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

COMPATIBILITY AND SHARING ANALYSIS BETWEEN DVB–T AND OB (OUTSIDE BROADCAST) AUDIO LINKS IN BANDS IV AND V

Edinburgh, October 2000

Executive Summary

This study assesses the compatibility between OB links and DVB–T in bands IV and V and determines the necessary separation distances between OB links and DVB–T as a function of frequency. The study takes account of three spectrum masks: the spectrum mask for sensitive cases according to the Chester Agreement, 1997[1] and the two spectrum masks recommended by SE PT 21[2]. The results are only valid for the DVB–T and OB links system parameters given in this study.

In order to establish if in a given set of circumstances:
- the DVB-T service and
- OB link usage at a given location

are compatible, the relevant separation distances derived in Sections 2 and 3, must be examined. If both separation distances are respected, then usage is compatible.

The main results of the study are as follows:

- In most cases, Co-channel operation (frequency difference from 0 to 4 MHz between the centre frequencies) of DVB–T and OB links within a DVB–T coverage area will cause unacceptable interference to OB links and vice-versa.

- For an operation of OB links in the 1st adjacent channel of DVB–T (frequency difference from 4 to 12 MHz between the centre frequencies), the necessary separation distances obtained in this study are quite large. Nevertheless, this study is based on worst case assumptions with no antenna discrimination, whereas, in practice, OB links use directional antennas that in most cases would improve the situation. Furthermore, OB links are generally planned in advance. Therefore, in some cases, first adjacent compatibility may be achieved for frequency separation greater than 4.5 MHz on a case by case basis.

- In practice, use of the 2nd adjacent channel by OB links will be possible in some cases, subject to a case by case analysis, allowed by the generally planned use of OB links.

All protection ratio measurements were limited to professional DVB–T receivers. The immunity of domestic receivers, particularly for adjacent channel rejection, is not yet known. Therefore the frequency separation needed between the future wanted DVB–T channel and OB links operation may change for domestic receivers.

These conclusions are based on the use of the sensitive spectrum mask specified in the Chester Agreement. The use of less stringent masks such as the SE PT 21 mask will increase the required separation distances in the adjacent channels.

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[1] The Chester 1997 Multilateral Coordination Agreement relating to Technical Criteria, Coordination Principles and Procedures for the introduction of Terrestrial Digital Video Broadcasting (DVB-T), Chester, 25 July 1997

[2] Limits for out-of-band emissions adopted by CEPT SE PT 21.

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COMPATIBILITY AND SHARING ANALYSIS BETWEEN DVB–T AND OB (OUTSIDE BROADCAST) AUDIO LINKS IN BANDS IV AND V

1 INTRODUCTION

The aim of this compatibility analysis is to determine the interference potential of DVB–T transmissions with regard to OB[1] link reception (see Section 2) and OB link transmissions with regard to DVB-T reception (see Section 3). For this purpose, the necessary separation distances between OB links and DVB–T as a function of the frequency separation between the two applications are determined. Section 4 of this document uses the results from Sections 2 and 3 to produce overall conclusions with regard to compatibility between DVB-T and OB links.

2 INTERFERENCE SCENARIO: DVB–T INTERFERES WITH OB LINKS

All compatibility results and conclusions are valid only for the system parameters given below. In case of changes, new calculations are necessary.

2.1 Calculations with the system parameters according to the Chester Agreement

2.1.1 DVB–T system parameters

DVB–T e.r.p.:	100 W, 200 W, 1 kW, 2 kW, 10 kW, 20 kW, 100 kW;	
DVB–T effective antenna heights:	150 m, 300 m.	
Modulation:	16 QAM, 64 QAM and QPSK	(no influence on results)
Number of carriers:	2k, 8k	(no influence on results)
Bandwidth:	8 MHz	
Shoulder attenuation:	50 dB	

Spectrum mask:

Breakpoints	
Relative frequency (MHz)	**Relative level dB**
-12	-87.2
-6	-62.2
-4.2	-50.2
-3.8	0
+3.8	0
+4.2	-50.2
+6	-62.2
+12	-87.2

Table 1: Spectrum mask

Note: The out of channel values in this spectrum mask correspond to the breakpoints in Figure A1.2 in the Chester Agreement (8 MHz channel in the sensitive case). The value of 3.8 MHz was used because it is more accurate than the value given in the Chester Agreement (In Chester, the true value of 3.81 MHz was rounded up to 3.9 MHz).

[1] Outside Broadcast is the temporary provision of program making facilities at the location of ongoing news, sport, or other events, lasting from a few hours to several weeks. This report addresses audio links only; further information can be found in ERC Report 42.

2.1.2 OB link system parameters

The parameters in the table below are given in Annex 5 of the Chester Agreement.

Wanted:	OB link (stereo non-companded)		Default field strength to be protected (dBμV/m)		86	Default receiving antenna height (m)			10
Service Identifier		NS8	at frequency (MHz)		650				
Unwanted	DVB–T/8 MHz								
Δf (MHz)	-12.0	-10.0	-8.0	-6.0	-4.2	-3.8	-3.6	0.0	3.6	3.8
PR (dB)	-18.0	-17.0	-12.0	-9.0	-5.0	36.0	43.0	43.0	43.0	36.0
Δf (MHz)	4.2	6.0	8.0	10.0	12.0					
PR (dB)	-5.0	-9.0	-12.0	-17.0	-18.0					

Table 2: Protection ratios for OB links at 650 MHz

The values in the table above are valid for OB links operating at 650 MHz. For OB links operating at other frequencies, the default field strength to be protected is obtained, using the following extrapolation equation :

$$E(f) = E(650) + 20\log_{10}(f/650),$$

where f is the frequency in MHz, E(650) the field strength at 650 MHz and E(f) the field strength at the wanted frequency.

2.1.3 Considered interference scenario

The OB link equipment are used outdoor. Therefore, this study is only related to this scenario.

No building attenuation is taken into account. OB link receiving antenna heights of 10 m and 40 m are assumed.

The analysis is based on the propagation curve in Rec. ITU-R P.370, Figure 11 (1% of time, 50% of location). This propagation curve applies for a receiving antenna height of 10 m.

For an OB link receiving antenna height of 40 m, a correction factor needs to be considered (corr_height), which is given in the Annex 1 of Rec. ITU-R P.370 (formula 5) :

$$\text{corr\_height} = (c/6).20\log_{10}(h/10),$$

where h is the receiving antenna height and c is a gain factor depending on the frequency range and the environment. In band IV and V, considering a rural environment, this gain factor is equal to 4, which leads to the following value for corr_height :

$$\text{corr\_height} = 8 \text{ dB}.$$

The Rec. ITU-R P.370 curve does not apply to distances of less than 10 km. The curves for the effective antenna heights of 150 m and 300 m were therefore extrapolated to the free-space propagation curve for distances of less than 10 km (to explain the interpolation procedure, the curves for a DVB-T transmitter of ERP of 1kW are displayed in Annex 1).

2.1.4 Results for an 8 MHz DVB–T signal

Diagrams 1 to 4 and Tables 3a, 3b, 3c and 3d show the required separation distance as a function of the frequency separation, the DVB-T e.r.p., the DVB-T effective transmitting antenna height and the OB link effective receiving antenna height.

The results show that the required separation distances from a DVB-T transmitter in the range 0 to 3.8 MHz from the centre of a DVB-T channel are very large and, although there is a rapid transition to shorter separation distances in the range of frequency separations from 3.8 to about 4.2 MHz i.e., from co - channel to adjacent channel operation, these distances are still considerable.
Nevertheless, this study is based on worst case assumptions with no antenna discrimination, in practice, OB links use directional antennas that in many cases would improve the situation.
Furthermore, OB links are generally planned in advance, so compatibility may be achieved in some cases for frequency separation greater than 4.2 MHz.

The separation distances given in Section 3, however, must also be respected.

Diagram 1

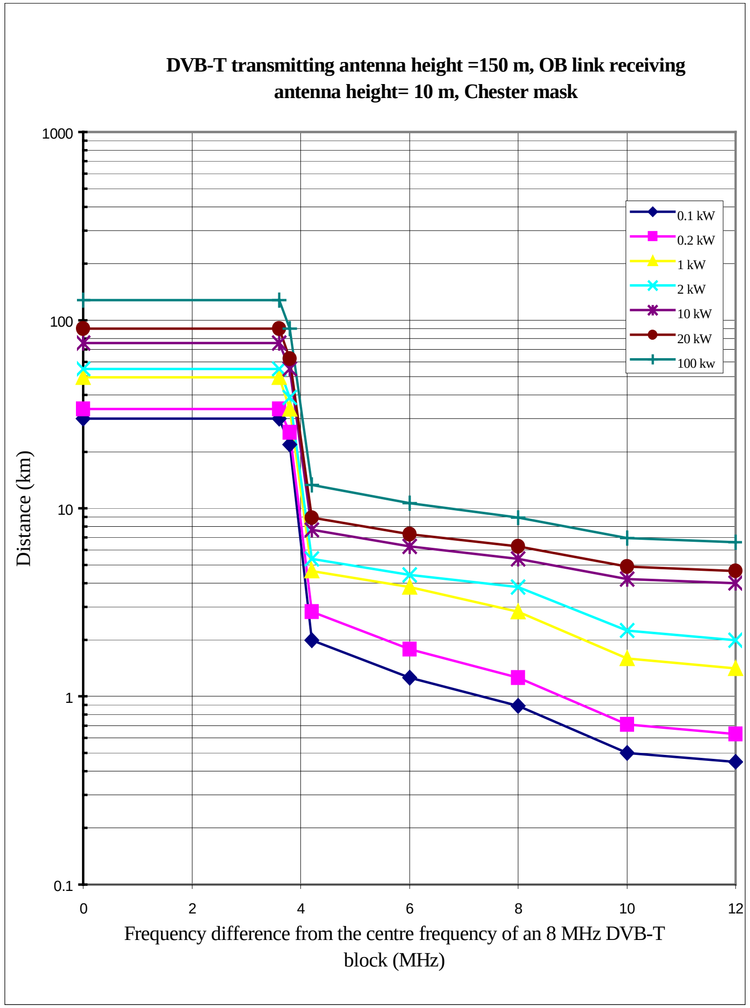


Diagram 2

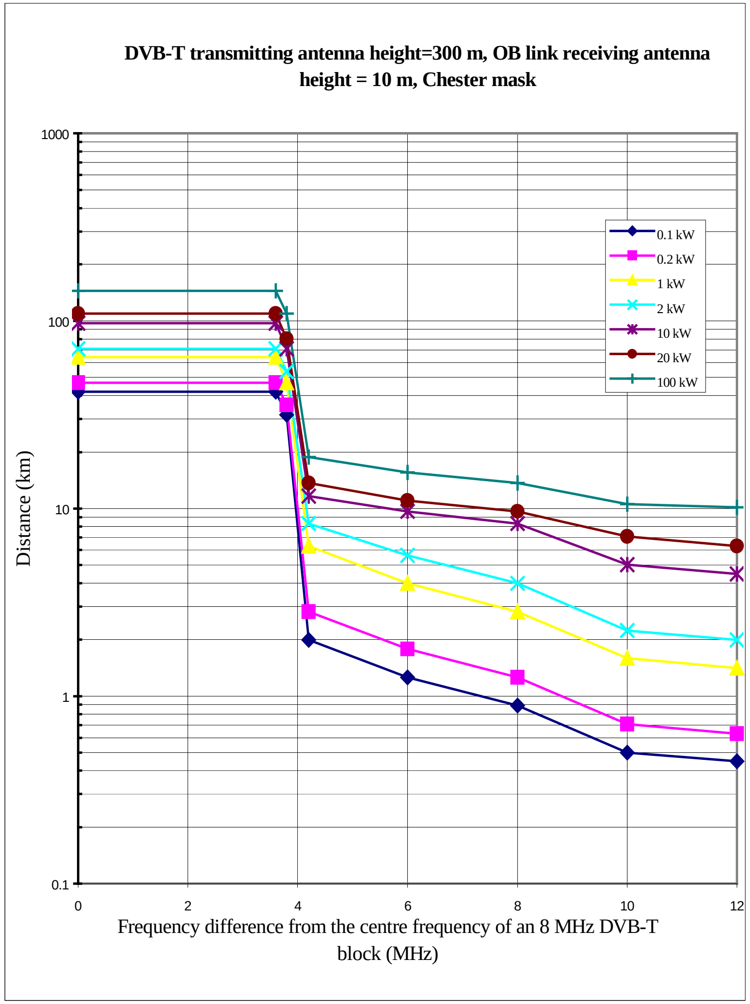


Diagram 3

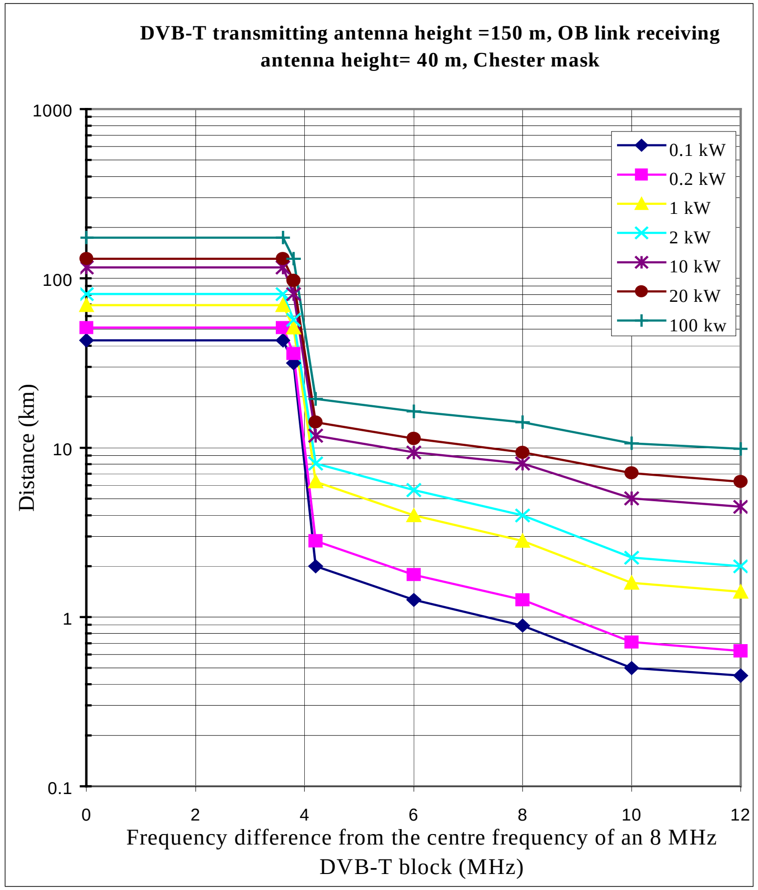
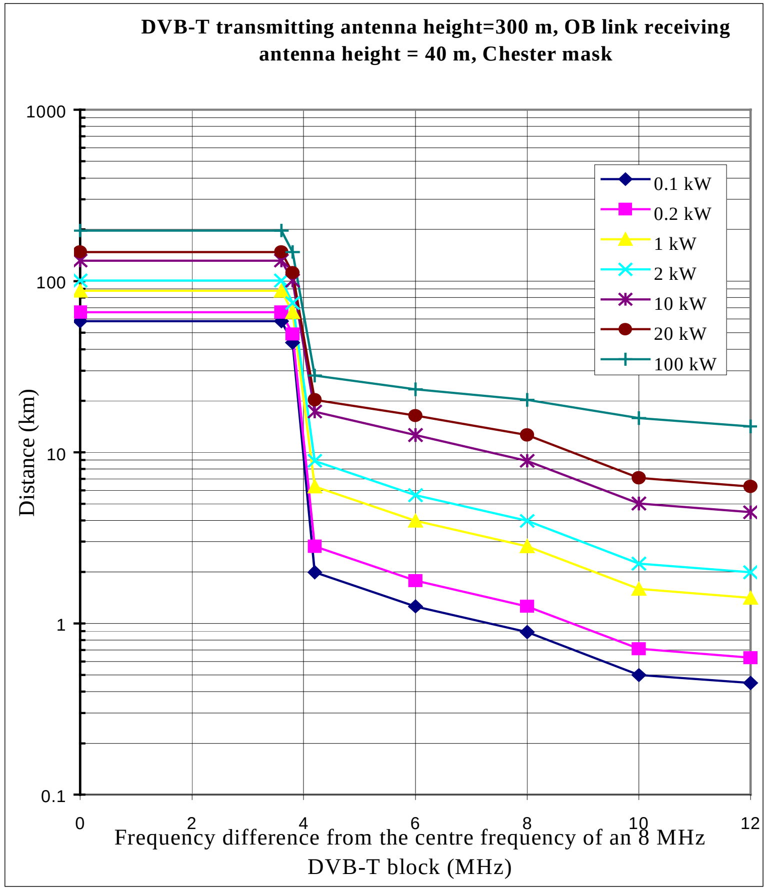


Diagram 4



Necessary separation distances in km between DVB–T and OB links in bands IV and V

	DVB–T e.r.p.						
Frequency difference (MHz)	**0.1 kW**	**0.2 kW**	**1 kW**	**2 kW**	**10 kW**	**20 kW**	**100 kW**
3.6	30.0	33.8	49.8	55.2	75.7	90.2	128
3.8	21.9	25.3	33.8	38.9	55.2	62.4	90.2
4.2	2.00	2.82	4.65	5.4	7.67	8.91	13.3
6.0	1.26	1.78	3.81	4.42	6.28	7.29	10.6
8.0	0.89	1.26	2.82	3.81	5.4	6.28	8.91
10.0	0.5	0.71	1.59	2.24	4.21	4.89	6.94
12.0	0.45	0.63	1.41	1.99	4	4.65	6.6

Table 3a : Chester mask, DVB-T transmission antenna height = 150 m, OB link reception antenna height = 10 m.

	DVB–T e.r.p.						
Frequency difference (MHz)	**0.1 kW**	**0.2 kW**	**1 kW**	**2 kW**	**10 kW**	**20 kW**	**100 kW**
3.6	42.0	46.7	64.0	71	97.2	109.3	144.8
3.8	31.6	35.6	46.7	53.6	71	80.2	109.3
4.2	1.99	2.82	6.31	8.31	11.6	13.7	18.8
6.0	1.26	1.78	3.98	5.62	9.66	11.0	15.6
8.0	0.89	1.26	2.82	3.98	8.31	9.66	13.7
10.0	0.5	0.71	1.59	2.24	5.02	7.08	10.6
12.0	0.45	0.63	1.41	1.99	4.47	6.31	10.1

Table 3b : Chester mask, DVB-T transmission antenna height = 300 m, OB link reception antenna height = 10 m.

Necessary separation distances in km between DVB–T and OB links in bands IV and V

	DVB–T e.r.p.						
Frequency difference (MHz)	**0.1 kW**	**0.2 kW**	**1 kW**	**2 kW**	**10 kW**	**20 kW**	**100 kW**
3.6	42.9	51.1	69.3	80.8	116.0	130.8	174.3
3.8	31.6	35.9	51.1	56.9	80.7	97.0	130.8
4.2	1.99	2.82	6.31	8.06	11.8	14.2	19.4
6.0	1.26	1.78	3.98	5.62	9.37	11.3	16.4
8.0	0.89	1.26	2.82	3.98	8.06	9.37	14.2
10.0	0.5	0.71	1.59	2.24	5.01	7.08	10.6
12.0	0.45	0.63	1.41	1.99	4.47	6.31	9.85

Table 3c : Chester mask, DVB-T transmission antenna height = 150 m, OB link reception antenna height = 40 m.

	DVB–T e.r.p.						
Frequency difference (MHz)	**0.1 kW**	**0.2 kW**	**1 kW**	**2 kW**	**10 kW**	**20 kW**	**100 kW**
3.6	58.2	65.7	87.5	100.5	131.9	148.3	197.4
3.8	43.7	49	65.7	74.5	100.5	111.9	148.2
4.2	1.99	2.82	6.31	8.91	17.31	20.2	28.0
6.0	1.26	1.78	3.98	5.62	12.6	16.4	23.3
8.0	0.89	1.26	2.82	3.98	8.91	12.6	20.2
10.0	0.5	0.71	1.59	2.24	5.01	7.08	15.8
12.0	0.45	0.63	1.41	1.99	4.47	6.31	14.1

Table 3d : Chester mask, DVB-T transmission antenna height = 300 m, OB link reception antenna height = 40 m.

2.2 Calculations with the DVB-T spectrum masks adopted by CEPT SE PT 21 for out-of-band emissions

2.2.1 DVB–T system parameters

DVB–T e.r.p.:	100 W, 200 W, 1 kW, 2 kW, 8 kW, 10 kW, 20 kW, 100 kW	
DVB–T effective antenna heights:	150 m, 300 m	
Assumed antenna gain:	0-10 dBd	
Modulation:	16 QAM, 64 QAM and QPSK	(no influence on results)
Number of carriers:	2k, 8k	(no influence on results)
Bandwidth:	8 MHz	
Shoulder attenuation:	35 dB	

Spectrum mask:

Breakpoints	**Pout = 9-29 dBW**	**Pout = 39-50 dBW**
Relative frequency (MHz)	**Relative level dB**	
- 20	-56.2	-66.2
-12	-48.2	-58.2
-4.2	-35	-35
-3.9	0	0
+3.9	0	0
+4.2	-35	-35
+12	-48.2	-58.2
+20	-56.2	-66.2

Table 4: Spectrum masks

Note: The values of the DVB-T transmitter output power (Pout) in this spectrum mask correspond to the breakpoints adopted by SE PT 21 for out-of-band emissions.

It was necessary to assume a DVB-T antenna gain in order to calculate the DVB-T e.r.p for the analysis of compatibility. The antenna gain relative to a half-wave dipole was assumed to be 0-10 dB. Some of the DVB-T e.r.p. values are therefore higher than Pout.

2.2.2 OB links system parameters

The following parameters were obtained by averaging results from a series of measurements.

Default field strength to be protected	86 dB(µV/m)
Default receiving antenna height	10 m
Transmitter frequency:	605.67 MHz

Frequency difference (in MHz)	Protection ratio	
	Pout = 9-29 dBW	Pout = 39-50 dBW
0	45 dB	45 dB
± 2	44 dB	44 dB
± 3.8	40 dB	40 dB
± 4.2	8 dB	8 dB
± 6.0	7 dB	6 dB
± 8.0	2 dB	2 dB
± 10.0	-5 dB	-6 dB
± 12.0	-7 dB	-13 dB
± 20.0	-15 dB	-19 dB

Table 5: Protection ratios

These values of protection ratios have been obtained from a full set of recent measurements. It is noted that in the co-channel case, the measured value (45 dB) is slightly different from the one obtained with the sensitive Chester mask (43 dB).

2.2.3 Considered interference scenarios

The same outdoor operation scenario as described in Section 2.1.3 is considered, with two possible values for the DVB-T transmission antenna height (150 and 300 m) and two possible values for the OB link reception antenna height (10 and 40 m).
However, there are two SE PT 21 spectrum masks for out-of-band emissions: the first mask applies to a DVB-T transmission output power of 9-29 dBW and the second to a DVB-T transmission output power of 39-50 dBW. For power levels between 29 and39 dBW, a variable mask is used to provide a smooth transition. Statements about compatibility therefore need to distinguish between these two cases.

2.2.4 Results for an 8 MHz DVB–T signal

Diagrams 5a/5b, 6a/6b, 7a/7b and 8a/8b and Tables 6a/6b/6c/6d show the required separation distance as a function of the frequency separation, the DVB-T e.r.p. ,the DVB-T effective transmitting antenna height and the OB link effective receiving antenna height.

Results are presented for each of the two SE21 masks. In the case of DVB-T with 8kW ERP, two results are presented :
- One for Pout = 29 dBW with 10 dB antenna gain
- One for Pout = 39 dBW with no antenna gain.

The results are different due to the differences in the transmitter masks.

The results show that the required separation distances from a DVB-T transmitter to an OB link receiver are, in this case, larger than when considering DVB-T Chester mask, following the same rapid transition as in Section 2.1.4. The separation distances in the range 0 to 3.8 MHz from the centre of a DVB-T channel are very large and, although there is a rapid transition to shorter separation distances in the range of frequency separations from 3.8 to about 4.2 MHz i.e., from co - channel to adjacent channel operation, these distances are still considerable.
Nevertheless, this study is based on worst case assumptions with no antenna discrimination, in practice, OB links use directional antennas that in many cases would improve the situation.
Furthermore, OB links are generally planned in advance, so compatibility may be achieved in some cases for frequency separation greater than 4.2 MHz.

For a full conclusion, the separation distances given in Section 3, however, must also be respected.

Diagram 5a

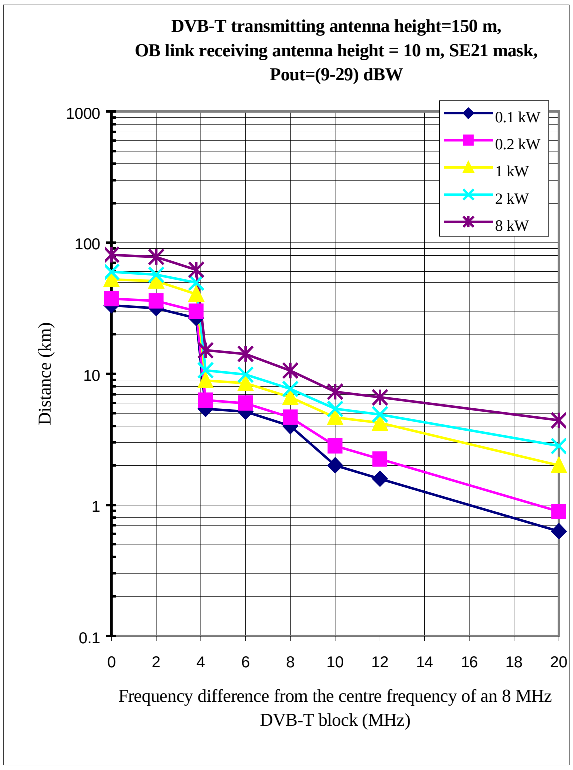


Diagram 5b

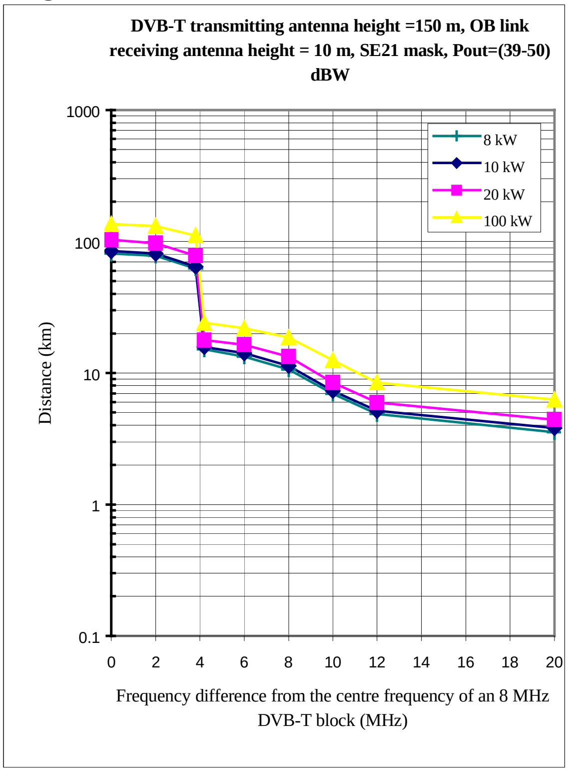


Diagram 6a

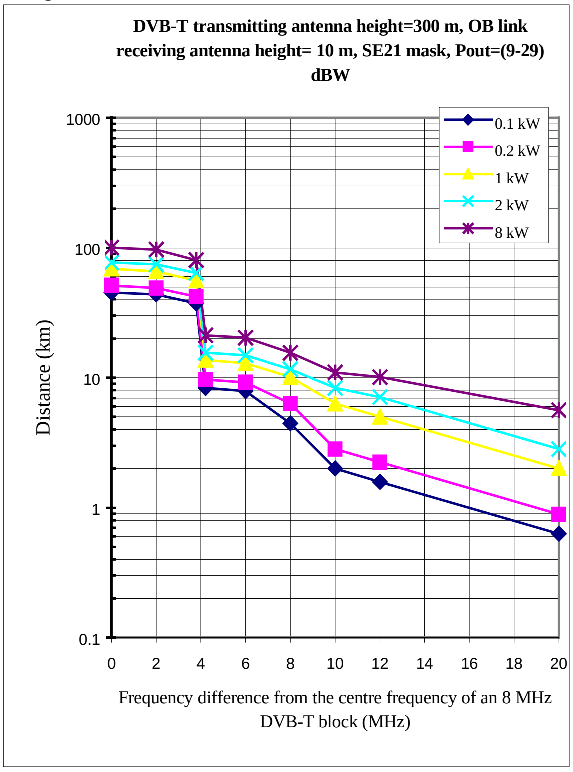


Diagram 6b

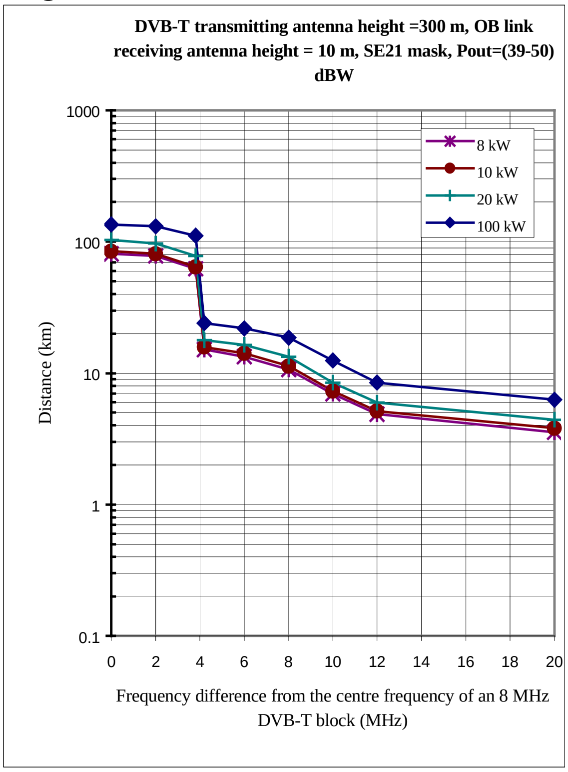


Diagram 7a

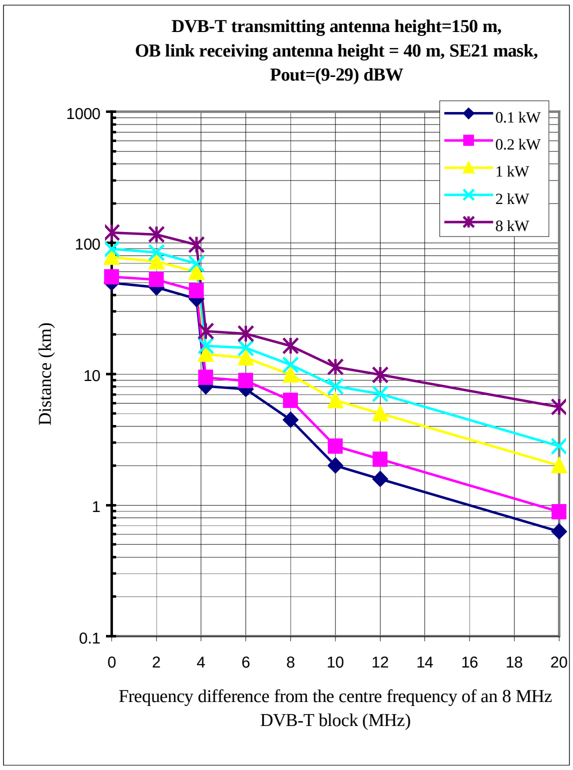


Diagram 7b

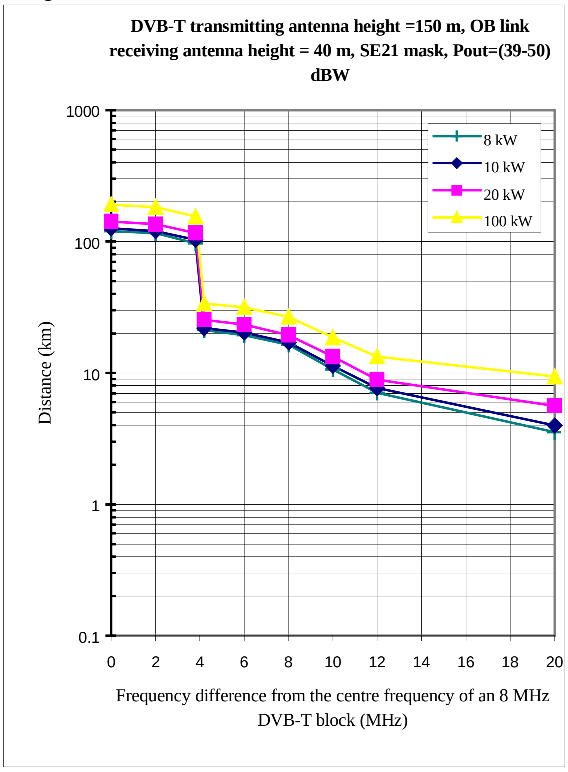


Diagram 8a

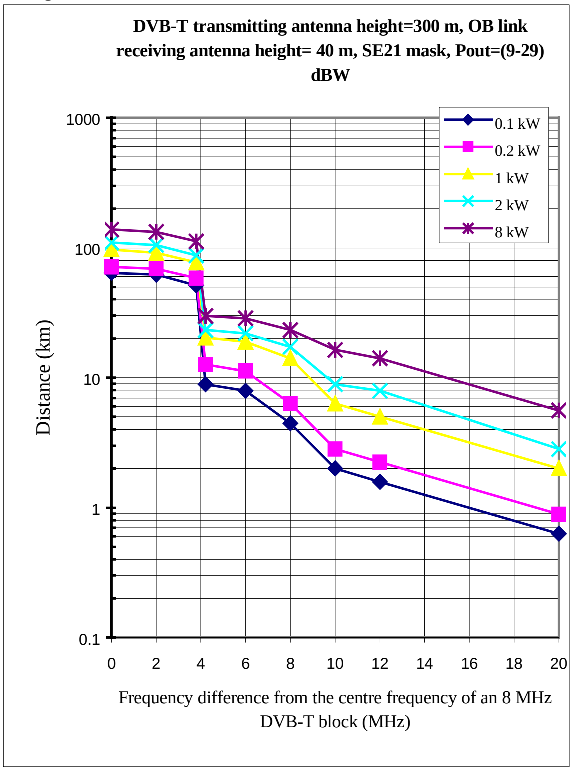
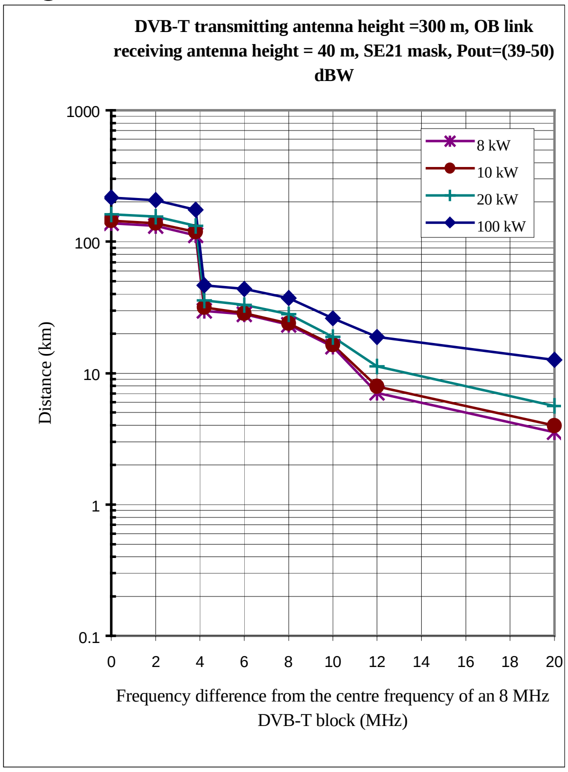


Diagram 8b



Necessary separation distances in km between DVB–T and OB links in bands IV and V

	DVB-T e.r.p								
SE PT 21 mask	(Pout_max = 9-29 dBW)					(Pout_max = 39-50 dBW)			
Frequency difference (MHz)	0.1 kW	0.2 kW	1 kW	2 kW	8 kW	8 kW	10 kW	20 kW	100 kW
0.00	33.3	37.4	52.6	59.7	80.7	80.7	84.5	102.9	135.5
2.00	31.6	35.9	51.1	56.9	77.9	77.9	80.7	97.0	130.8
3.80	26.6	30.0	40.45	49.7	62.1	62.1	64.3	77.9	110.9
4.20	5.4	6.3	8.91	10.6	15.1	15.1	15.8	17.8	24
6.00	5.1	6.0	8.48	9.85	14.2	13.3	14.2	16.4	21.9
8.00	4	4.65	6.6	7.67	10.6	10.6	11.3	13.3	18.6
10.00	2	2.82	4.65	5.4	7.3	6.94	7.29	8.48	12.5
12.00	1.6	2.24	4.21	4.89	6.6	4.88	5.14	5.97	8.48
20.00	0.6	0.89	2	2.82	4.42	3.55	3.81	4.42	6.28

Table 6a : SE21 masks, DVB-T transmission antenna height = 150 m, OB link reception antenna height = 10 m

	DVB-T e.r.p								
SE PT 21 mask	(Pout_max = 9-29 dBW)					(Pout_max = 39-50 dBW)			
Frequency difference (MHz)	0.1 kW	0.2 kW	1 kW	2 kW	8 kW	8 kW	10 kW	20 kW	100 kW
0.00	45.3	51.4	68.9	76.7	100.5	100.5	104.8	118.8	154.7
2.00	43.7	49	65.7	74.5	97.2	97.2	100.5	111.9	148.3
3.80	37.2	42.0	55.9	64.0	80.2	80.2	82.8	97.2	128.1
4.20	8.31	9.66	13.7	15.6	21.2	21.2	21.9	25.1	33.8
6.00	7.9	9.18	12.9	14.9	20.25	18.8	20.2	23.3	31.6
8.00	4.47	6.31	10.1	11.6	15.6	15.6	16.4	18.8	26.0
10.00	2	2.82	6.31	8.31	11.0	10.6	11.0	12.9	18.0
12.00	1.58	2.24	5.01	7.08	10.1	7.08	7.9	9.18	12.9
20.00	0.63	0.89	2	2.82	5.62	3.55	3.98	5.62	9.66

Table 6b : SE21 masks, DVB-T transmission antenna height = 300 m, OB link reception antenna height = 10 m

Necessary separation distances in km between DVB–T and OB links in bands IV and V

	DVB-T e.r.p								
SE PT 21 mask	(Pout_max = 9-29 dBW)					(Pout_max = 39-50 dBW)			
Frequency difference (MHz)	0.1 kW	0.2 kW	1 kW	2 kW	8 kW	8 kW	10 kW	20 kW	100 kW
0.00	49.7	55.2	77.9	89.6	119.9	119.9	125.7	142.2	191.2
2.00	45.6	52.6	72.2	84.5	116.0	116.0	119.9	135.5	182.3
3.80	37.4	42.9	59.7	69.3	97.0	97.0	102.9	116.0	154.7
4.20	8.06	9.37	14.2	16.4	21.2	21.2	21.9	25.4	33.8
6.00	7.67	8.91	13.3	15.8	20.3	19.4	20.3	23.3	31.6
8.00	4.47	6.31	9.85	11.8	16.4	16.4	17.0	19.4	26.6
10.00	2	2.82	6.31	8.06	11.3	10.6	11.3	13.3	18.6
12.00	1.58	2.24	5.01	7.08	9.85	7.08	7.67	8.91	13.3
20.00	0.63	0.89	2	2.82	5.62	3.55	3.98	5.62	9.37

Table 6c : DVB-T transmission antenna height = 150 m, OB link reception antenna height = 40 m, SE21 masks

	DVB-T e.r.p								
SE PT 21 mask	(Pout_max = 9-29 dBW)					(Pout_max = 39-50 dBW)			
Frequency difference (MHz)	0.1 kW	0.2 kW	1 kW	2 kW	8 kW	8 kW	10 kW	20 kW	100 kW
0.00	63.9	71	97.2	109.3	138.4	138.4	144.8	161.2	216.3
2.00	61.8	68.9	91.3	104.8	131.9	131.9	138.4	154.7	207.2
3.80	51.4	58.2	76.7	87.5	111.9	111.9	118.8	131.9	175.3
4.20	8.91	12.6	20.2	23.3	29.8	29.8	31.6	35.6	46.7
6.00	7.94	11.2	18.84	21.9	28.6	28.0	28.5	33.1	43.7
8.00	4.47	6.31	14.12	17.3	23.3	23.3	23.9	28.0	37.2
10.00	2	2.82	6.31	8.91	16.4	15.84	16.4	18.8	26.0
12.00	1.58	2.24	5.01	7.94	14.1	7.08	7.94	11.2	18.8
20.00	0.63	0.89	2	2.82	5.6	3.55	3.98	5.62	12.6

Table 6d : DVB-T transmission antenna height = 300 m, OB link reception antenna height = 40 m, SE21 masks

3 INTERFERENCE SCENARIO: OB LINKS INTERFERE WITH DVB–T

3.1 OB link system parameters

A signal generator having the following modulation characteristics was used as the interferer to simulate an OB link transmitter.

Baseband input:	1 kHz sinusoidal
Modulation:	FM, deviation 40.0 kHz; UK measurements
	FM, deviation 75.0 kHz; German measurements

3.2 DVB–T system parameters

DVB–T receiver:	Professional type (NDS system 3000)
UK measurements:	
RF wanted DVB–T levels:	DVB–T Modes
-46.0 dBm:	2k, 16 QAM, FEC 3/4, guard interval 1/32 (measurement 1)
-52.0 dBm:	2k, 16 QAM, FEC 3/4, guard interval 1/32 (measurement 2)
GER measurements:	
RF wanted DVB–T levels:	DVB–T Modes
-66.0 dBm:	2k, QPSK, FEC 2/3
	2k, 16 QAM, FEC 1/2
	2k, 16 QAM, FEC 2/3
	2k, 64 QAM, FEC 1/2
	2k, 64 QAM, FEC 2/3
Baseband I/P:	MPEG-2 transport stream
Interference criterion:	BER 2E-4 after Viterbi decoder

Note that these are a small sub-set of all the variants shown in the DVB specification. They were chosen purely for convenience of measuring and may not represent currently preferred systems.

3.3 Calculations and considered interference scenario

3.3.1 Measurement results for the protection ratio values

The necessary protection ratio values for DVB–T professional receivers were measured by the United Kingdom and Germany. The results are shown in the table below.

Frequency difference (MHz)	Protection ratios (dB)		
	UK measurement results		German measurement results
	wanted DVB–T RF level **-46 dBm** Modulation 2k, 16 QAM, FEC 3/4 (measurement 1)	wanted DVB–T RF level **-52 dBm** Modulation 2k, 16 QAM, FEC 3/4 (measurement 2)	wanted DVB–T RF level **-66 dBm** Modulation 2k, QPSK, FEC 2/3 2k, 16 QAM, FEC 1/2 or 2/3 2k, 64 QAM, FEC 1/2 or 2/3
0	-3	-3	-4 to -10 (*)
± 2.0	-4	-4	--
± 3.8	-9	-10	--
± 4.5	-37	-36	--
± 6.0	-51	-45	--
± 7.0	-52	-48	--
± 8.0	-53	-52	--

Table 9: protection ratio measurement results for DVB–T receivers

(*): This depends on the DVB mode (FEC 2/3 for 2k QPSK, FEC 1/2 and 2/3 for 2k16 QAM and 2k 64QAM).
--: Only the co-channel protection ratios were measured.

The differences in measured protection ratios for 6 and 7 MHz difference are unexpected and must be due to receiver effects that can not be explained theoretically.
In this context it is important to mention that the wanted DVB–T level in the measurements differed from those given in the Chester Agreement. In what way this fact affects the protection ratio values, especially for the adjacent channel, is not yet known.
Furthermore it must be mentioned that the values were measured for professional and not for domestic DVB–T receivers. As the immunity of future domestic receivers is not yet known, the results for such receivers may change.

All further calculations were based on the protection ratio values in column 3 of table 9 for 16 QAM modulation with a code rate of ¾ for a 2k-system. This column contains the worst protection ratio values for the different interference situations and unlike column 4 gives a complete set of values for the adjacent channel.

While other system variants like 64QAM have higher protection ratios, they also need a higher wanted signal level resulting in similar permissible interference levels due to a cancellation of the two effects. Conclusions from this study are therefore also valid for other DVB-T systems.

*3.3.2 **Description of the interference scenario***

In practice there are many different interference scenarios. In this report only the critical case was considered, namely the fixed DVB-T reception condition.

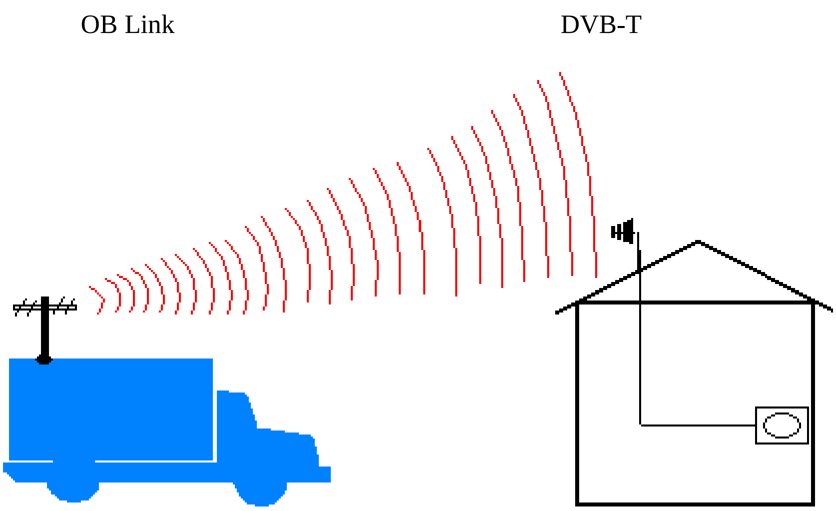


Figure 1

Another possible scenario is portable DVB-T reception and outdoor OB links operation: Preliminary studies showed that this condition gives shorter separation distances than the fixed case, i. e. if the fixed reception conditions are satisfied then portable is also possible.

3.3.3 Maximum permissible interfering field strength at the DVB-T receiving location for fixed reception

The minimum equivalent field strength at the receiving place depends on the modulation and code rate of the DVB–T signal. As mentioned above in the paragraph 3.3.1 on further calculations 2k, 16 QAM and the code rate ¾ were chosen. This system variant corresponds to "B3" in table A1.1 of the Chester Agreement. The required C/N for a BER = $2*10^{-4}$ after the Viterbi decoder is 13 dB for fixed reception (Ricean channels). With this C/N value plus the implementation margin of 3 dB (16 dB) the corresponding minimum median equivalent field strength for bands IV and V can be determined. The tables A1.6 and A1.7 in the Chester Agreement are important in this context:

Minimum median equivalent field strength (E_{med}) for DVB-T at 10 m a.g.l. 50% of time and 50% of locations	Band IV (f = 500 MHz)	Band V (f = 800 MHz)
fixed reception	49 dB(µV/m)	53 dB(µV/m)

Table 10: Minimum median equivalent field strength for DVB-T (location probability of 95 %)

The maximum permissible interfering field strength at the DVB-T receiving location, E_{max_int} ,can be calculated as;

$E_{max\_int} = E_{med} - C/I - Lc$

where

Emed is the minimum median equivalent field strength in table 10
C/I is the measured protection ratio value in table 9
Lc is the location correction factor in table 11

– Location correction factor (the corresponding values are given in table 11 below). Different location correction factors for short and long distances between DVB–T and the OB links have to be taken. This is necessary because the standard deviation “τ” especially of the interfering signal depends on the separation distance between the two services. The calculation of the location correction factor is described below:

  Long distance (> 100m):

$$Lc = \mu * \sqrt{(\tau_{DVB-T})^2 + (\tau_{OBlink})^2} = 1.64 * \sqrt{(5.5)^2 + (5.5)^2} \approx 13dB$$

  Short distance (≤ 100m):

$$Lc = \mu * \sqrt{(\tau_{DVB-T})^2 + (\tau_{OBlink})^2} = 1.64 * \sqrt{(5.5)^2 + (0)^2} \approx 9dB$$

  µ: distribution factor
  τ_{DVB-T} and τ_{OBlink}: standard deviations of the distribution

– For longer distances, a standard deviation of the distribution applies to both the wanted and unwanted signal, whereas for short distances the standard deviation of the distribution for the unwanted signal (i.e. the OB link signal) is 0 dB.

Location correction factors to be applied are:

Victim DVB-T Reception Condition from OB link	Location correction factor in dB	
	Short Separation Distance	Long Separation Distance
Fixed Reception	9	13

Table 11: Location correction factors

DVB-T Reception Condition: Fixed, E_{med} = 49 dB(µV/m)

Frequency difference (MHz)	Maximum permissible interfering field strength at the receiving location, dB(µV/m)	
	Short Separation Distance (≤ 100 m)	Long Separation Distance (> 100 m)
0	43	39
± 2.0	44	40
± 3.8	50	46
± 4.5	76	72
± 6.0	85	81
± 7.0	88	84
± 8.0	92	88

Table 12 a: Band IV (A1.6 from Chester)

DVB-T Reception Condition: Fixed, E_{med} = 53 dB(µV/m)

Frequency difference (MHz)	Maximum permissible interfering field strength at the receiving location, dB(µV/m)	
	Short Separation Distance (≤ 100 m)	Long Separation Distance (> 100 m)
0	47	43
± 2.0	48	44
± 3.8	54	50
± 4.5	80	76
± 6.0	89	85
± 7.0	92	88
± 8.0	96	92

Table 12b: Band V (A1.7 from Chester)

Note:
The values are valid for 500 MHz (Band IV) and 800 MHz (Band V). Values at other frequencies may be obtained from a conversion factor of,

20 log Fr/Fx dB,

where Fr is the required frequency, Fx is the reference frequency for the considered band.

3.3.4 Calculation of the equivalent radiated power of the OB links

In this report, the following characteristics have been assumed for the OB link transmitters :
Maximum e.i.r.p. : 16 dBW including an antenna gain of 6 dBi.

The OB link transmitting antenna is supposed to be a 10m mast.

3.3.5 Determination of the propagation model

The propagation model for the calculation of the interference from OB links transmitters to DVB–T receivers was based on free-space propagation for distances < 800 m between the two services.
For distances between 800 m and 4 km, the propagation loss is generally higher than for free space attenuation. The higher propagation loss is due to clutter and topography. Therefore in this calculation a propagation loss of 30 dB per decade was assumed. In the case of separation distances greater than 4 km a propagation loss of 40 dB per decade was chosen from the two-ray model.

The diagram below illustrates the propagation model.

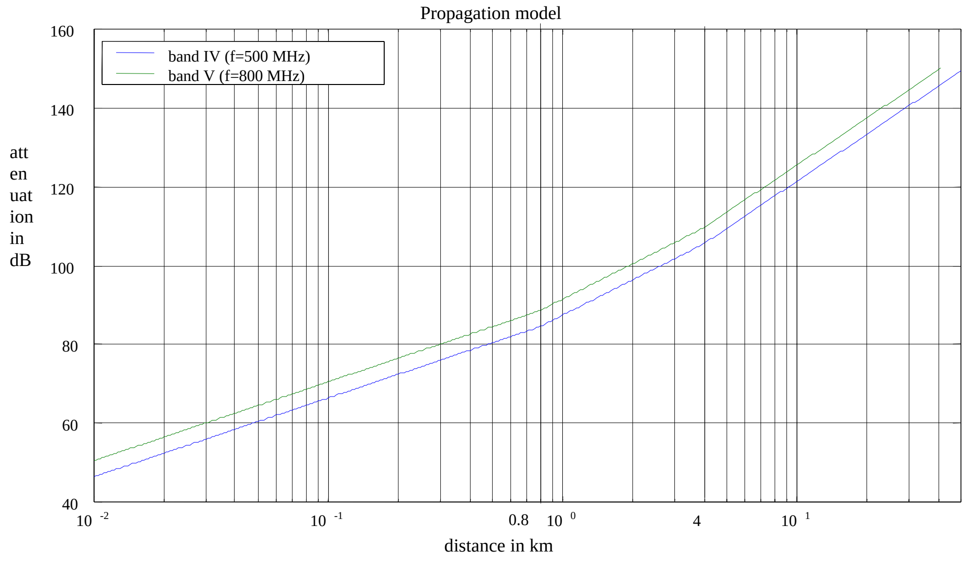


Diagram 9

3.3.6 Description and results of the calculations

The necessary separation distances between an OB-link and a DVB–T receiver are presented in diagram 10. The diagram shows the results for band IV and V. The values for Diagram 10 were derived from the parameters given in tables 12a and 12b.
In this case with high eirp OB link, the obtained distances are always greater than 100 m. Only the values from tables 12a and 12b corresponding to the long distance case are relevant.

Diagram 10 should be interpreted as follows:
The x-axis shows two parameters, namely the necessary frequency separation in MHz and the separation distances between the two services in km.
The y-axis shows the values both for the maximum permissible interfering field strength for a DVB–T receiver as a function of the frequency separation and for the interfering field strength of the radio microphone as a function of the corresponding separation distance.

An example based on 6 MHz is given to facilitate understanding of the diagram.

In a first step the x-axis is used to determine the maximum permissible interfering field strength for a frequency difference of 6 MHz between the two services. The corresponding value for
band V is 85 dB(µV/m).

In a second step the x-axis shows the necessary separation distance in km. An interfering field strength of 85 dB(µV/m) is produced by an OB link at approximately 1.7 km. So the necessary separation distance between the two services is approximately 1.7 km.
It is also possible to determine the necessary frequency difference for a specific separation distance.

The maximum permissible interfering field strength of 85 dB(µV/m) shown in the curve is calculated as follows:

53 dB(µV/m)	minimum median equivalent DVB–T field strength at 10 m a.g.l. table 12b for fixed reception (Band V)
- (13 dB)	location correction factor (long distance)
- (-45 dB)	C/I value, table 9, column 3, for a frequency difference of 6.0 MHz
85 dB(µV/m)	maximum permissible interfering field strength for DVB–T receiver.

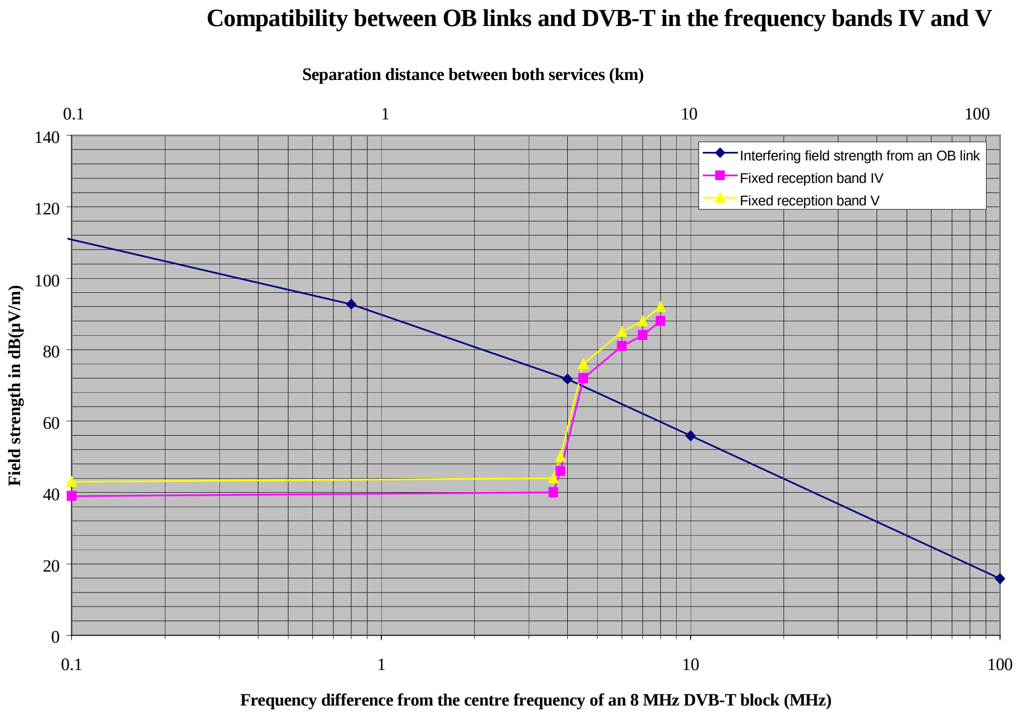


Diagram 10

The necessary separation distances for the fixed reception scenario are shown below in tabular form.

Frequency difference in MHz	Necessary separation distance in km	
	Band IV	Band V
0	25	20
± 2	25	20
± 3.8	18	15
± 4.5	4	3
± 6.0	2	1.7
± 7.0	1.7	1.2
± 8.0	1.2	0.8

Table 14: Separation distances in km for DVB –T fixed reception and outdoor operation of OB links

3.4 Interpretation of the results

The fixed reception scenario with outdoor operation of the OB link (16 dBW eirp) constitutes the worst case. For co-channel operation separation distances in the region of 20 km are necessary. In practice, these distances will not be acceptable in most cases. Therefore, co-channel operation in the same area is not possible.
For 1st adjacent channel operation, apart from the first 500 kHz of this channel, separation distances around 2 km will be needed. In many cases, such distances may not be acceptable. However, this study is based on worst case assumptions with no antenna discrimination, in practice, OB links use directional antennas that in most cases would improve the situation.
Furthermore, OB links use is generally planned in advance. Therefore, co-ordination may be used to enable in some cases first adjacent channel compatibility between OB link and DVB-T.

4 CONCLUSION

In order to establish if in a given set of circumstances:
- the DVB-T service and
- OB link usage at a given location

are compatible, the relevant separation distances derived in Sections 2 and 3, must be examined. If both separation distances are respected, then usage is compatible.

- In most cases, Co-channel operation of DVB–T and OB links within a DVB–T coverage area will cause unacceptable interference to OB links and vice-versa.

- For an operation of OB links in the 1st adjacent channel of DVB–T, the necessary separation distances obtained in this study are quite large. Nevertheless, this study is based on worst case assumptions with no antenna discrimination, whereas, in practice, OB links use directional antennas that in most cases would improve the situation. Furthermore, OB links are generally planned in advance. Therefore, in some cases, first adjacent compatibility may be achieved for frequency separation greater than 4.5 MHz on a case by case basis.
  The necessary separation distances for DVB-T transmitters SE PT 21 spectrum masks are longer than for the Chester spectrum mask.

- In practice, use of the 2nd adjacent channel by OB links will be possible in some cases, subject to a case by case analysis, allowed by the generally planned use of OB links. The necessary separation distances for SE PT 21 spectrum masks are longer than for the Chester mask.

All protection ratio measurements were limited to professional DVB–T receivers. The immunity of domestic receivers, particularly for adjacent channel rejection, is not yet known. Therefore the frequency separation needed between the future wanted DVB–T channel and OB links operation may change for domestic receivers.

ANNEX 1

Rec ITU-R P.370-7 propagation model Figure 11 (1% of the time, 50% of location)

DVB-T transmitter power **ERP = 1kW**

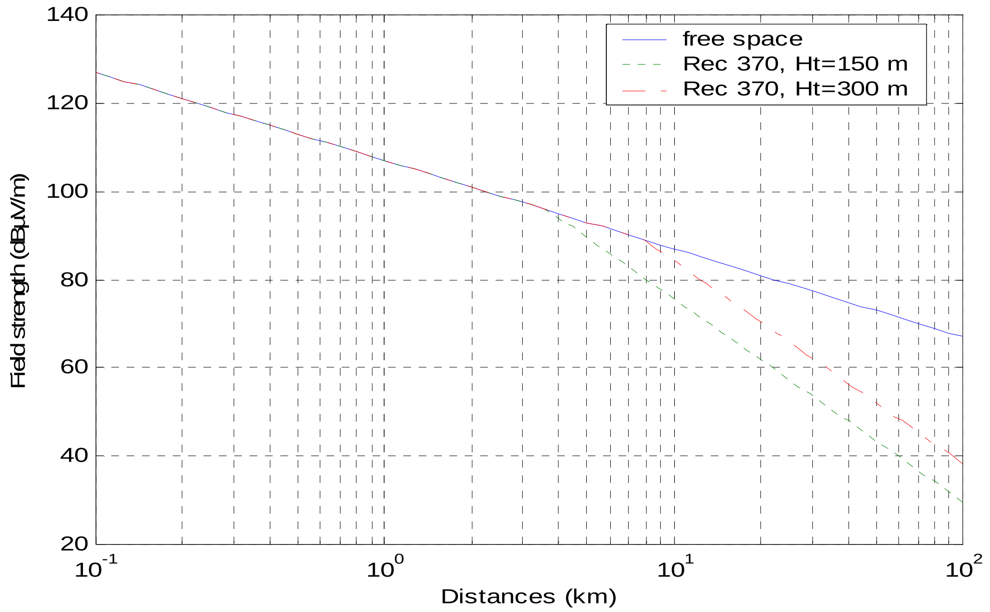


Figure A1.1: Extrapolation between the free space model and the Rec ITU-R P.370-7 model (figure 11) for a reception antenna height of 10 m

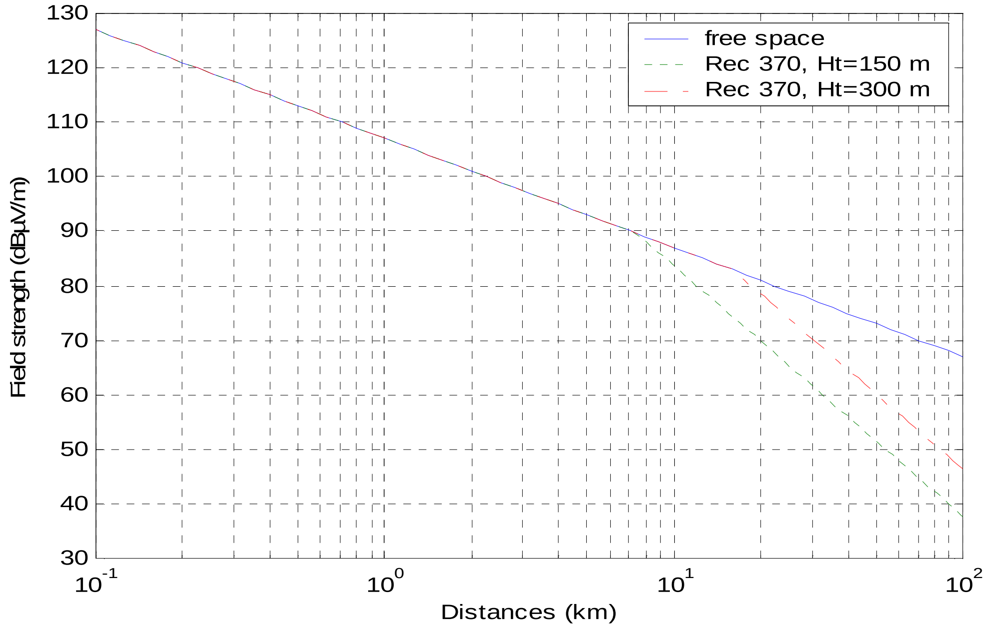


Figure A1.2: Extrapolation between the free space model and the Rec ITU-R P.370-7 model (figure 11) for a reception antenna height of 40 m