

3.2 Calculation of interference protection distances

The following steps were used for calculation of protection distances:

1) The input data for existing radio services was taken from ECC Report 1, Table 3 regarding the sub-bands 135 – 148.5 kHz, 4.78 – 8.78 MHz and 11.56 – 15.56 MHz.

2) The field strength limits –5 dBµA@10m , -10dBµA@10m , -15 dBµA@10m, -20dBµA@10m and -25dBµA@10m in 10 kHz were chosen to evaluate the protection distances in Table 2.

3) The calculations for the propagation models are based on the methods given in ERC Report 69 [2]. In case of Aeronautical Mobile, the free space model is used (victim not at ground level). For Fixed and Broadcasting services and all other services the model developed in ERC Report 69 [2] to calculate the field strength was considered as an applicable approach.

4) As it is known today, the main area of deployment for inductive services which could comply with proposed generic field strength limit are urban and predominantly inside buildings and are most of the time very close to the body. Additionally, orientation of the inductive antenna has influence on any probability of interference. Therefore, a conservative mitigation factor of 5 dB was used for all calculations.

5) The calculations are based on different levels of degradation: 3dB, 2 dB, 1 dB and 0.5 dB. According to Annex 3, the interference levels (Permissible Interference or Environment noise) have to be corrected by the following factors:

Degradation level (dB)	Correction (dB)
3	0
2	-2.3
1	-5.9
0.5	-9.1

Table 1: Degradation level and corresponding correction factor

The results of these calculations were done with the program CILIR[1]. The results for a 3dB degradation level are shown in the Table 2. Results for other degradation levels are provided in Annex 4.

The results given in Table 2 should be interpreted noting that they were calculated assuming that the maximum field strength of the SRD system will be falling into 10 kHz.

For SRD systems operating with a maximum field strength of -5dBµA/m and using an operating bandwidth:

- of 100 kHz, the values for the separation distances given in column "–15 dBµA/m" should be considered in Table 2.
- of 500kHz, values between those given in the column "–20 dBµA/m" and those given in the column "–25 dBµA/m" from Table 2 (exact value would be –22 dBµA/m) should be considered for the separation distance;
- of 1MHz, the values for the separation distances given in the column "–25 dBµA/m" should be considered in Table 2.

[1] CILIR software is available on the ERO web site at the same location that the ERC Report 69 [2].

Table 2: Calculated protection distances for –5; -10; -15; -20; -25 dBμA/m limit for 3 dB degradation level

Services *	**Frequency Range**	**Victim receiver BW**	**E_1kW@ 1km Land**	**Permissib. Interf.**	**Environment Noise**		**Protection distance in metres for limit (dBμA/m@10m) in 10 kHz**				
	MHz	kHz	dBμV/m	dBμV/m	dBμV/m	% avail.	**-5**	**-10**	**-15**	**-20**	**-25**
LF range	**0.030 – 0.300**										
Maritime mobile											
Fixed											
Amateur											
Aeronautical Radionavigation	0.225 - 0.495	2.7	147	21.9			17	14	12	10	8
Analogue/digital broadcasting	0.1485 – 0.2835	9	147	26			18	15	12	10	8
MF range	**0.300 – 3**										
Aeronautical Radionavigation	0.505 - 0.5625	2.7	134	21.9			17	14	12	10	8
Analogue/digital broadcasting	0.527 – 1.61	10	120	20			23	19	16	13	11
Amateur	1.81-1.88	2.7	110	0	-25	**	1101	643	362	203	114
HF range	**3 – 30.0**										
Fixed (point to p.)	4.75 – 4.995	2.7	97	0			277	181	102	57	32
	5.005 – 5.06	2.7	97	0			287	184	104	58	35
	6.765 – 7.00	2.7	94	0			299	224	168	95	53
	7.30 – 8.195	2.7	92	0			280	210	157	104	59
	11.40 – 11.60	2.7	90	0			324	243	182	137	99
	12.10 – 12.23	2.7	88	0			288	216	162	121	91
	13.36 – 13.60	2.7	87	0			270	202	151	114	85
	14.35 –14.99	2.7	86	0			254	190	143	107	80
	15.80 – 16.36	2.7	85	0			239	179	134	101	76
	18.03 – 18.052	2.7	84	-3			267	200	150	113	84
	19.80 – 19.99	2.7	84	-3			266	199	150	112	84
	22.855 – 23.0	2.7	82	-8			315	236	177	133	100
	26.175 – 27.50	2.7	81	-8			297	223	167	125	94
Maritime mobile	6.20 – 6.525	2.7	94		5	80	211	149	84	47	27
	8.10 – 8.15	2.7	92		3	80	252	189	142	84	48
	12.23 – 13.20	2.7	88		-2	80	323	242	181	136	102
	16.36 – 17.41	2.7	85		-4	80	300	225	169	127	95
	18.78 – 18.90	2.7	84		-8	80	355	266	200	150	112
	25.07 – 25.21	2.7	81		-14	(gn)	419	315	236	177	133
Aeronautical mob. (OR)	3.025 - 3.155	2.7	free sp	6			78	44	24	18	14
	3.800 - 3.950	2.7	free sp	6			114	64	36	19	14
	4.70 – 4.85	2.7	free sp	6			159	89	50	28	15
	5.45 – 5.48	2.7	free sp	6			198	111	62	35	16
	5.68 - 5.73	2.7	free sp	6			210	118	66	37	21
	6.685 - 6.765	2.7	free sp	6			262	147	83	47	26
	8.965 - 9.040	2.7	free sp	6			381	214	121	68	38
	11.175 - 11.275	2.7	free sp	6			495	279	157	88	50
	13.20 - 13.26	2.7	free sp	6			488	275	154	87	49
	15.01 - 15.1	2.7	free sp	1			858	482	271	152	86
	17.97 - 18.03	2.7	free sp	1			846	476	268	150	85
	23.2 - 23.35	2.7	free sp	1			835	469	264	148	83
Aeronautical mob (R)	2.850 -3.025	2.7	free sp		-6	50	280	158	89	50	26
	3.400 - 3.500	2.7	free sp.		-5	50	337	190	107	60	34
	4.650 - 4.700	2.7	free sp.		-2	50	393	221	124	70	39
	5.480 - 5.680	2.7	free sp.		-1	50	446	251	141	79	45
	6.525 - 6.685	2.7	free sp.	6			254	143	80	45	25
	8.815 - 8.965	2.7	free sp.		-3	50	1053	592	333	187	105
	10.005 - 10.100	2.7	free sp.		+1	80	774	435	245	138	77
	11.275 - 11.400	2.7	free sp.		0	80	994	559	314	177	99
	13.260 - 13.360	2.7	free sp.	6			488	274	154	87	49
	17.900 - 17.979	2.7	free sp.	1			846	476	268	150	85
	21.924 - 22.000	2.7	free sp.	-4			1488	837	471	265	149
Land mobile	4.75 – 4.85	2.7	97		6	80	162	91	51	29	15
	5.45 – 5.48	2.7	96		6	80	198	111	62	35	16
	5.73 – 5.90	2.7	95		6	80	200	119	67	38	21
	7.35 – 8.10	2.7	94		4	80	251	188	118	67	37

Analogue Broadcasting	3.95 – 4.0	10	99	10			150	85	48	21	16
	5.95 –6.20	10	95	10			233	162	91	51	27
	7.10 – 7.30	10	93	10			231	173	113	64	36
	11.60 – 12.10	10	89	10			238	179	134	101	60
	13.57 – 13.87	10	87	10			211	158	118	89	59
	15.10 –15.80	10	86	10			198	148	111	83	59
	18.90 – 19.02	10	84	10			175	131	98	74	55
	21.45 – 21.85	10	83	10			165	123	93	69	52
	25.67 – 26.10	10	81	10			146	110	82	62	46
Digital Broadcasting	3.95 – 4.0	10	99	0***			377	267	150	85	48
	5.95 –6.20	10	95	0			414	310	232	162	91
	7.10 – 7.30	10	93	0			411	308	231	173	113
	11.60 – 12.10	10	89	0			424	318	238	179	134
	13.57 – 13.87	10	87	0			374	281	211	158	118
	15.10 –15.80	10	86	0			352	264	198	148	111
	18.90 – 19.02	10	84	0			311	233	175	131	98
	21.45 – 21.85	10	83	0			293	219	165	123	93
	25.67 – 26.10	10	81	0			260	195	146	110	82
Standard freq.	4.995 – 5.005	2.7	97		6	80	174	98	55	31	15
	14.99 – 15.01	2.7	86		-3	80	301	226	170	127	95
	19.99 – 20.005	2.7	84		-12	80	447	335	251	188	141
	24.99 – 25.005	2.7	81		-13	80	396	280	210	158	125
Amateur	3.5 - 3.8	2.7	100	-25	-25	**	1127	845	634	475	356
	7.00 – 7.20	2.7	94		-15	20	725	543	407	306	229
	10.1 – 10.15	2.7	90	-9	-9	20	513	385	288	216	162
	14.00 – 14.35	2.7	86		-13	20	537	403	302	227	170
	18.068 – 18.168	2.7	84		-13	(gn)	474	356	267	200	150
	21 – 21.450	2.7	83	-13	-13	(gn)	446	334	251	188	141
	24.89 – 24.99	2.7	81		-13	(gn)	396	297	223	167	125
	28.00 – 29.70	2.7	80		-14	(gn)	395	296	222	167	125
Radio Astronomy	13.36 – 13.41	50	87	-55			13429	9967	7474	5605	4203
	25.55 –25.67	120	81	-53			10221	7665	5748	4310	3232

* The listed services are only a part of all existing.
**Below quiet rural level, above 20%. Recent measurements have shown that the given noise level is realistic.
*** Value derived from ITU-R BS.1615

The minimum protection distances shown in Table 2 are illustrated graphically in Figure 2 below.

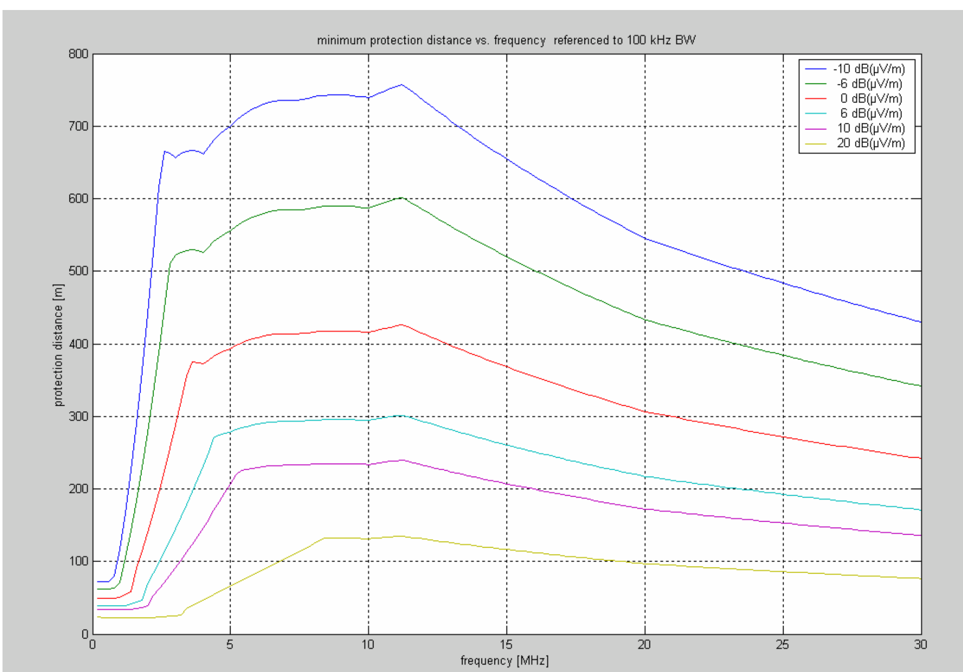


Figure 2: minimum protection distance vs. frequency and permitted interference level – 100 kHz interferer bandwidth

The Victim is a 10 kHz system. The interferer is operating at –5 dBµA/m in a 100 kHz bandwidth corresponding to –15 dBµA/m in a 10 kHz.

The calculations given in Table 2 cover the case of single source of interference. Calculations covering the case of multiple sources of interference are provided in Annex 5.

3.2.1 Comments to the protection distances calculations based on a 3dB degradation level

For 2dB, 1B and 0.5dB degradation level the protection distances are provided in Annex 4.

It should be noted that the numbers provided in this section are applicable only to SRDs systems operating in 10 kHz or less. For SRDs systems operating with larger bandwidth the correction factor described in the sections before Table 2 should be considered (see also Figure 2).

3.2.1.1 Aeronautical Mobile Service

This service includes (see the Radio Regulations (**RR**) [6]):

a) Aeronautical Mobile Off-Route (OR) Service: An aeronautical mobile service intended for communications including those relating to flight coordination, primarily outside national or international civil air routes (**RR No. 1.34**) ;

b) Aeronautical Mobile (R) Service: An aeronautical mobile service used for communications relating to the safety and regularity of flight, primarily along national or international civil air routes (**RR No. 1.33)**. These are used both along national/international civil air routes for long distance communications and for aeronautical operational control to allow operating agencies to meet the obligations prescribed in ICAO Annex 6 Part I.

3.2.1.2 Maritime Mobile Service

Maritime Mobile Service is a mobile service between coast stations and ship stations, between ship stations, or between associated on-board communication stations; survival craft stations and emergency position- indicating radiobeacon stations may also participate in this service (**RR No. 1.28**).

In the frequency range 12 - 20 MHz the protection distances for GMDSS services are:

- for field strength -5 dBµA/m@10 m: 300 - 355 m
- for field strength -10 dBµA/m@10 m: 225 - 266m
- for field strength -15 dBµA/m@10 m: 169 - 200 m
- for field strength -20 dBµA/m@10 m: 127 - 150 m
- for field strength -25 dBµA/m@10 m: 95 - 112 m.

The GMDSS is a complex system. This distance will automatically protect the vast majority of system components such as satellite and ship based stations. The main issue for interference to GMDSS is related to fixed coastal stations working in HF band. The frequencies 2182 kHz, 3023 kHz, 4125 kHz and 5680 kHz are used for primary search and rescue on the ground or near the cost. It should be noted that these frequencies are also used for the aeronautical mobile emergency service. These specific frequencies must be protected.

The total amount of costal stations in Europe is very small. The stations are mainly located in isolated rural areas far away from man made sources of the interference. As today, the coastal stations in the four European countries, which operate without protection from low power VSRD, have not filed any interference complains from other services.

3.2.1.3 Amateur Radio Services

Article **No. 1.56** of the ITU Radio Regulations (**RR** [6]) defines the amateur radio service as: "A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest". The protection distances from VSRD to Amateur services range from 24 - 728 for the frequency range 0.135 - 30.0 MHz and a maximum field strength range from -5dBµA/m@10m to -25 dBµA/m@10m in 10 kHz bandwidth.

In the frequency band 12 - 20 MHz the protection distance depends of the field strength and the corresponding protection distance was calculated as:

- for field strength -5 dBµA/m@10 m: 474 - 537 m
- for field strength -10 dBµA/m@10 m: 356 - 403 m
- for field strength -15 dBµA/m@10 m: 267 - 302 m
- for field strength -20 dBµA/m@10 m: 200 - 227 m
- for field strength -25 dBµA/m@10 m: 150 - 170 m.

It is to be noted that the environment noise level for the protection distance calculation is taken very low to either the galactic noise level or to a 20% case low environment noise level.

3.2.1.4 Aeronautical Radionavigation Service

Aeronautical Radionavigation Service is defined as *radionavigation service* intended for the benefit and for the safe operation of aircraft (**RR No. 1.46**). The frequency bands 225 - 526.5 kHz are allocated for usage by ground-based Non-Directional Beacons (NDB) which are used in conjunction with Automatic Direction Finding (ADF) receivers mounted in the aircraft. The NDBs are monitored by ground-based ADF receivers located in the far-field.

Protection is required between 255 kHz and 526.5 kHz.

3.2.1.5 Radio Astronomy Service

The Radio Astronomy Service is defined as a service based on the reception of radio waves of the cosmic origin for the purposes of astronomy (**RR No. 1.13**).

RR No 5.149 states that for the bands 13.36 - 13.41 MHz, 25.55 - 25.67 MHz, "administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. For example, emissions from spaceborne or airborne stations can be particularly serious sources of interference the radio astronomy service".

The band 13.36-13.41 MHz is shared with the fixed service, while the band 25.55-25.67 MHz is exclusively allocated to the radio astronomy service.

Currently Radio Astronomy stations in four CEPT countries (i.e. Austria, France, the Netherlands and Ukraine) use frequencies for continuum observations below 30 MHz. This frequency range is also of great interest for future radio astronomy usage because of the development of a new generation of radio telescopes such as the Low Frequency Array Network, LOFAR. LOFAR is currently already operating at small scale and will become fully operational in the frequency range between 10 – 240 MHz and its first operations with the complete system are planned to start in 2007 (see http://www.lofar.org [7] for further details).

The LOFAR project is unique in that it provides not only a breakthrough in higher resolution and sensitivities but also features unique RFI mitigation capabilities. It is among the first radio telescopes in which RFI mitigation forms an integral part of the system design.

Based on the protection criteria for radio astronomy continuum observations given in Table 1 of Recommendation ITU-R RA.769 [5], the separation distances necessary to protect a radio astronomy station from a single transmitting device are for the 13 MHz and 25 MHz frequency bands as follows:

- for field strength -5 dBµA/m@10 m: 13429 m and 10221 m, respectively
- for field strength -10 dBµA/m@10 m: 9967 m and 7665 m, respectively
- for field strength -15 dBµA/m@10 m: 7474 m and 5748 m, respectively
- for field strength -20 dBµA/m@10 m: 5605 m and 4310 m, respectively
- for field strength -25 dBµA/m@10 m: 4203 m and 3232 m, respectively.

It should be noted that the calculated separation distances may increase when an aggregate of transmitting devices is taken into account.

It is also to be noted that ITU-R Recommendation RA.769-2 [5] in section 2.3 states that interferometers and large arrays have inherently better immunity than single dish radio telescopes.

CEPT had previously studied the potential interference of inductive RFIDs operating at 13.56 MHz (Carrier) with modulation emissions into the 13.36–13.41 MHz range at the Nançay Observatory (France) which use a large array of 144 individual antennas distributed over 10.000 square meters. Results showed that e.g. at a distance of 1.5 km no interference was recorded. Tests included also measurements of the RFID carrier operating at 42 dBµA/m equivalent to approx. 10 mW e.r.p. at the same distance of 1.5 km. This carrier level was also not detectable and below the noise level of the instrument. (See ERC/REP 074 [8]). The Nançay observatory uses the frequency band 13.553-13.567 MHz for planetary research, i.e. Jovian emission.

Since there are a limited number of radio astronomy sites operating in the 13 MHz and 25 MHz bands any site specific scenario can be handled by the Administrations concerned.

3.2.1.6 Broadcast service

Currently, there is an increasing requirement worldwide for suitable means of broadcasting high quality monophonic or stereophonic sound to mobile, portable and fixed receivers. The frequency bands below 30 MHz (LF, MF and HF bands) are very attractive because of their favourable propagation conditions particularly for wide area coverage requirements. The amplitude modulated (AM) sound broadcast system, which has been operating in these bands for many years will soon share them with the new digital sound broadcast system called DRM (Digital Radio Mondiale). At midterm the DRM will replace the existing AM system in the LF, MF and HF bands. DRM will offer the potential for new and improved services to listeners. Listeners will also benefit from the existing single worldwide standard for the transmission of digital signals

3.2.1.6.1 System description

Two types of systems are used to ensure sound broadcast in the bands allocated to the broadcast service below 30 MHz: analogue broadcasting (AM) and digital broadcasting (DRM: Digital Radio Mondiale). DRM is the world's only non-proprietary, universally standardized digital system for short wave, medium wave and long wave transmission that can use the frequencies allocated to the broadcast service across the globe. The protection criteria of these two broadcast systems are quite different due to the difference in their minimum usable field strengths (40 dBµV/m for AM and 20 to 30 dBµV/m for DRM for the HF frequency band).

The commercial LF/MF/HF receivers are designed to operate in indoor and outdoor environments. They are quite small (portable) and are equipped with telescopic antennas measuring about 1 m. A wire antenna provided with the receiver can also be fixed on the telescopic antenna to match better to LF/MF/HF reception (extension possible up to 5.5m). In any case, in indoor use, the antenna is fixed to the receiver (see Annex 8).

3.2.1.6.2 Interference scenarios

In the presence of SRD, two interference scenarios are possible:

- Both the victim broadcast receiver and the interfering SRD are operating in indoor environment (in the same room or flat for example). In this case the interfering SRD could be very close (few metres) to the victim broadcast receiver.

- The victim broadcast receiver antenna is situated in outdoor (or neighbour indoor) environment, whereas the interfering SRD transmitter is operating in indoor environment, and vice-versa. In this case the interfering SRD could be at a distance of 10 m (urban areas) to 30 m (rural areas) from the victim broadcast receiver

3.2.1.6.3 Analogue broadcasting

For analogue broadcasting service, the protection distances from SRD to the victim broadcast receiver range from 8 to 238 m for the LF,MF and HF bands and a field strength in 10 kHz varying from -5dBµA/m@10m to -25 dBµA/m@10m . In the frequency range 3.95 – 26.10 MHz (HF band), depending on SRD transmitter power and the considered field strength limit, the calculated protection distances are:

- for field strength -5 dBµA/m@10m: 146 - 238 m
- for field strength -10 dBµA/m@10 m: 85 - 179 m
- for field strength -15 dBµA/m@10 m: 48 - 134 m
- for field strength - 20 dBµA/m@10 m: 21 - 101 m
- for field strength -25 dBµA/m@10 m: 16 - 60 m

These distances are very large; consequently, they cannot guaranty the protection of analogue broadcast service operating below 30 MHz. An interfering field strength of -30 dBµA/m@10 m, which ensures a maximum protection distance of 34 m from SRD to the victim broadcast receiver, would be acceptable in case of "indoor to outdoor" or "outdoor to indoor" interference. However, an interfering filed strength of - 30 dBµA/m@10 m will still cause interference to analogue broadcast receiver if the latter operates in indoor in the vicinity of SRD (in the same room for example). As for the LF and MF broadcasting bands, an interfering SRD field strength of -15 dBµA/m@10 m in a 10 kHz bandwidth would be acceptable in case of "indoor to outdoor" or "outdoor to indoor" interference.

3.2.1.6.4 Digital broadcasting

For digital broadcasting service, the protection distances from SRD to the victim broadcast receiver range from 8 to 424 m for the LF, MF and HF bands and a maximum field strength varying from -5dBµA/m@10m to -25 dBµA/m@10m (in a 10 kHz bandwidth). In the frequency range 3.95 –26.10 MHz (HF band), depending on SRD transmitter power and the considered field strength limit, the calculated protection distances are:

- for field strength -5 dBµA/m@10m: 260 - 424 m
- for field strength -10 dBµA/m@10 m: 195 - 318 m
- for field strength -15 dBµA/m@10 m: 146 - 238 m
- for field strength - 20 dBµA/m@10 m: 85 - 179 m
- for field strength -25 dBµA/m@10 m: 48 - 134 m

These distances are very large; consequently they cannot guaranty the protection of digital broadcast service operating below 30 MHz. An interfering field strength of -40 dBµA/m@10 m, which ensures a maximum protection distance of 34 m from SRD to the victim broadcast receiver, would be acceptable in case of "indoor to outdoor" or "outdoor to indoor" interference. However, an interfering filed strength of -40 dBµA/m@10 m will still cause interference to digital broadcast receiver if the latter operates in indoor in the vicinity of SRD (in the same room for example). As for the LF and MF broadcasting bands, an interfering SRD field strength of -15 dBµA/m@10 m in a 10 kHz bandwidth would be acceptable in case of "indoor to outdoor" or "outdoor to indoor" interference.

3.2.1.7 Fixed Service

The protection distances range for chosen field strength levels and different frequencies are 32 to 324 m. In the frequency range 12 - 20 MHz for corresponding field strength levels the protection distance was calculate as:

- for field strength -5 dBµA/m@10m: 239 - 288 m
- for field strength -10 dBµA/m@10m: 179 - 216 m
- for field strength -15 dBµA/m@10m: 134 -162 m
- for field strength -20 dBµA/m@10m: 101 - 121 m
- for field strength -25 dBµA/m@10m: 76 - 91 m

The Fixed Services are operating at protected sites.

ECC Report 003 [9] on "Fixed service in Europe - Current use and future trends POST-2002" as well as ERC Report 040 [10] on "Fixed Service System Parameters For Frequency Sharing" doesn't mention the Fixed Services below 30 MHz as currently or for future use.

Furthermore, the reception at above 12MHz is taking place mainly via sky wave and most of the time, directional antennas are used which give more protection from possible VSRD's.

Taking into account all information available on the Fixed Services below 30 MHz, it is recommended that additional protection for the Fixed Services in the frequency bands below 30 MHz is not required.

3.2.1.8 Standard Frequencies

The protection distance range is 95 to 447 m depends of frequency band and radiated field strength. In the frequency band 12 -20 MHz for the corresponding field strength the protection distances are:

- for field strength - 5 dBµA/m@10m: 301-447 m
- for field strength -10 dBµA/m@10m: 226-335 m
- for field strength -15 dBµA/m@10m: 170-251 m
- for field strength -20 dBµA/m@10m: 127-188 m
- for field strength -25 dBµA/m@10m: 95-141 m

3.2.1.9 Military Applications

The military are also users of the 1.6 – 30 MHz HF band. Depending on the application, military circuits are deployed in the appropriate allocated sub-bands. The frequencies should be coordinated with the relevant national administrations and registered with the ITU-R as well. Therefore NATO does not feel able to indicate specific frequency bands that will be used by the military. In addition, it was made clear that the frequency range of interest is from 1.6 - 30 MHz and that in particular the part 1.6 - 12 MHz is of most importance, since sky-wave propagation is mainly conducted below 12 MHz.

Therefore, as NATO has great interest in protecting the HF band and is of the opinion that the criterion of 0.5dB reduction in the sensitivity level based on the criterion for protection of HF radio services detailed in ECC Report 24 [11], should be applied to the whole HF band, in addition to those bands that are designated for use by the military.

For information purposes, Annex 6 contains the overview of the NATO calculations as well as differences to the ERC Report 69 methodology.

4 POSITIONS OF INTERNATIONAL ORGANIZATIONS

The Military position reflected by NATO (see Annex 6) is as follows:

a. The minimal separation distances required in case of SRD limit of -5 dBµA/m@10m in 10 kHz are in principle too large to ensure proper reception of HF radio transmissions. This conclusion is valid for Fixed, Mobile as well as Aeronautical ITU-R Allocations.

b. The application of limit –5 dBµA/m@10m in 10 kHz in the range 12 – 30 MHz, may be considered for allocations where no Aeronautical as well as Mobile are present (only Fixed allocations).

c. The probability of interference if the limit of SRD equals -25 dBµA/m@10m in 10 kHz, should be reasonable for all allocations between 12 – 30 MHz.

The position of the broadcasters, which is based on the results of this report, is as follows:

The protection distances required in case of SRD limit of -5 dBµA/m@10m in 10 kHz are too large to ensure proper reception in the LF, MF and HF broadcasting bands. The following SRD limits should be reasonable to minimise the probability of interference from SRD to broadcast receivers in the case of “indoor to outdoor”, “outdoor to indoor” or “outdoor” interference (for information purposes, Annex 7 provides calculations in the HF bands based on the ERC Report 69 methodology [2]):

- -5 dBµA/m@10m which should imply an SRD operating bandwidth ≥100 kHz for the LF band to ensure an adequate protection of both analogue and digital broadcasting;
- -5 dBµA/m@10m which should imply an SRD operating bandwidth ≥30 kHz for the MF band to ensure an adequate protection of both analogue and digital broadcasting.
- **-**35 dBµA/m@10m in 10 kHz for the HF bands for analogue broadcasting corresponding to -25dBµA/m@10m in 100 kHz;
- -45 dBµA/m@10m in 10 kHz for the HF bands for digital broadcasting corresponding to -35dBµA/m@10m in 100 kHz.

Note that these limits reduce the protection distances required to 20-30 m, but they do not guarantee the protection of the analogue and digital broadcast services in case of “indoor” interference where the interfering SRD device could be very close (a few meters) to the victim broadcast receiver.

CRAF considers that a generic limit for inductive systems below 30 MHz should take into account the protection requirements for radio astronomy for frequency bands allocated to radio astronomy. This leads to a generic limit of the order of –112 dBµA/m/10 kHz @ 10m. To the frequency bands concerned **RR** No.**5.149** applies (see Annex 9) [6].

5 CONCLUSIONS

ECC/SRDMG has proposed to a establish a new generic limit of –5 dBµA/m @ 10 m to fulfil the existing and future market needs.
This report has considered this proposal and compatibility studies were conducted to assess the impact of this proposal. Based on the results of these studies the following generic limit is proposed in the frequency range 148.5 kHz – 30 MHz:

- a maximum field strength of -15 dBµA/m @ 10m in a bandwidth of 10 kHz allowing
- a total field strength up to -5 dBµA/m @ 10m for systems with an operating bandwidth larger than 10 kHz whilst keeping the density limit above.

However, it should be noted that this generic limit may not provide adequate protection to some of existing services.

In particular, in the band 3 MHz - 30 MHz, this generic limit does not guarantee adequate protection to the broadcast services and additional measures such as more stringent limits (e.g. -25 dBµA/m) may be needed on a national basis.

Additional measures may also be needed in military bands on a national basis.

Such measures may be implemented by including specific limits in Appendix 3 of Rec. 70-03 [1].

For the RAS case, since there are a limited number of radio astronomy sites operating in the 13 MHz and 25 MHz bands any site specific scenario can be handled by the Administrations concerned.

ANNEX 1: (INFORMATIVE): REGULATORY BACKGROUND

A generic inductive limit is necessary to cover the market needs for Short Range Devices. Both CEPT and other Administrations already deal with this need. National inductive limits given in Table 1 below have been in force for years without any significant reported interference. In the "current" SRD applications as EAS and RFID the number of installations is not very high and mainly limited to business areas, shopping centers, city centers, etc. In the new SRD applications the expected market volume is very high and the use is foreseen in residential areas mainly. This means that we cannot refer to earlier experiences concerning the number of interference complaints.

Country	Regulation	Frequency	Limit	Bandwidth	Distance (m)
UK		9 - 185 kHz	48 dBuA/m	10 kHz	10 m
UK		240 - 315 kHz	24 dBuA/m	10 kHz	10 m
UK	Note 1 and 2	2 - 30 MHz	+9.0 dBµA/m	10 kHz	10 m
Germany	Note 3	135 kHz – 30 MHz	-5 dBµA/m	Note 3	10 m
USA and Canada	FCC 15.209	9 - 490 kHz	2400/f (kHz) µV/m	Not limited	300 m
USA and Canada	FCC 15.209	490 kHz – 1.705 MHz	24000/f (kHz) µV/m	Not limited	30 m
USA and Canada	FCC 15.209	1.705 MHz – 30 MHz	30 µV/m	Not limited	30 m
Japan	Extreme low power	9 kHz - 30 MHz	500 µV/m @ 3m	Not limited	3 m

Table A.1.1: Existing national generic limits for inductive applications

Note 1: UK Radio Interface Requirement 2030, Table 2.12 for Short Range Devices, Oct. 1, 2002.
Note 2: Additionally, a level of -9.5 dBuA/m @ 10 m is allowed for speech systems, in the band 2 to 30 MHz.
Note 3: The Bandwidth is limited to 10% of the center frequency or 500 kHz, and the smaller shall be used.

In the Swedish legislation, “inductive applications” are now considered as radio transmitters, and may only be used if they conform to the Swedish rules for exception from individual licence, based on ECC/Rec. 70-03.

Some CEPT countries do not have a restriction if the field strength is less than –3.5 dBµA/m@ 10m.

CEPT has previously studied, proposed and implemented several limits in the frequency range 135 kHz – 30 MHz, which are provided in ERC Rec. 70-03.

ANNEX 2 (INFORMATIVE): MARKET AND APPLICATION DESCRIPTIONS FOR INDUCTIVE SRDs

The market for inductive SRDs can be divided into disferent applications as RFID related applications and Personal Area Network (PAN) applications.

PANs are subdivided into distinct categories driven by distance and bandwidth, which imply acceptable excitation power levels. Distance can be described as less than 1m (on-the-body) and 1-3 metres applications. Applications above 3 metres range are not addressed in this document but most often referred to as the Local Area Networks (LAN).

Current transceiver technology is based on single chip devices and can easily deliver 256 kb/s for simultaneous transmission and reception within a total bandwidth of less than 500 kHz. Higher data rate chips are under development by various companies with a bandwidth of up to 1 MHz.

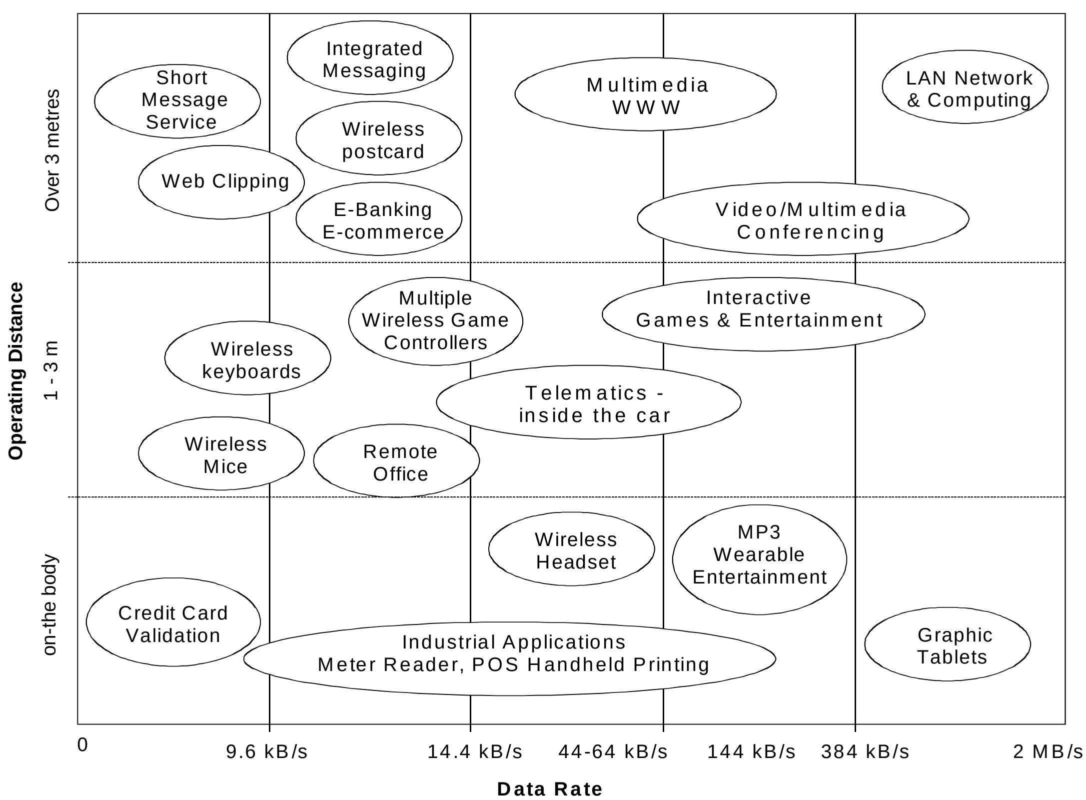
Other major markets and applications are in the telemetry and data communication field and based on RFID technology. Typical passive transponders of RFID systems are emitting field strength levels far below the -5 dBµA/m level and are operating below 30 MHz with bandwidth of 1 MHz.

The combination of distance and data rate enables a number of high volume applications, including but not limited to:

- -wireless headsets,
- -wireless telematics,
- -wireless portable electronic devices,
- -wireless handheld printers,
- -wireless mice and keyboards,
- -wireless MP3 players, and
- -RFID passive and active transponders
- -Manufacturing automation and logistic systems.

A categorisation of the market applications are shown in Figure A2.1 below:

Figure A2.1: Categorisation of wireless market applications for Very Short Range Devices (VSRD)



The Total Available Market (TAM) in 2002 for Very Short Range Devices (VSRD) was approximately 40 million units. As a high percentage of the applications are related to on or near the body communication, for which the users are carrying the equipment on travelling, there is a need for a reasonable worldwide harmonisation of a low-level generic field strength limit for VSRDs.

ANNEX 3: METHOD FOR CALCULATION OF PROTECTION DISTANCES FOR SEVERAL DEGRADATION LEVELS

Some investigations has been made regarding how the 3 dB degradation has been taken into account in calculation of the protection distances in the report regarding SRDs in the frequency range below 30 MHz.

In the 4th paragraph of executive summary in the ERC Report 69 it is written that:

"The interfering range is the distance at which field strength decays to either the specified protection level or, where this is not available, to the noise level."

In general the increase in noise, M at the receiver can be calculated as:

$$M = \frac{I + N}{N} \tag{1}$$

where I is the interfering signal and N is background noise.

When the power of interference, I is equal the Noise power, N this means that the increase in the noise level, M is 3 dB.

For any specified value of M the level of the interfering signal may be calculated using the formula in equation (1).

$$M = \frac{I + N}{N} \Leftrightarrow I + N = M \cdot N$$

$$\Updownarrow$$

$$I = N \cdot (M - 1)$$

$$\Updownarrow$$

$$\frac{I}{N} = M - 1$$

It has been chosen to do calculations for M = 0.5 dB, M=1 dB and M=2dB

The correction factor M-1 [dB] is shown in the following table.

M [dB]	M	M-1	M-1 [dB]
3	2	1	0
2	1.585	0.585	-2.3
1	1.259	0.259	-5.9
0.5	1.122	0.122	-9.1

Table A.3.1: Degradation level and corresponding correction factor

ANNEX 4: PROTECTION DISTANCES FOR 2DB, 1DB AND 0.5DB DEGRADATION LEVEL

This annex provides protection distances for degradation levels of 2dB, 1dB and 0.5dB. The factor described before Table 2 should be used for SRD systems using a bandwidth larger than 10 kHz.

Table A4.1: Calculated protection distances for –5; -10; -15; -20; -25 dBµA/m limit in 10 kHz - 2 dB degradation level.

Services *	**Frequency Range**	**Victim receiver BW**	**E_1kW@ 1km Land**	**Permissib. Interf.**	**Environment noise**		**Protection distance in metres for limit in 10 kHz (dBµA/m@10m):**				
	MHz	kHz	dBµV/m	dBµV/m	dBµ V/m	% avail.	**-5**	**-10**	**-15**	**-20**	**-25**
LF range	**0.030 – 0.300**										
Aeronautical Radionavigation	0.225 - 0.495	2.7	147	19.6			19	16	13	11	9
Analogue/digital broadcasting	0.1485 – 0.2835	9	147	23.7			20	16	13	11	9
MF range	**0.300 – 3**										
Aeronautical Radionavigation	0.505 - 0.5625	2.7	134	19.6			19	16	13	11	9
Analogue/digital broadcasting	0.527 – 1.61	10	120	23.7			25	21	17	14	12
Amateur	1.81 – 1.88	2.7	110	-27.3		**	1256	838	471	265	149
HF range	**3 – 30.0**										
Fixed (point to p.)	4.75 – 4.995	2.7	97	-2.3			316	236	133	75	42
	5.005 – 5.06	2.7	97	-2.3			328	246	144	81	45
	6.765 – 7.00	2.7	94	-2.3			341	256	192	123	69
	7.30 – 8.195	2.7	92	-2.3			320	240	180	135	77
	11.40 – 11.60	2.7	90	-2.3			370	278	208	156	117
	12.10 – 12.23	2.7	88	-2.3			329	246	185	139	104
	13.36 – 13.60	2.7	87	-2.3			308	231	173	130	98
	14.35 –14.99	2.7	86	-2.3			290	218	163	122	92
	15.80 – 16.36	2.7	85	-2.3			273	205	153	115	86
	18.03 – 18.052	2.7	84	-5.3			305	228	171	128	96
	19.80 – 19.99	2.7	84	-5.3			304	228	171	128	96
	22.855 – 23.0	2.7	82	-10.3			360	270	202	152	114
	26.175 – 27.50	2.7	81	-10.3			339	254	190	143	107
Maritime mobile	6.20 – 6.525	2.7	94		2,7	80	241	181	109	62	35
	8.10 – 8.15	2.7	92		0.7	80	287	215	162	110	62
	12.23 – 13.20	2.7	88		-4.3	80	368	276	207	155	117
	16.36 – 17.41	2.7	85		-6.3	80	343	257	193	145	108
	18.78 – 18.90	2.7	84		-10.3	80	406	304	228	171	128
	25.07 – 25.21	2.7	81		-16.3	(gn)	479	359	269	202	151
Aeronautical mob. (OR)	3.025 - 3.155	2.7	free sp	3.7			102	57	27	20	15
	3.800 - 3.950	2.7	free sp	3.7			149	84	47	22	16
	4.70 – 4.85	2.7	free sp	3.7			207	116	66	37	17
	5.45 – 5.48	2.7	free sp	3.7			258	145	81	46	26
	5.68 - 5.73	2.7	free sp	3.7			273	154	86	49	27

	6.685 - 6.765	2.7	free sp	3.7			342	192	108	61	34
	8.965 - 9.040	2.7	free sp	3.7			497	280	157	88	50
	11.175 - 11.275	2.7	free sp	3.7			645	363	204	115	65
	13.20 - 13.26	2.7	free sp	3.7			637	358	201	113	64
	15.01 - 15.1	2.7	free sp	-1.3			1118	629	353	199	112
	17.97 - 18.03	2.7	free sp	-1.3			1103	620	347	196	110
	23.2 - 23.35	2.7	free sp	-1.3			1088	612	344	193	109
Aeronautical mob (R)	2.850 -3.025	2.7	free sp		-8.3	50	365	205	116	65	29
	3.400 - 3.500	2.7	free sp.		-7.3	50	440	247	139	78	44
	4.650 - 4.700	2.7	free sp.		-4.3	50	512	288	162	91	51
	5.480 - 5.680	2.7	free sp.		-3.3	50	581	327	184	103	58
	6.525 - 6.685	2.7	free sp.	3.7			331	186	105	59	33
	8.815 - 8.965	2.7	free sp.		-5.3	50	1372	772	434	244	137
	10.005 - 10.100	2.7	free sp.		-1.3	80	1009	567	319	179	101
	11.275 - 11.400	2.7	free sp.		-2.3	80	1295	728	409	230	129
	13.260 - 13.360	2.7	free sp.	3.7			636	358	201	113	64
	17.900 - 17.979	2.7	free sp.	-1.3			1103	620	349	196	110
	21.924 - 22.000	2.7	free sp.	-6.3			1940	1091	613	345	194
Land mobile	4.75 – 4.85	2.7	97		3.7	80	210	118	67	37	17
	5.45 – 5.48	2.7	96		3.7	80	233	145	81	46	26
	5.73 – 5.90	2.7	95		3.7	80	228	156	87	49	28
	7.35 – 8.10	2.7	94		1.7	80	286	215	154	87	49
Analogue broadcasting	3.95 – 4.0	10	99	7.7			196	110	62	35	18
	5.95 –6.20	10	95	7.7			266	199	118	67	37
	7.10 – 7.30	10	93	7.7			264	198	147	83	47
	11.60 – 12.10	10	89	7.7			272	204	153	115	79
	13.57 – 13.87	10	87	7.7			240	180	135	101	76
	15.10 –15.80	10	86	7.7			226	169	127	95	71
	18.90 – 19.02	10	84	7.7			200	150	112	84	63
	21.45 – 21.85	10	83	7.7			188	141	106	79	59
	25.67 – 26.10	10	81	7.7			167	125	94	70	53
Digital broadcasting	3.95 – 4.0	10	99	-2.3***			430	323	196	110	62
	5.95 –6.20	10	95	-2.3			472	354	266	199	118
	7.10 – 7.30	10	93	-2.3			470	352	264	198	147
	11.60 – 12.10	10	89	-2.3			484	363	272	204	153
	13.57 – 13.87	10	87	-2.3			428	321	240	180	135
	15.10 –15.80	10	86	-2.3			402	301	226	169	127
	18.90 – 19.02	10	84	-2.3			355	266	200	150	112
	21.45 – 21.85	10	83	-2.3			334	250	188	141	106
	25.67 – 26.10	10	81	-2.3			297	222	167	125	94
Standard freq.	4.995 – 5.005	2.7	97		3.7	80	227	128	72	40	23
	14.99 – 15.01	2.7	86		-5.3	80	344	258	194	145	109
	19.99 – 20.005	2.7	84		-14.3	80	510	382	287	215	161
	24.99 – 25.005	2.7	81		-15.3	80	452	339	254	191	143
Amateur	3.5 - 3.8	2.7	100	-27.3		*	1287	965	724	543	407
	7.00 – 7.20	2.7	94		-17.3	20	827	620	465	349	262
	10.1 – 10.15	2.7	90	-11.3		20	585	439	329	247	185
	14.00 – 14.35	2.7	86		-15.3	20	614	460	345	259	194
	18.068 – 18.168	2.7	84		-15.3	(gn)	542	406	305	228	171
	21 – 21.450	2.7	83	-15.3		(gn)	509	382	286	215	161
	24.89 – 24.99	2.7	81		-15.3	(gn)	452	339	254	191	143
	28.00 – 29.70	2.7	80		-16.3	(gn)	451	338	254	190	143
Radio Astronomy	13.36 – 13.41	50	87	-57.3			15172	11377	8532	6398	4798
	25.55 –25.67	120	81	-55.3			11668	8750	6562	4920	3690

* The listed services are only a part of all existing.
**Below quiet rural level, above 20%. Recent measurements have shown that the given noise level is realistic.
*** Value derived from ITU-R BS.1615

Table A4.2: Calculated protection distances for –5; -10; -15; -20; -25 dBµA/m limit in 10 kHz - 1 dB degradation level.

Services *	**Frequency Range**	**Victim receiver BW**	**E_1kW@ 1km Land**	**Permissib. Interf.**	**Environment noise**		**Protection distance in metres for limit (dBµA/m@10m) in 10 kHz**				
	MHz	kHz	dBµV/m	dBµV/m	dBµ V/m	% avail.	**-5**	**-10**	**-15**	**-20**	**-25**
LF range	**0.030 – 0.300**										
Aeronautical Radionavigation	0.225 - 0.495	2.7	147	16			22	18	15	12	10
Analogue/digital broadcasting	0.1485 – 0.2835	9	147	20.1			23	19	15	13	11
MF range	**0.300 – 3**										
Aeronautical Radionavigation	0.505 - 0.5625	2.7	134	16			22	18	15	12	10
Analogue/digital broadcasting	0.527 – 1.61	10	120	14.1			29	24	20	16	13
Amateur	1.81 – 1.88	2.7	110	-30.9		**	1546	1159	713	401	226
HF range	**3 – 30.0**										
Fixed (point to p.)	4.75 – 4.995	2.7	97	-5.9			388	291	201	113	64
	5.005 – 5.06	2.7	97	-5.9			404	303	217	122	69
	6.765 – 7.00	2.7	94	-5.9			420	315	236	177	105
	7.30 – 8.195	2.7	92	-5.9			393	295	221	166	116
	11.40 – 11.60	2.7	90	-5.9			455	341	256	192	144
	12.10 – 12.23	2.7	88	-5.9			404	303	227	170	128
	13.36 – 13.60	2.7	87	-5.9			379	285	213	160	120
	14.35 –14.99	2.7	86	-5.9			357	268	201	151	113
	15.80 – 16.36	2.7	85	-5.9			336	252	189	141	106
	18.03 – 18.052	2.7	84	-8.9			375	281	211	158	118
	19.80 – 19.99	2.7	84	-8.9			374	280	210	158	118
	22.855 – 23.0	2.7	82	-13.9			443	332	249	187	140
	26.175 – 27.50	2.7	81	-13.9			417	313	234	176	132
Maritime mobile	6.20 – 6.525	2.7	94		-0.9	80	297	222	166	93	52
	8.10 – 8.15	2.7	92		-2.9	80	354	265	199	149	94
	12.23 – 13.20	2.7	88		-7.9	80	453	340	255	191	143
	16.36 – 17.41	2.7	85		-9.9	80	422	316	237	178	133
	18.78 – 18.90	2.7	84		-13.9	80	499	374	281	210	158
	25.07 – 25.21	2.7	81		-19.9	(gn)	589	442	331	248	186
Aeronautical mob. (OR)	3.025 - 3.155	2.7	free sp	0.1			154	87	49	25	19
	3.800 - 3.950	2.7	free sp	0.1			225	127	71	40	20
	4.70 – 4.85	2.7	free sp	0.1			314	176	99	56	31
	5.45 – 5.48	2.7	free sp	0.1			390	219	123	69	39

	5.68 - 5.73	2.7	free sp	0.1			413	232	131	74	41
	6.685 - 6.765	2.7	free sp	0.1			517	291	164	92	52
	8.965 - 9.040	2.7	free sp	0.1			752	423	238	134	75
	11.175 - 11.275	2.7	free sp	0.1			977	549	309	174	98
	13.20 - 13.26	2.7	free sp	0.1			963	542	305	174	96
	15.01 - 15.1	2.7	free sp	-4.9			1692	951	535	301	169
	17.97 - 18.03	2.7	free sp	-4.9			1669	938	528	297	167
	23.2 - 23.35	2.7	free sp	-4.9			1647	926	521	293	165
Aeronautical mob (R)	2.850 -3.025	2.7	free sp		-11.9	50	553	311	175	98	55
	3.400 - 3.500	2.7	free sp.		-10.9	50	665	374	210	118	67
	4.650 - 4.700	2.7	free sp.		-7.9	50	775	436	245	138	77
	5.480 - 5.680	2.7	free sp.		-6.9	50	880	495	278	156	88
	6.525 - 6.685	2.7	free sp.	0.1			501	282	158	89	50
	8.815 - 8.965	2.7	free sp.		-9.9	50	2330	1310	737	414	233
	10.005 - 10.100	2.7	free sp.		-4.9	80	1527	858	483	271	153
	11.275 - 11.400	2.7	free sp.		-5.9	80	1960	1102	620	348	196
	13.260 - 13.360	2.7	free sp.	0.1			963	542	305	174	96
	17.900 - 17.979	2.7	free sp.	-4.9			1669	939	528	297	167
	21.924 - 22.000	2.7	free sp.	-9.9			2936	1651	928	522	294
Land mobile	4.75 – 4.85	2.7	97		0.1	80	275	179	101	57	32
	5.45 – 5.48	2.7	96		0.1	80	287	215	123	69	39
	5.73 – 5.90	2.7	95		0.1	80	281	211	132	74	42
	7.35 – 8.10	2.7	94		-1.9	80	352	264	198	131	74
Standard freq.	4.995 – 5.005	2.7	97		0.1	80	285	193	109	61	34
	14.99 – 15.01	2.7	86		8.9	80	423	317	238	179	134
	19.99 – 20.005	2.7	84		-17.9	80	627	470	353	264	198
	24.99 – 25.005	2.7	81		-18.9	80	556	417	313	235	176
Analogue broadcasting	3.95 – 4.0	10	99	4.1			297	167	94	53	30
	5.95 –6.20	10	95	4.1			327	245	179	101	57
	7.10 – 7.30	10	93	4.1			325	244	183	125	71
	11.60 – 12.10	10	89	4.1			335	251	188	141	106
	13.57 – 13.87	10	87	4.1			296	222	166	125	94
	15.10 –15.80	10	86	4.1			278	208	156	117	88
	18.90 – 19.02	10	84	4.1			246	184	138	104	78
	21.45 – 21.85	10	83	4.1			231	173	130	97	73
	25.67 – 26.10	10	81	4.1			205	154	115	87	65
Digital broadcasting	3.95 – 4.0	10	99	-5.9***			529	397	297	167	94
	5.95 –6.20	10	95	-5.9			581	436	327	245	179
	7.10 – 7.30	10	93	-5.9			578	433	325	244	183
	11.60 – 12.10	10	89	-5.9			596	447	335	251	188
	13.57 – 13.87	10	87	-5.9			526	394	296	222	166
	15.10 –15.80	10	86	-5.9			494	370	278	208	156
	18.90 – 19.02	10	84	-5.9			437	327	246	184	138
	21.45 – 21.85	10	83	-5.9			411	308	231	173	130
	25.67 – 26.10	10	81	-5.9			365	274	205	154	115
Amateur	3.5 - 3.8	2.7	100	-30.9		**	1583	1187	890	667	501
	7.00 – 7.20	2.7	94		-20.9	20	1018	763	572	429	322
	10.1 – 10.15	2.7	90	-14.9		20	720	540	405	304	228
	14.00 – 14.35	2.7	86		-18.9	20	755	566	425	318	239
	18.068 – 18.168	2.7	84		-18.9	(gn)	666	500	375	281	211
	21 – 21.450	2.7	83	-18.9		(gn)	626	470	352	264	198
	24.89 – 24.99	2.7	81		-18.9	(gn)	556	417	313	235	176
	28.00 – 29.70	2.7	80		-19.9	(gn)	555	416	312	234	176
Radio Astronomy	13.36 – 13.41	50	87	-60.9			18666	13997	10497	7871	5903
	25.55 –25.67	120	81	-58.9			14355	10765	18072	6053	4539

* The listed services are only a part of all existing.
**Below quiet rural level, above 20%. Recent measurements have shown that the given noise level is realistic.
*** Value derived from ITU-R BS.1615

Table A4.3: Calculated protection distances for –5; -10; -15; -20; -25 dBµA/m limit in 10 kHz - 0.5 dB degradation level

Services *	Frequency Range	Victim receiver BW	E_1kW@ 1km Land	Permssib. Interf.	Environment noise		Protection distance in metres for limit (dBµA/m@10m) in 10 kHz				
	MHz	kHz	dBµV/m	dBµV/m	dBµ V/m	% avail.	-5	-10	-15	-20	-25
LF range	0.030 – 0.300										
Aeronautical Radionavigation	0.225 - 0.495	2.7	147	12.8			25	20	17	14	11
Analogue/digital broadcasting	0.1485 – 0.2835	9	147	16.9			26	21	18	14	12
MF range	0.300 – 3										
Aeronautical Radionavigation	0.505 - 0.5625	2.7	134	12.8			25	20	17	14	11
Analogue/digital broadcasting	0.527 – 1.61	10	120	10.9			33	27	22	18	15
Amateur	1.81 – 1.88	2.7	110	-34.1		**	1858	1394	1031	580	326
HF range	3 – 30.0										
Fixed (point to p.)	4.75 – 4.995	2.7	97	-9.1			467	350	262	163	92
	5.005 – 5.06	2.7	97	-9.1			485	364	273	177	99
	6.765 – 7.00	2.7	94	-9.1			504	378	284	213	152
	7.30 – 8.195	2.7	92	-9.1			473	354	266	199	149
	11.40 – 11.60	2.7	90	-9.1			547	410	308	231	173
	12.10 – 12.23	2.7	88	-9.1			486	364	273	205	154
	13.36 – 13.60	2.7	87	-9.1			456	342	257	192	144
	14.35 –14.99	2.7	86	-9.1			429	322	241	181	136
	15.80 – 16.36	2.7	85	-9.1			403	303	227	170	128
	18.03 – 18.052	2.7	84	-12.1			450	338	253	190	142
	19.80 – 19.99	2.7	84	-12.1			449	337	253	189	142
	22.855 – 23.0	2.7	82	-17.1			532	399	299	224	168
	26.175 – 27.50	2.7	81	-17.1			501	376	282	211	158
Maritime mobile	6.20 – 6.525	2.7	94		-4.1	80	357	267	201	135	76
	8.10 – 8.15	2.7	92		-6.1	80	425	319	239	179	134
	12.23 – 13.20	2.7	88		-11.1	80	545	409	306	230	172
	16.36 – 17.41	2.7	85		-13.1	80	507	380	285	214	160
	18.78 – 18.90	2.7	84		-17.1	80	600	450	337	253	190
	25.07 – 25.21	2.7	81		-23.1	(gn)	708	531	398	299	224
Aeronautical mob. (OR)	3.025 - 3.155	2.7	free sp	-3.1			223	125	70	40	22
	3.800 - 3.950	2.7	free sp	-3.1			325	183	103	88	33
	4.70 – 4.85	2.7	free sp	-3.1			453	255	143	81	45
	5.45 – 5.48	2.7	free sp	-3.1			563	317	178	100	56
	5.68 - 5.73	2.7	free sp	-3.1			598	336	189	106	60
	6.685 - 6.765	2.7	free sp	-3.1			748	420	236	133	75
	8.965 - 9.040	2.7	free sp	-3.1			1087	611	344	193	109
	11.175 - 11.275	2.7	free sp	-3.1			1412	794	447	251	141
	13.20 - 13.26	2.7	free sp	-3.1			1393	783	440	248	139
	15.01 - 15.1	2.7	free sp	-8.1			2445	1375	773	435	245
	17.97 - 18.03	2.7	free sp	-8.1			2412	1356	763	425	245
	23.2 - 23.35	2.7	free sp	-8.1			2380	1339	753	423	238
Aeronautical mob (R)	2.850 -3.025	2.7	free sp		-15.1	50	799	450	253	142	80
	3.400 - 3.500	2.7	free sp.		-14.1	50	962	541	304	171	96
	4.650 - 4.700	2.7	free sp.		-11.1	50	1120	630	354	199	112
	5.480 - 5.680	2.7	free sp.		-10.1	50	1271	715	402	226	127
	6.525 - 6.685	2.7	free sp.	-3.1			724	407	229	129	72
	8.815 - 8.965	2.7	free sp.		-12.1	50	3002	1688	949	534	300
	10.005 - 10.100	2.7	free sp.		-8.1	80	2207	1241	698	392	221
	11.275 - 11.400	2.7	free sp.		-9.1	80	2833	1593	896	504	283
	13.260 - 13.360	2.7	free sp.	-3.1			1392	783	440	248	139
	17.900 - 17.979	2.7	free sp.	-8.1			2413	1357	763	429	241
	21.924 - 22.000	2.7	free sp.	-13.1			4243	2386	1342	755	424
Land mobile	4.75 – 4.85	2.7	97		-3.1	80	330	248	146	82	46

	5.45 – 5.48	2.7	96		-3.1	80	345	259	178	100	56
	5.73 – 5.90	2.7	95		-3.1	80	338	253	190	108	61
	7.35 – 8.10	2.7	94		-5.1	80	423	317	238	178	107
Analogue broadcasting	3.95 – 4.0	10	99	0.9			358	241	136	76	43
	5.95 –6.20	10	95	0.9			393	295	221	146	82
	7.10 – 7.30	10	93	0.9			391	293	220	165	102
	11.60 – 12.10	10	89	0.9			403	302	226	170	127
	13.57 – 13.87	10	87	0.9			356	267	200	150	112
	15.10 –15.80	10	86	0.9			334	250	188	141	106
	18.90 – 19.02	10	84	0.9			295	221	166	125	93
	21.45 – 21.85	10	83	0.9			278	208	156	117	88
	25.67 – 26.10	10	81	0.9			247	185	139	104	78
Digital broadcasting	3.95 – 4.0	10	99	-9.1***			636	477	358	241	136
	5.95 –6.20	10	95	-9.1			699	524	393	295	221
	7.10 – 7.30	10	93	-9.1			695	521	391	293	220
	11.60 – 12.10	10	89	-9.1			716	537	403	302	226
	13.57 – 13.87	10	87	-9.1			632	474	356	267	200
	15.10 –15.80	10	86	-9.1			594	445	334	250	188
	18.90 – 19.02	10	84	-9.1			525	394	295	221	166
	21.45 – 21.85	10	83	-9.1			494	370	278	208	156
	25.67 – 26.10	10	81	-9.1			439	329	247	185	139
Standard freq.	4.995 – 5.005	2.7	97		-3.1	80	343	257	157	88	50
	14.99 – 15.01	2.7	86		-12.1	80	509	382	286	215	161
	19.99 – 20.005	2.7	84		-21.1	80	754	565	424	318	238
	24.99 – 25.005	2.7	81		-22.1	80	669	501	376	282	211
Amateur	3.5 - 3.8	2.7	100	-34.1		**	1903	1427	1070	803	602
	7.00 – 7.20	2.7	94		-24.1	20	1224	918	688	516	387
	10.1 – 10.15	2.7	90	-18.1	-9	20	866	649	487	365	274
	14.00 – 14.35	2.7	86		-22.1	20	908	681	511	383	287
	18.068 – 18.168	2.7	84		-22.1	(gn)	801	601	450	338	253
	21 – 21.450	2.7	83	-22.1		(gn)	753	565	423	317	238
	24.89 – 24.99	2.7	81		-22.1	(gn)	669	501	376	282	211
	28.00 – 29.70	2.7	80		-23.1	(gn)	667	501	375	281	211
Radio Astronomy	13.36 – 13.41	50	87	-64.1			22441	16828	12620	9463	7097
	25.55 –25.67	120	81	-62.1			17259	12942	9705	7278	5458

* The listed services are only a part of all existing.
**Below quiet rural level, above 20%. Recent measurements have shown that the given noise level is realistic.
*** Value derived from ITU-R BS.1615

ANNEX 5: ASSUMPTIONS FOR SEAMCAT SIMULATIONS

Introduction

Seamcat calculation of interference probability between SRD and fixed and broadcast services in the frequency band below 30 MHz

It has been found possible that SRD may cause interference to services in the frequency band below 30 MHz in particular taking into account the aggregate impact. Services, which may be affected, are broadcast services and fixed services. In urban environments private people use broadcast to get information from abroad, and fixed services are used by embassies and by the police for communication purposes. Simulations with SEAMCAT have been carried out in order to calculate the probability of interference between SRD and those services. The used propagation model is free space, as the other propagation models in SEAMCAT are not defined for the frequency range below 30 MHz. Among other measures a 5 dB mitigation factor has been introduced to take the uncertainty with this model into account. The propagation model given in the ERC Report 69 (see section A5.9) should be used to review the results given in this Annex.

A5.1. Activity factor considerations for SRDs

The anticipated use of SRD employing an extended frequency band is not known. This makes it impossible for WG SE to have knowledge about how much it will be used. Nevertheless it seems reasonable that the usage on many occasions could be similar the usage of UWB. Some applications may be offered in both technologies.
The services are supposed to be divided into groups with different bandwidths and corresponding data rates: low 50 kHz (50 kbps), medium 500 kHz (500 kbps) and high rates 1 MHz (1Mbps).

In the **office environment** the following services can be anticipated:

- Mice/tracking balls etc.
- Keyboards
- Headsets
- Portable printers
- PDA’s for file downloads (calender/email synchronization).

In the **home/domestic environment** the following services can be anticipated:

- Mice/tracking balls etc.
- Keyboards
- PC speakers/Headsets
- Portable printers
- PDA’s for file downloads (calender/email synchronization)
- MP3 players for file downloads.

Each type of environment is split in two to account for “typical users” – average user- and “high demanding users” – power user.

Note that the usage models and activity percentages given below are only “best guesses” estimates based on the UWB report and experience with similar technologies (wired USB, for example). In this study five user groups have been considered.

Based on the assumed usage per hour the activity factor per user can be calculated.

Table A5.1 and Table A5.2 show the results for office users, and Table A5.3 and Table A5.4 show the results for domestic users.

The activity factor for the office environment is calculated based on an 8 hours day and the activity factor for the domestic environment is calculated based on a 16 hours day. In this study it has been chosen to consider the worst case situation, so the activity has not been averaged over 24 hours.

It has been assumed that the SRD activity is very low in the night. Activity during the day has been assumed to have a uniform time distribution. Consequently the occurrence of peak hours during the day has not been taken into account.

Table A5.1: Office environment - Power user activity.

Service/Usage	Data requirements kbps (1)	Data Rate used kbps (2)	% of link rate (3)=(1)*(2)	Daily use (4)	Daily usage based on 8 h day [%] (5)=(4)/8 h	Overall activity [%] (6)=(3)*(5)
Mice/tracking balls	16	50	32	20 min/hour	33.3	10.7
Keyboards	16	50	32	25 min/hour	41.7	13.3
Headset	448	500	89.6	3h/day	37.5	33.6
Printer	1000	1000	100	20xhourly @ 100 kbyte - 16 s/hour	0.44	0.44
PDA	1000	1000	100	10xdaily @ 1 Mbyte - 80 s/day	0.28	0.28

Table A5.2: Office environment - Average user activity.

Service/Usage	Data requirements kbps (1)	Data Rate used kbps (2)	% of link rate (3)=(1)*(2)	Daily use (4)	Daily usage based on 8 h day [%] (5)=(4)/8 h	Overall activity [%] (6)=(3)*(5)
Mice/tracking balls	16	50	32	10 min/hour	16.7	5.3
Keyboards	16	50	32	15 min/hour	25.0	8.0
Headset	448	500	89.6	1.5 h/day	18.75	16.8
Printer	1000	1000	100	10xhourly @ 100 kbyte - 8 s/hour	0.22	0.22
PDA	1000	1000	100	2xdaily @ 1 Mbyte - 16 s/day	0.06	0.06

Table A5.3: Domestic environment - Power user activity.

Service/Usage	Data requirements kbps (1)	Data Rate used kbps (2)	% of link rate (3)=(1)*(2)	Daily use (4)	Daily usage based on 16 h day [%] (5)=(4)/16 h	Overall activity [%] (6)=(3)*(5)
Mice/tracking balls	16	50	32	45 min/day	4.7	1.7
Keyboards	16	50	32	45 min/day	4.7	1.7
PC speakers	448	500	89.6	1.0 h/day	6.25	5.6
Printer	1000	1000	100	3xdaily @ 100 kbyte – 2.4 s/day	0.004	0.004
PDA	1000	1000	100	5xdaily @ 1 Mbyte - 19.2 s/day	0.033	0.033
MP3 players (file download)	1000	1000	100	2x weekly @ 100 Mbyte 0.44 h/week	0.004	0.004

Table A5.4: Domestic environment - Average user activity.

Service/Usage	Data requirements kbps (1)	Data Rate used kbps (2)	% of link rate (3)=(1)*(2)	Daily use (4)	Daily usage based on 16 h day [%] (5)=(4)/16 h	Overall activity [%] (6)=(3)*(5)
Mice/tracking balls	16	50	32	15 min/day	1.6	0.5
Keyboards	16	50	32	15 min/day	1.6	0.5
PC speakers	448	500	89.6	1 h/day	6.25	5.6
Printer	1000	1000	100	1xdaily @ 100 kbyte – 0.8 s/day	0.001	0.001
PDA	1000	1000	100	1xdaily @ 1 Mbyte - 1 s/day	0.002	0.002

The activity factors should be related to population densities for homes and offices to find the aggregate interference level for a large number of entities in a given area.

Distribution of user categories is shown in the Table A5.5 and Table A5.6 below.

Table A5.5: Density of different office users.

User	Population density (% of employees)
Power office user	15
Average office user	85

Table A5.6: Density of different domestic users.

User	Population density (% of population)
Power domestic user	10
Average domestic user	70
Non - SRD user (or very small aggregate activity)	20

Those two kinds of environment are used in the simulations. It has been assumed that the possible interfered systems will be used in embassy districts in larger cities or in the city centre.
A typical embassy district in Copenhagen:

- has a population density of 3000 people per km^2 and,
- it will be assumed that the number of employees in offices is 3000 per km^2.

In the central part of Copenhagen the number of employees in offices is around 13.000 per km^2.

Densities for office employees and population in two different districts of Copenhagen are shown in Table A5.7.

Table A5.7: Density of office employees and population in two different districts of Copenhagen.

Environment/type of district	Number of office employees per km^2	Population density (per km^2
Dense urban (city centre)	13.000	0 [(1)]
Urban	3.000	3000

(1) The population in dense urban is of course not 0, but in the daytime the most dominant users are the business users.

A5.2 Description of victim

The antenna of the victim receiver is supposed to be placed on the roof of a larger building. Consequently an antenna height of 30 meters is used in SEAMCAT.

The data of the victim receiver:

Bandwidth:	2.4 kHz (see Note 1)
Usable field strength:	40 dBμV/m
Necessary S/N:	30 dB

Note 1: for broadcast, the used receiver bandwidths are 9 and 10 kHz.

A5.3 Data of SRD

Antenna height: 1.5 m

To conduct simulations in SEAMCAT it is necessary to calculate the corresponding e.i.r.p. from the SRD magnetic field strength. For frequencies above approximately 5 MHz the 10 m distance is in the far field zone, which means that the e.i.r.p. is constant in the frequency range 5 - 30 MHz. For frequencies below 5 MHz the 10 metre distance is not in the far field zone (see section A5.5). This means that another formula should be used to calculate the e.i.r.p., as it is necessary to take the -60dB/decade in the near field into account. Corresponding values of magnetic field strength and e.i.r.p. for different bandwidths are expressed in Table A5.8 below.

Table A5.8: Calculated e.i.r.p [dBm] for different frequencies based on the limit -5 dBμA/m at 10 m distance in 10 kHz bandwidth. also the spectral density is evaluated for different bandwidths.

	PSD [dBm/10 kHz]			
Bandwidth Frequency	**≤ 10 kHz**	**50 kHz**	**500 kHz**	**1 MHz**
500 kHz	-77	-84	-94	-97
2 MHz	-53	-60	-70	-73
>5 MHz	-38	-45	-55	-58

A5.4 Description of simulation in SEAMCAT

Simulations are made for 6 scenarios for each value of the magnetic field strength, as the probability for interference is calculated for two types of environment (urban and dense urban) for each of the used bandwidths (50 kHz, 500 kHz and 1 MHz). For each scenario an average activity per user is calculated as it is weighted relative to population densities from Tables A5.5 andA5.6. It results in the following probabilities of transmission related to each type of bandwidth as shown in Table A5.9.

Table A5.9: Probabilities of transmission related to each type of bandwidths and environment

	50 kHz	500 kHz	1 MHz
Urban	0.16	0.237	0.00356
Dense urban	0.149	0.193	0.00346

A5.5 Propagation model

The used propagation model is free space, as the other propagation models in SEAMCAT are not defined for the frequency range below 30 MHz. Free space propagation model can be used for distances less than the roll off distance d_{tr}.

Calculation of e.i.r.p. from the magnetic field strength (for more detailed explanations see also Report ERC 69)

The point between near field and far field is at the so called radian wavelength which is calculated by:

$$d_r = \frac{\lambda}{2\pi}$$

$$f = 5MHz \Rightarrow \lambda = \frac{c}{f} = 60m \Rightarrow d_r \approx 10m$$

The limits in magnetic field strength are measured at 10 meters distance from the transmitting device.

Far field

When the 10m measurement point is in the far field, the electric field strength at 10 m can be calculated from

U = R*I

R = η = 120 π = 377 Ω =20 log 377= 51.5 dB

This gives for instance for -5 dBμA:

-5 dBμA ≈ -5 + 51.5 dB = 46.5 dBμV/m ≈ 47 dBμV/m@10m, 10 kHz

$$E = \sqrt{5} * 10^{-4} \text{ V/m}$$

When f > 5 MHz, the e.i.r.p. can be calculated using the following equation (see Recommendation ITU-R P.525):

$$E = \frac{\sqrt{30P}}{d} \text{ [V/m]} \qquad (1)$$

where:

E : r.m.s. field strength (V/m)

P : equivalent isotropically radiated power (e.i.r.p.) of the transmitter in the direction of the point in question (W)

d : distance from the transmitter to the point in question (m) i.e. 10 m.

This gives:

$$P = \frac{(E * d)^2}{30} = \frac{\left(\sqrt{5} * 10^{-4} * 10\right)^2}{30} = \frac{5 * 10^{-6}}{30} = 1.6 * 10^{-7} = -68dBW = -38dBm, 10kHz$$

Converted to relevant bandwidths gives for f > 5 MHz:

50kHz: $P_{e.i.r.p.}$ = -38dBm - 10log(50/10) = -38 dBm - 7dB = -45 dBm
500 kHz: $P_{e.i.r.p.}$ = -45 dBm -10 log(500/50) = -55 dBm
1 MHz: $P_{e.i.r.p.}$ = -55 dBm + 10 log(1000/500) = -58 dBm

Near field

When the 10 meter measurement point is in the near field for f < 5 MHz the roll-off the field with distance is -60 dB/dec until d_r. Free space propagation has a roll-off of -20 dB/dec. This gives a correction factor of $(10/d_r)^4$

$$P_{EIRP} = P_{\lim}\left(\frac{10}{d_r}\right)^4 = P_{\lim}[dB] + 40\log\left(\frac{10}{d_r}\right) \quad \text{for 10 kHz @ 10m}$$

This formula gives the values for f < 5 MHz in Table A4.8 above.

Calculation of received Power at the victim

$$P_{rec} = \frac{\lambda^2}{4\pi} \cdot G \cdot \Phi = \frac{\lambda^2 \cdot G}{4\pi} \cdot \frac{E^2}{\eta}$$

η = intrinsic impedance of space = 120π

Broadcast: E = 40 dBμV/m ⇒ E = $10^{40/20}$ = 100 μV/m = 10^{-4} V/m

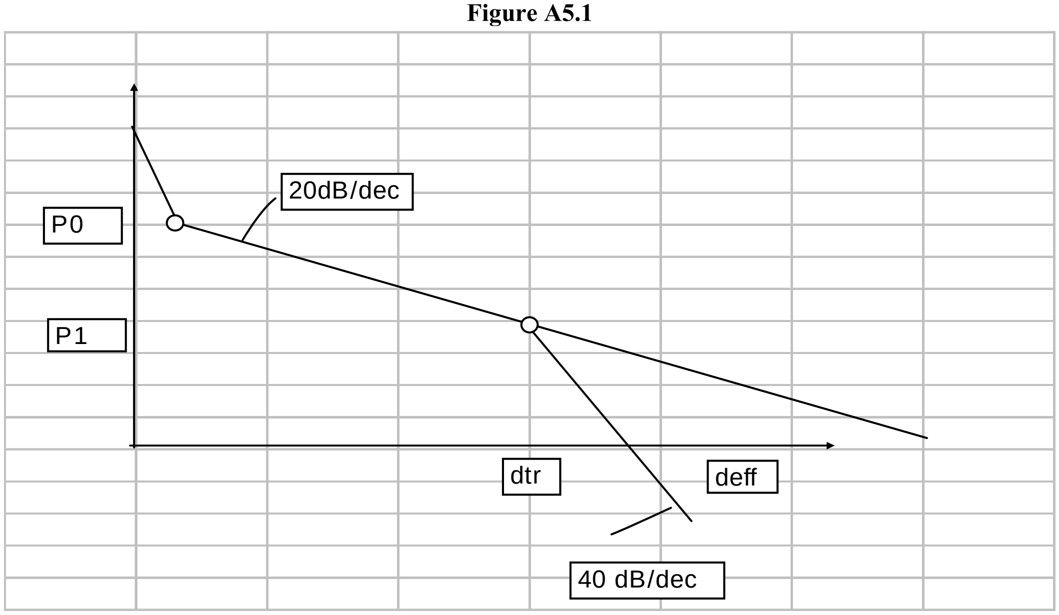
20 MHz: λ = 15 m
G = 0 dBi

$$P_{rec}(dipol, G = 0dB) = \frac{15^2 \cdot 1 \cdot \left(10^{-4}\right)^2}{4\pi \cdot 120\pi} = \frac{15 \cdot 10^{-8}}{4\pi^2 \cdot 8} = 0.5 \cdot 10^{-9} = -3dBnW = -63dBm$$

Correction of not using ground wave propagation model

According to ERC Rep. 69 ground wave propagation shall be used for distances (from the antenna) of more than the roll off transition distance d_{tr}. For distances below d_{tr} the free space propagation model can be used. The situation is illustrated in Figure A5.1 below.

Figure A5.1



It is assumed that SRD at a larger distance than 150 m can not cause interference. For frequencies less than 10 MHz the vicinity area (150 m) is less than the transition distance d_{tr}. d_{tr} can be found in ERC Rep. 69 for relevant frequencies. This means that the propagation can be regarded as free space propagation for f < 10 MHz.

For frequencies above 10 MHz the radius of the vicinity area is higher than d_{tr}. This means that in some parts of the vicinity area ground wave propagation will have to be considered.

We will find an effective radius of the vicinity area so we can use the free space propagation model in the whole vicinity area. This can be done by calculation of a correction factor.

When free space propagation is valid the field strength roll-off is 20 dB/dec. When ground wave propagation is valid the field strength roll-off is 40 dB/dec. This is illustrated in Figure A4.1. By using integration it is possible to find an effective distance d_{eff} where the contribution from the ground wave propagation area can be replaced by a similar contribution using free space propagation model.

The calculations are as follows. The received power from the two regions shall be equal:

$$\int_{d_{tr}}^{d_{eff}} P_0 \frac{1}{r^2} 2\pi r dr = \int_{d_{tr}}^{\infty} P_1 \frac{1}{r^4} 2\pi r dr$$

$$\Downarrow$$

$$P_0 \int_{d_{tr}}^{d_{eff}} \frac{1}{r} dr = P_1 \int_{d_{tr}}^{\infty} \frac{1}{r^3} dr$$

$$\Downarrow$$

$$\frac{P_0}{P_1} [\ln r]_{d_{tr}}^{d_{eff}} = \left[-\frac{1}{2r^2} \right]_{d_{tr}}^{\infty}$$

$$\Downarrow$$

$$\frac{P_0}{P_1} \ln \frac{d_{eff}}{d_{tr}} = \frac{1}{2d_{tr}^2}$$

The relationship between P_0 og P_1 can be found, as the power densities at the transition distance shall be equal:

$$P_0 \frac{1}{d_{tr}^2} = P_1 \frac{1}{d_{tr}^4} \Rightarrow \frac{P_0}{P_1} = \frac{1}{d_{tr}^2}$$

This gives:

$$\frac{P_0}{P_1} \ln \frac{d_{eff}}{d_{tr}} = \frac{1}{d_{tr}^2} \ln \frac{d_{eff}}{d_{tr}} = \frac{1}{2d_{tr}^2}$$

$$\Downarrow$$

$$\ln \frac{d_{eff}}{d_{tr}} = \frac{1}{2}$$

$$\Downarrow$$

$$\frac{d_{eff}}{d_{tr}} = 1.65$$

For 20 MHz d_{tr} is 53 meter and d_{eff} = 87.5 meter, for 10 MHz d_{tr} is 110 meter and d_{eff} = 180 m, which exceeds the vicinity area at 150 meter, so the 150 meter is used in the simulation as it is for frequencies below 10 MHz.

For distances longer than d_{tr} ground wave propagation has to be used. For frequencies below 10 MHz d_{tr} is higher than 150 meter, but for frequencies above 10 MHz the vicinity area has to be reduced as calculated above.

It has been assumed that devices at a distance larger than 150 m are not likely to cause interference. But if a fixed distance of a vicinity area of 150 meter is used it produces strange effects in the results. To avoid this, the distribution of interfering sources has been extended outside the distance of 150 m with a lower emitted power. In SEAMCAT it has been introduced as a second interfering system with a protection distance of 150 m and a power decrease of 20 dB. A standard deviation in the propagation of 10 dB has been used to take into account the variability of the environment.

Even inside the vicinity area this variability has to be taken into account. Due to this a decrease in the power of 5 dB has been introduced together with a deviation of 5 dB in the propagation. When doing the simulation the number of devices has been adjusted until the vicinity area fits to the above theory.

Note: The used built-in propagation models used in the SEAMCAT simulation are extrapolated from those used for frequencies above 30 MHz. The free space propagation model may be subject to validation. Nevertheless an uncertainty factor of 5dB is used in the simulations to reflect this issue.

A.5.6 Results of simulations

The results are shown in Table A5.10 and Table A5.11.

Table A5.10: Interference probability in % for different frequencies, different bandwidths and different PSD's in Dense Urban environment. Differences in interference probability for different bandwidth is mainly due to different activity factors for the limits defined in 10kHz.

Bandwidth Frequency	50 kHz	500 kHz	1 MHz
500 kHz	0	0	0
2 MHz	0	0	0
5 MHz	3.0	15	0.1
10 MHz	7.7	12	0.1
20 MHz	4.5	10	0.1

Table A5.11: Interference probability in % for different frequencies, different bandwidths and different PSD's in Urban environment. Differences in interference probability for different bandwidth is mainly due to different activity factors for the limits defined in 10kHz.

Bandwidth Frequency	50 kHz	500 kHz	1 MHz
500 kHz	0	0	0
2 MHz	0	0	0
5 MHz	3.0	4.5	0
10 MHz	2.3	3.3	0
20 MHz	5.4	4.1	0

A.5.7 Comments to the results

Several factors does influence on the results:

- ♦ Missing exact knowledge of usage of SRD's

No exact data of anticipated usage was not available at the time of the study. It gives a significant uncertainty in calculations.

- ♦ Propagation mode

Free space propagation model is used in the simulations. It is only correct for short distances between victim and interferer. As SRD however does not transmit with very high e.i.r.p. this is met by limit the vicinity area to around 150 metres from the victim. The used built-in propagation models used in the SEAMCAT simulation are extrapolated from those used for frequencies above 30 MHz. The free space propagation model may be subject to validation.

- ♦ Constant utility power for victim

A constant received power is used for the victim receiver. A varying signal would have been more appropriate. But supposedly it has no substantial effect of the results.

- ♦ Radiated Power

Industrial installations are not considered as they are operating in larger industrial sites and where free propagation does not occur due to indoor operation which benefits from a mitigation factor of approx 10 - 15 dB depending on the frequency and (metallic) construction structures often provide a screening effect to radiation outside the buildings. Larger protection distances are given by the size of the manufacturing sites.
Common frequency ranges are below 2 MHz.

The above simulations assumed that the technology all transmitters deployed in same area use the same technology. Market forecasts expect that the terminals may use different technologies: Inductive SRDs, UWB and Bluetooth representing approximately 30%, 40% and 30 % respectively of the market.

A.5.8 Conclusions of the SEAMCAT simulations

It should be noted that applications used for almost continuous communication for instance headsets and speakers are a potential source for interference against radiocommunication services.

A5.9 Implementation of the propagation model defined in the ERC/REP 069

This part provides the formulae given by the ERC/REP 069 (CILIR).

The complete coverage range can be divided into four sub-ranges (see Figure A5.2 below):

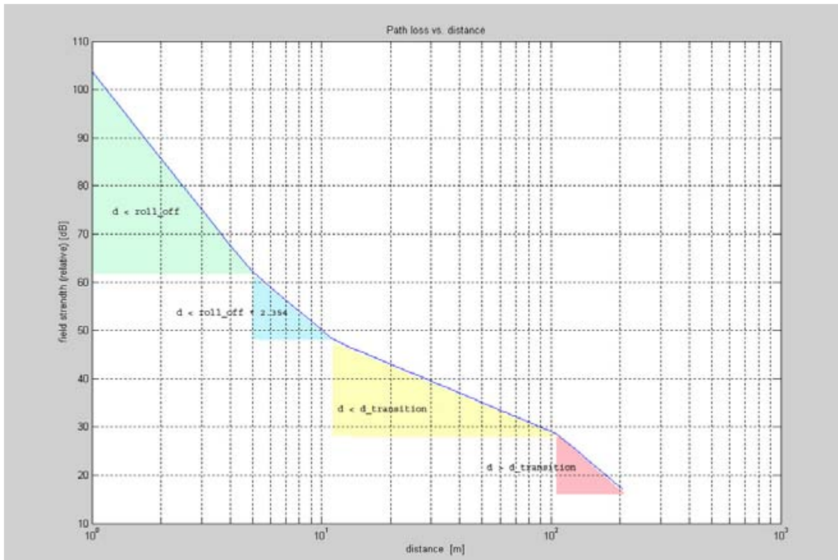


Figure A5.2: propagation range

These ranges are called:

- near field (green); distances less than roll_off (60 dB/decade)
- close to the near field (blue); distances between roll_off and 2.354*roll_off (about 60 dB/decade)
- far field (yellow); distances between roll_off*2.354 and d_transition (20 dB/decade)
- ground wave propagation (red); distances beyond d_transition (40 dB/decade)

Formulae used within the propagation model:

near field:

$$L = 20 \cdot \log_{10}\left(\frac{m}{2\pi}\right) - 60 \cdot \log_{10}(d) + 51.5$$

close to near field:

$$L = 20 \cdot \log_{10}\left(\frac{m}{2\pi \cdot \bar{\lambda}}\right) - 40 \cdot \log_{10}(d) + 51.5$$

far field:

$$L = 169.5 + P_{1kW} - 20 \cdot \log_{10}(d)$$

ground wave propagation:

$$L = E_{1kW} + P_{1kW} - 40 \cdot \log_{10}(d/1000)$$

<u>with:</u>

L	=	propagation loss
m	=	magnetic dipole moment [µAm^2]
d	=	interference distance [m]
$\bar{\lambda}$	=	radian wave length ($\lambda / 2\pi$)
E_{1kW}	=	field strength [dB(µV/m)] @ d_transition
P_{1kW}	=	power of the interferer (e.r.p.) [dB(kW)]

ANNEX 6: NATO POSITION

Highlights from this annex:

-Minimum separation distances required to protect HF radio services from interference of SRD's.

-Comments from SE24 Ad-hoc 30M group to NATO document on protection distances between HF radio services and SRD.

A6.1 Comparison between NATO calculations and calculations based on ERC rep. 69

General assumptions :
- -soil condition : land
- -residential area for manmade noise condition
- -fieldstrength –5dBuA/m@10m and 5 dB mitigation
- -table values are protection distances in metres
- -interferer is broadband in respect to victim
- -victim recvr b/w = 2.7 kHz (SSB)

Note : Compatibility Study is based upon ERC report 69 calculations done with the aid of the program CILIR.

Freq	*NATO calculation 0.5 dB sens. degradation*		*Ad-hoc group compatibility study based on ERC rep. 69*		*Calc. assumptions Rep. 69 calc. : 80% for envir. noise*	
MHz	Grdwave Metres	Freespace Metres	Grdwave Metres	Freespace Metres	*E_1kW (dBµV/m)*	*Noise dBµV/m*
5	509	1092	174	174	*97*	*6*
10	387	1416	241	548	*90*	*4*
14	345	1589	214	769	*85*	*2*
20	298	1886	211	841	*84*	*1*
24	286	1948	193	883	*82*	*0.5*

Table A6.1

Note the quite substantial difference between the results for e.g. the free space condition.

A6.2 NATO detailed calculation of the noise levels and protection distance

The Military position reflected by a NATO document is as follows:

a. The minimal separation distances required in case of SRD limit of -5 dBµA/m@10m are in principle too large to ensure proper reception of HF radio transmissions. This conclusion is valid for Fixed, Mobile as well as Aeronautical Rr Allocations.

b. The application of limit –5 dBµA/m@10m in the range 12 – 30 MHz, may be considered for allocations where no Aeronautical as well as Mobile are present (only Fixed allocations).

c. The probability of interference if the limit of SRD equals -25 dBµA/m@10m, should be reasonable for all allocations between 12 – 30 MHz.

Table A6.1

Frequency (MHz)	Noise Quiet Rural (dB above kTo)	Total Noise per Hz at Rx (dBm/Hz)	Max Interference Level Quiet Rural (dBm/Hz)	Max Interference Level Quiet Rural per Hz (dBuV/m/Hz)	Noise Rural (dB above kTo)	Total Noise per Hz at Rx (dBm/Hz)	Max Interference Level Rural (dBm/Hz)	Max Interference Level Rural (dBuV/m/Hz)	Noise Residential (dB above kTo)	Total Noise per Hz at Rx (dBm/Hz)	Max Interference Level Residential (dBm/Hz)	Max Interference Level Residential (dBuV/m/Hz)	Noise Business (dB above kTo)	Total Noise per Hz at Rx (dBm/Hz)	Max Interference Level Business (dBm/Hz)	Max Interference Level Business (dBuV/m/Hz)
1.5	48.6	-125.4	-134.6	-53.8	62.3	-111.7	-120.8	-40.1	67.6	-106.4	-115.5	-34.8	71.9	-102.1	-111.2	-30.5
2	45.0	-129.0	-138.1	-54.9	58.9	-115.1	-124.3	-41.1	64.2	-109.8	-119.0	-35.8	68.5	-105.5	-114.7	-31.5
3	40.0	-134.0	-143.1	-56.4	54.0	-120.0	-129.2	-42.4	59.3	-114.7	-123.9	-37.1	63.6	-110.4	-119.6	-32.8
4	36.5	-137.5	-146.6	-57.4	50.5	-123.5	-132.6	-43.4	55.8	-118.2	-127.3	-38.1	60.1	-113.9	-123.0	-33.8
5	34.1	-139.9	-149.0	-57.9	47.9	-126.1	-135.3	-44.1	53.1	-120.9	-130.0	-38.8	57.4	-116.6	-125.7	-34.5
6	32.5	-141.5	-150.6	-57.9	45.7	-128.3	-137.4	-44.7	51.0	-123.0	-132.2	-39.4	55.3	-118.7	-127.9	-35.1
7	31.5	-142.5	-151.6	-57.5	43.9	-130.1	-139.2	-45.1	49.1	-124.9	-134.0	-39.9	53.4	-120.6	-129.7	-35.6
8	30.8	-143.2	-152.3	-57.0	42.3	-131.7	-140.8	-45.5	47.5	-126.5	-135.6	-40.3	51.8	-122.2	-131.3	-36.1
10	28.9	-145.0	-154.2	-57.0	39.7	-134.3	-143.4	-46.2	44.9	-129.1	-138.3	-41.1	49.1	-124.9	-134.0	-36.8
10	32.5	-141.5	-150.6	-53.4	40.2	-133.8	-143.0	-45.8	45.0	-129.0	-138.1	-40.9	49.2	-124.8	-134.0	-36.8
12	30.1	-143.8	-153.0	-54.2	37.9	-136.1	-145.2	-46.4	42.8	-131.2	-140.3	-41.5	47.0	-127.0	-136.2	-37.4
14	28.2	-145.8	-154.9	-54.8	36.1	-137.9	-147.1	-46.9	40.9	-133.1	-142.2	-42.1	45.1	-128.9	-138.0	-37.9
16	26.5	-147.4	-156.6	-55.3	34.4	-139.5	-148.7	-47.4	39.3	-134.7	-143.8	-42.5	43.5	-130.5	-139.6	-38.3
18	25.1	-148.8	-157.9	-55.6	33.0	-140.9	-150.1	-47.8	37.9	-136.1	-145.2	-42.9	42.1	-131.9	-141.0	-38.7
20	23.9	-149.9	-159.0	-55.8	31.8	-142.2	-151.3	-48.1	36.7	-137.3	-146.5	-43.2	40.8	-133.2	-142.3	-39.1
22	22.9	-150.9	-160.0	-55.9	30.7	-143.3	-152.4	-48.4	35.5	-138.5	-147.6	-43.6	39.7	-134.3	-143.4	-39.4
24	22.0	-151.7	-160.8	-56.0	29.6	-144.3	-153.4	-48.6	34.5	-139.5	-148.6	-43.8	38.6	-135.3	-144.5	-39.7
26	21.2	-152.5	-161.6	-56.1	28.7	-145.2	-154.4	-48.9	33.5	-140.5	-149.6	-44.1	37.7	-136.3	-145.4	-39.9
28	20.4	-153.2	-162.3	-56.2	27.8	-146.1	-155.2	-49.1	32.6	-141.3	-150.5	-44.3	36.8	-137.2	-146.3	-40.2
30	19.7	-153.8	-163.0	-56.2	27.0	-146.9	-156.0	-49.3	31.8	-142.2	-151.3	-44.5	36.0	-138.0	-147.2	-40.4

ANNEX 7: BROADCAST SERVICE

Tentative SRD limit for Analogue Broadcasting (AM) operating in the HF band

INTERFERENCE RANGE CALCULATION BY USING CILIR SOFTWARE

This program calculates the interference range of an
inductive loop system from the measured magnetic field
strength at a given measuring range according to the propagation
model given in the ERC Report 69.

For the calculation data about the groundwave propagation
from the ITU-R PN.368-7 has to be inputted as well as the
noise fieldstrength, which has been derived from the ITU-R
Recommendation P.372.
These data is supplied with this program as two graphics.
==

The input data are:
Frequency : 11600.00 kHz.
The magnetic field strength limit : -35.0 dBuA/m.
The measuring distance : 10.0 m.
The E_1kW@1km according ITU-R PN.368-7 : 89.0 dBuV/m.
The max. acceptable interference level : 10.0 dBuV/m.
The bandwidth of the victim receiver : 10000.00 Hz.

The results are:

The 20/40 dB/decade transition distance: 94.4 m.
Broadband interference; bandwidth ratio: -0.5 dB.

The field strength at the measuring position is maximal in
the coplanar direction.

Magnetic dipole momemt : 4.1e-005 A.m2.
The Effective radiated power : -129.4 dBkW / 1.2e-001 nW.
The interference range is limited to the 20 dB/dec. roll-off range.

The groundwave interference range is : 34 m.

===

Tentative SRD limit for Digital Radio Mondiale (DRM) operating in the HF band

INTERFERENCE RANGE CALCULATION BY USING CILIR SOFTWARE

This program calculates the interference range of an
inductive loop system from the measured magnetic field
strength at a given measuring range according to the propagation
model given in the ERC Report 69.

For the calculation data about the groundwave propagation
from the ITU-R PN.368-7 has to be inputted as well as the
noise fieldstrength, which has been derived from the ITU-R
Recommendation P.372.
These data is supplied with this program as two graphics.
==

The input data are:
Frequency : 11600.00 kHz.
The magnetic field strength limit : -40.0 dBuA/m.
The measuring distance : 10.0 m.
The E_1kW@1km according ITU-R PN.368-7 : 89.0 dBuV/m.
The max. acceptable interference level : 0.0 dBuV/m.
The bandwidth of the victim receiver : 10000.00 Hz.

The results are:

The 20/40 dB/decade transition distance: 94.4 m.
Broadband interference; bandwidth ratio: -0.5 dB.

The field strength at the measuring position is maximal in
the coplanar direction.

Magnetic dipole momemt : 2.3e-005 A.m2.
The Effective radiated power : -134.4 dBkW / 3.7e-002 nW.
The interference range is limited to the 20 dB/dec. roll-off range.

The groundwave interference range is : 60 m.
==

The input data are:
Frequency : 11600.00 kHz.
The magnetic field strength limit : -45.0 dBuA/m.
The measuring distance : 10.0 m.
The E_1kW@1km according ITU-R PN.368-7 : 89.0 dBuV/m.
The max. acceptable interference level : 0.0 dBuV/m.
The bandwidth of the victim receiver : 10000.00 Hz.

The results are:

The 20/40 dB/decade transition distance: 94.4 m.
Broadband interference; bandwidth ratio: -0.5 dB.

The field strength at the measuring position is maximal in
the coplanar direction.

Magnetic dipole momemt : 1.3e-005 A.m2.
The Effective radiated power : -139.4 dBkW / 1.2e-002 nW.
The interference range is limited to the 20 dB/dec. roll-off range.

The groundwave interference range is : 34 m.
==

ANNEX 8: COMMERCIALLY AVAILABLE AM AND DRM RECEIVERS

Figure A8.1: AM/FM receivers (LF,MF,HF and VHF ranges)

Figure A8.2: Mobile DRM receiver

ANNEX 9
CRAF POSITION - SPECTRAL FIELD STRENGTH LIMITS FOR INDUCTIVE SRD's BELOW 30 MHz NECESSARY TO PROTECT THE RADIO ASTRONOMY SERVICE

A9.1 GENERAL SCENARIO

During an observation, a radio astronomy telescope points towards a celestial radio source at a specific right ascension and declination corresponding with a specific azimuth and elevation at a certain moment in time. During this observation the pointing direction of the telescope is continuously adjusted to compensate for the rotation of the Earth. It is assumed that interference from a terrestrial transmitter is generally received through the sidelobes of the radio astronomy antenna (see below).

Inductive short range devices, SRD's, transmitting below 30 MHz may have impact on radio astronomy operations at these frequencies. The allocation status for radio astronomy in these bands is given in Table A9.1.

The ITU-R Recommendations taken as a basis for the compatibility study carried out are:

ITU-R **RA.769**: "*Protection Criteria used for Radioastronomical Measurements*";

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*".

ITU-R **P.525**: "*Calculation of free space attenuation*" while also the model for attenuation by atmospheric gases given in Recommendation ITU-R **P.676** has been taken into account.

Recommendation ITU-R **RA.769** assumes that the interference is received in a sidelobe of the antenna pattern, i.e. at a level of 0 dBi at 19º from boresight (see also Recommendation ITU-R **SA.509**). It should be noted that a radio telescope is an antenna with a very high gain, typically in the order of 70 dB. If interference is received via the main lobe of the antenna pattern, this high gain should also be taken into account. However, Recommendation ITU-R **RA.769** assumed that the chance that the interference is received by the main lobe of the antenna is low, and therefore uses the level of 0 dBi in the calculation of the levels of detrimental interference given in this Recommendation.

It is considered that the interference received at the radio telescope antenna shall not exceed the levels of detrimental interference given in Recommendation ITU-R **RA.769**.

A9.2. PROTECTION REQUIREMENTS

As noted above, the protection requirements for radio astronomy observations are given in Recommendation ITU-R **RA.769**. Radio astronomy observing programs are a mixture of spectral line or narrow band and continuum or broadband observations, which each have different protection requirements. Therefore, radio astronomy always needs to be protected according to the most stringent protection levels as specified for the Radio Astronomy Service in the frequency bands under consideration.

The protection criteria for the frequency bands below 30 MHz are given in Table A9.1 for continuum observations (broadband).

Frequency band (MHz)	Detrimental spfd (Rec. ITU-R **RA.769**) ($dB(Wm^{-2}Hz^{-1})$)
13.36 – 13.41 [2]	-248 [1]
25.55 – 25.67 [2]	-249 [1]

Table A9.1: Frequency bands allocated to the Radio Astronomy Service, and their protection requirements

Notes to the table: [1]: continuum observations (broadband)

[2]: RR No. 5.149 applies

Footnote **5.149** states for the identified frequency bands that "administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. **4.5** and **4.6** and Article **29**)".

The protection requirements for Radio Astronomy bands are given in Table A9.1.

A9.3. METHODOLOGY USED TO DETERMINE THE MAXIMUM TOLERABLE SPECTRAL FIELD STRENGTH PER SRD TRANSMITTER

The summation methodology described and used in ECC Report 64 on the "Protection Requirements of Radiocommunication Systems below 10.6 GHz from generic UWB Applications" is used to estimate the maximum tolerable spectral field strength of a SRD device. The calculations lead to a maximum tolerable e.i.r.p. per SRD device necessary to protect radio astronomy. This result was converted to maximum tolerable field strength @10 m using the conversion given in Annex 5 section 5.

Using a uniform density of devices transmitting in the direction of a radio astronomy station, and taking into account the probability of interference in the radio astronomy band, this leads to a spectral field strength, which depends explicitly on the density of SRD devices.

A9.4. INPUT PARAMETERS FOR THE CALCULATIONS.

For compatibility studies applicable to all European radio astronomy telescopes, it must be assumed that a radio telescope can point to all directions in the sky, i.e. that its azimuth can vary between 0º and 360º and its elevation angle between 0º and 90º. For terrestrial interferers in the interference scenario an elevation angle of 0º is assumed.

With the input parameters given in Table A9.2 the maximum tolerable spectral field strength per SRD device has been estimated for 100% activity, outdoor use and as a function of the density of SRD devices per km^2 from which emission is received by a radio astronomy antenna.

Maximum permissible spectral power flux density	From table A9.1
Radio astronomy antenna gain	0 dBi
Frequency	From table A9.1
Bandwidth	Allocation bandwidth
Minimum separation distance from radio telescope	30 meter [1]
Air pressure	1013 hPa
Temperature	20º C
Sea level refractivity	320
Water vapour density	3 g/cm^3
Maximum distance for calculations	20 km
Ring width	10 m

Table A9.2 : Input parameters

Note: [1] The smallest distance between a radio telescope and the edge of the territory of a radio astronomy station. For European radio astronomy stations this ranges from about 30 meters to a few hundred meters. To ensure protection for all European radio astronomy stations a value of 30 meter was taken.

The radio astronomy antenna gain was taken as 0 dBi as assumed in Recommendation ITU-R **RA.769**.

Radio astronomy must be protected from all SRD devices anywhere outside the extent of the radio astronomy station territory, whereas SRD devices are not equipped with a facility to determine their position. Results are given for a minimum separation distance of 30 meter.

The maximum distance of 20 km was adopted for free space attenuation calculations.

A9.5. RESULTS OF CALCULATIONS

The results of the calculations lead to the following analytical expression for the maximum tolerable spectral e.i.r.p. , ε, per inductive SRD device at frequencies below 30 MHz necessary to protect radio astronomy below 30 MHz:

$$\Phi_{max} = -10 * \log \rho + \varepsilon_o(f) \qquad \text{dBm/10 kHz}$$

where:

ρ = number of inductive SRD devices per km^2 from which emission is received by a radio astronomy antenna;

$\varepsilon_o(f)$ = the permissible interference for frequency f for $\rho = 1$ SRD device per km^2.
The values for $\Phi_o(f)$ are given in column 2 of Table A9.3.

frequency band (MHz)	ε_{max} dBm/10 kHz		
	$\rho = 1$ per km^2	$\rho = 100$ per km^2	$\rho = 10000$ per km^2
13.36 – 13.41 [2]	-123 [2]	-143 [2]	-163 [2]
25.55 – 25.67 [2]	-125 [2]	-145 [2]	-165 [2]

Table A9.3: Maximum tolerable e.i.r.p, ε_{max}, per SRD device as function of density ρ per km^{2}of SRD devices transmitting toward a radio astronomy antenna (some examples)

Notes to the table: [1]: continuum observations (broadband)
[2]: RR No. 5.149 applies

Applying the conversion relations given in Annex 5 section 5, this leads to:

$$\Phi_{max} = -10^* \log \rho + \Phi_o(f) \qquad \text{dB}(\mu\text{A/m})/10 \text{ kHz}$$

where:
ρ = number of inductive SRD devices per km^2 from which emission is received by a radio astronomy antenna;
$\Phi_o(f)$ = the permissible interference for frequency f for $\rho = 1$ SRD device per km^2.

The values for $\Phi_o(f)$ are given in column 2 of Table A9.4.

frequency band (MHz)	Φ_{max} dB(μA/m)/10 kHz [@ 10m]		
	$\rho = 1$ per km^2	$\rho = 100$ per km^2	$\rho = 10000$ per km^2
13.36 – 13.41 [2]	-90 [2]	-110 [2]	-130 [2]
25.55 – 25.67 [2]	-92 [2]	-110[2]	-130 [2]

Table A9.4: Maximum tolerable spectral field strength, Φ_{max}, per SRD device as function of density ρ per km^{2}of SRD devices transmitting toward a radio astronomy antenna (some examples)

Notes to the table: [1]: continuum observations (broadband)
[2]: RR No. 5.149 applies

For practical reasons it is assumed that all SRD devices have the same transmitting power. Obviously, the results apply only for those SRD devices from which emission is received by a radio astronomy antenna. We were not able to estimate the density of SRD devices to be used in practice because of the possible mitigation factors that might be taken into account in the conversion of ρ to this number.

A9.6. CONCLUSIONS

The protection criteria for radio astronomy for frequencies below 30 MHz imply separation distances exceeding ~13 km for a single device case operating at -5 dBμA/m@10m in 10 kHz (see section 3.2.1.5) calculated on the basis of ERC Report 69.

For an aggregate of inductive short range devices operating below 30 MHz the maximum tolerable spectral field strengths in the order of -112 dBμA/m/10 kHz @ 10m for a density of 100 devices per km^2 calculated on the basis of Recommendation ITU-R P.525.
CRAF considers that a generic limit for inductive systems below 30 MHz should take into account the protection requirements the protection requirements for radio astronomy for frequency bands allocated to radio astronomy. These lead to a generic limit of the order of –112 dBμA/m/10 kHz @ 10m. To the frequency bands concerned RR No.**5.149** applies.

As explained above, the basis for the calculations was Recommendation ITU-R P.525 and RA.769. If groundwave effects are fully taken into account some relaxation of the limits can be expected.

ANNEX 10: LIST OF REFERENCES

[1] ECC/Rec. 70-03: "Relating to the use of Short Range Devices (SRD)"

[2] ERC Report 69: "Propagation model and interference range calculation for inductive systems 10 kHz - 30 MHz."

[3] TR 102 378: "Equipment for identification and location systems; System Reference Document for inductive systems for industrial applications operating in the frequency range from 400 kHz to 600 kHz"

[4] EN 300 330: "Radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz"

[5] RECOMMENDATION ITU-R RA.769: "PROTECTION CRITERIA USED FOR RADIO ASTRONOMICAL MEASUREMENTS"

[6] Radio Regulations (RR) (see www.itu.int)

[7] http://www.lofar.org

[8] ERC/REP 074: "Compatibility between radio frequency identification devices (RFID) and the radioastronomy service at 13 MHz"

[9] ECC Report 003: "Fixed service in Europe - Current use and future trends POST-2002"

[10] ERC Report 040: "Fixed Service System Parameters For Frequency Sharing"

[11] ECC Report 24: "PLT, DSL, Cable Communications (including Cable TV), LANs and their effect on Radio Services"