

INITIAL IDEAS CONCERNING THE REVISION OF THE
STOCKHOLM (1961) AGREEMENT

TECHNICAL ANNEX: CRITERIA FOR PLANNING DVB-T

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1. Coverage definitions for DVB-T

Digital television service coverages are characterised by a very rapid transition from near perfect reception to no reception and it thus becomes much more critical to be able to define which areas are going to be covered by a service which is being planned and which are not. However, because of the very rapid transition of the DVB-T system, there is a cost penalty if the coverage target within a small area (say, 200 m by 200 m). This occurs because it is necessary either to increase the transmitter powers or to provide a larger number of transmitters in order to guarantee coverage to the last few percent of the worst-served small areas.

It should be borne in mind that in a given situation it may be possible to improve reception by:

- finding a better position for the receiving antenna;
- using a (more) directional receiving antenna with a higher gain;
- using a low-noise antenna amplifier (in the case of fixed antenna reception);
- in case of portable or mobile reception the use of "intelligent" antenna systems like diversity or adaptive antennas may improve reception.

1.1 Percentage of locations covered and percentage of pixels covered

In previous studies, the percentage of locations covered within worst case small areas (the location probability) has been one of the parameters used to determine the minimum field strength necessary to provide the required DVB-T coverage, and is a familiar concept. These studies have assumed full coverage of the area covered by the network.

It is, however, possible to plan for less than 100% coverage of the whole area. In deed, this may be convenient in cases where there is an uneven distribution of the population or where it is desired to concentrate some services in areas of greatest population density. The percentage of pixel coverage parameter, which has not been used before, is now introduced to help quantify this situation of less than 100% area coverage. It is necessary to define this new parameter and to highlight the differences between it and the percentage of locations parameter.

Percentage of locations covered within a small area and percentage of pixels covered are two different concepts and great care has to be taken to avoid equating the "small area" used in the definition of location percentage with the definition of pixel given in this text.

1.1.1 Percentage of locations covered

In the use of this parameter the following assumptions are made:

- the area covered by the network is divided into a large number of small areas, about 200 m by 200 m;
- in each of these small areas, the distribution of field strength with location is log-normal with a standard deviation usually taken to be 5.5 dB, for fixed and portable outdoor reception. For portable indoor antenna reception, the standard deviation is larger (see § 3.5).

Thus 50% of the locations will have a field strength less than the median value and the other 50% of locations will have a field strength greater than the median value. Digital systems (including DVB-T) exhibit an abrupt failure as the C/N ratio falls to the threshold value. If satisfactory reception is required at a large percentage of the locations within each small area, the minimum field strength needed for reception must be exceeded at this large percentage of locations.

It is usual to plan for the minimum field strength to be exceeded at 70% or 95% of locations within each small area. This is achieved by adding a correction to the minimum field strength. This correction consists of the standard deviation of field strength with location (in dB) multiplied by the appropriate figure for the percentage of locations to be covered, taken from the log-normal distribution curve (see Table 3.4 in Section 3.2).

The coverage definition of “good” has been selected as the case where 95% of the locations within a small area are covered. Similarly, “acceptable” has been defined to be the case where 70% of the locations within a small area are covered.

It must be noted that the specified percentage of locations covered is for a location at the edge of the coverage area. Locations closer to the transmitter will, in general, have a higher percentage of locations covered.

It is not yet clear what the location coverage requirements will be for mobile television.

1.1.2 Percentage of pixels covered

A geographic area may be considered to be divided into a large number of smaller geographic areas, probably, but not necessarily, of equal size and consistent shape. If the whole of the geographic area is covered, to the required location percentage, then it is clear that this can be described as achieving 100% coverage. In the case that not all of the geographic area is covered, to the required location percentage, then this can be described as achieving, say, X% coverage. It has been found convenient to refer to the individual smaller areas as ‘pixels’ and then the coverage achieved can be referred to as X% pixel coverage.

In an limiting case, the pixel may be sufficiently small that it is equal to the ‘small area’ used in the definition of location percentage. However, if the coverage in all individual pixels in a geographic area is to be examined, this can result in an excessive number of calculations. It is thus generally more convenient to have pixels which are significantly larger than the ‘small areas’.

MFN

In the following illustrations the percentage of pixel coverage parameter within an MFN is given different values of 100, 80 and 50% - see Figure 1.1a, 1.1b and 1.1.c. In these figures, the contours are all drawn for the same location percentage.

If all locations are able to receive the signal from at least one transmitter then the pixel coverage is said to be 100%. Pixel coverage values lower than 100% represent the case where “islands” of coverage exist. In this example the value of 100% pixel coverage is taken to be the coverage of each of the individual circles shown in Figure 1.1a, with no account being taken of the effect of any of the coverage overlaps shown. This corresponds to the case where each of the transmitter sites shown is assumed to be radiating distinct programmes.

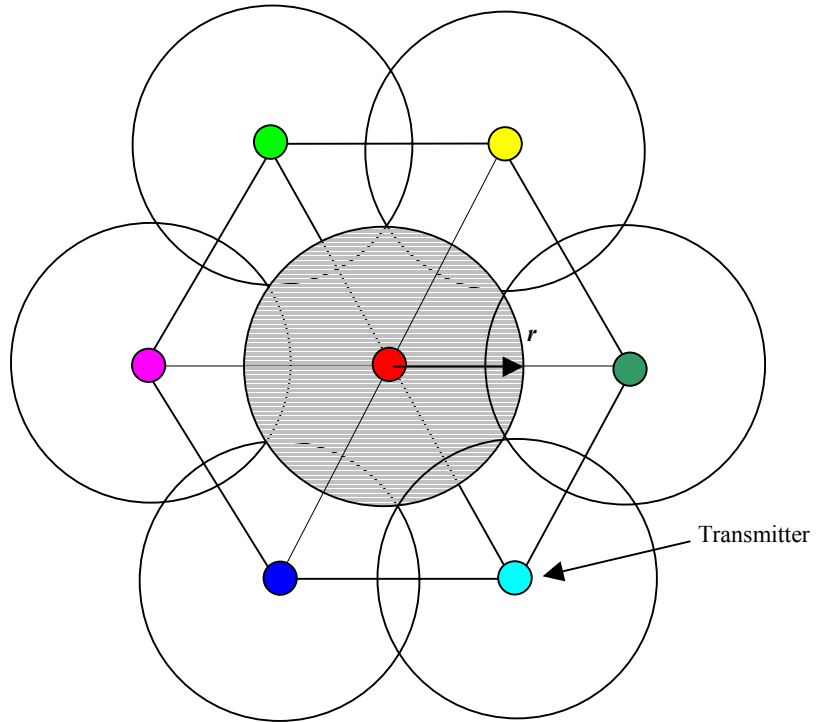
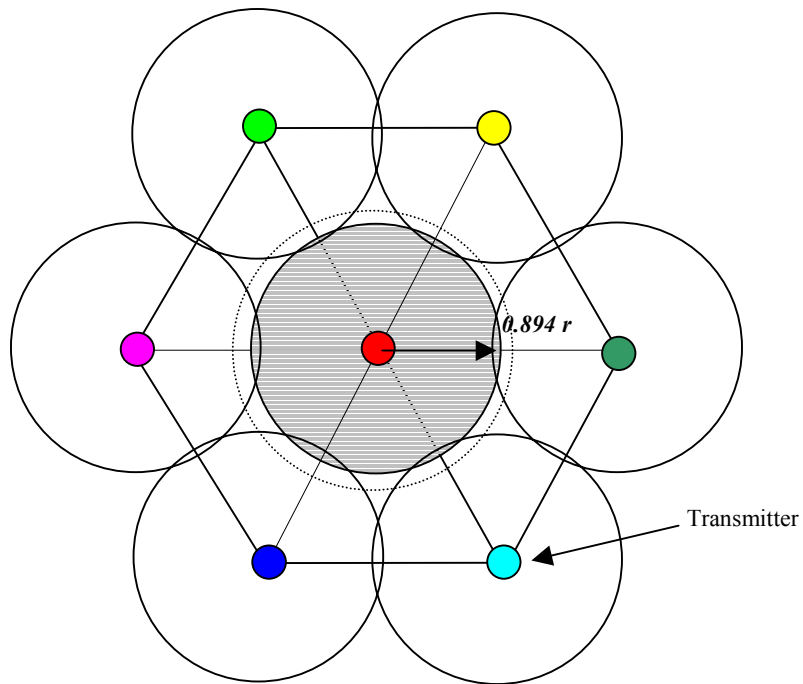
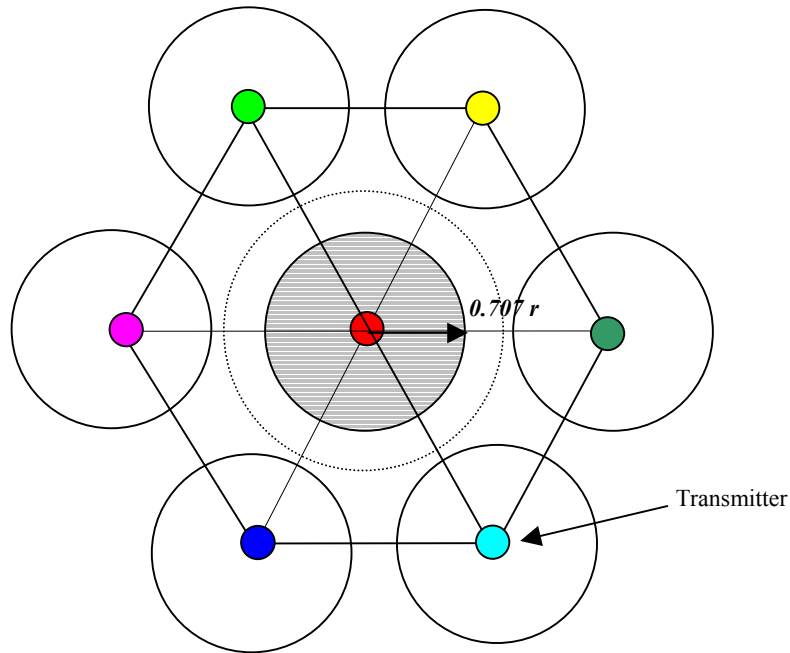


Figure 1.1a: 100% pixels covered, coverage radius = r .



The "dashed" circle corresponds to 100% pixels covered.

Figure 1.1b: 80% pixels covered, coverage radius = $r\sqrt{0.8}$



The “dashed” circle corresponds to 100% pixels covered.

Figure 1.1c: 50% pixels covered, coverage radius = $r \sqrt{0.5}$

SFN

100% pixel coverage of the theoretical semi-infinite area can be made by several SFNs using different frequencies. This corresponds to the previous MFN exercise with the exception that the transmitters forming each SFN are distributed throughout the circle. In the case where significantly less than 100% pixel coverage is required (SFN islands), it may be possible to use the same frequency throughout the theoretical semi-infinite area.

1.2 Fixed antenna reception

Fixed antenna reception is defined as ‘reception where a directional receiving antenna mounted at roof level is used’.

In calculating the field strength for fixed antenna reception a receiving antenna height of 10 m above ground level is usually considered to be representative of roof level, especially where Rec. ITU-R P.370, or any equivalent area coverage prediction method, is being used.

Standard radiation patterns for receiving antennas for the frequency bands I, III and IV/V are given in Rec. ITU-R BT.419-3 (see Figure 1.2).

Because of their directivity antennas for fixed reception are assumed to provide antenna gain and because of their location (at roof level) a certain amount of feeder loss is also assumed.

(The number of the broadcasting band is shown on the curve)

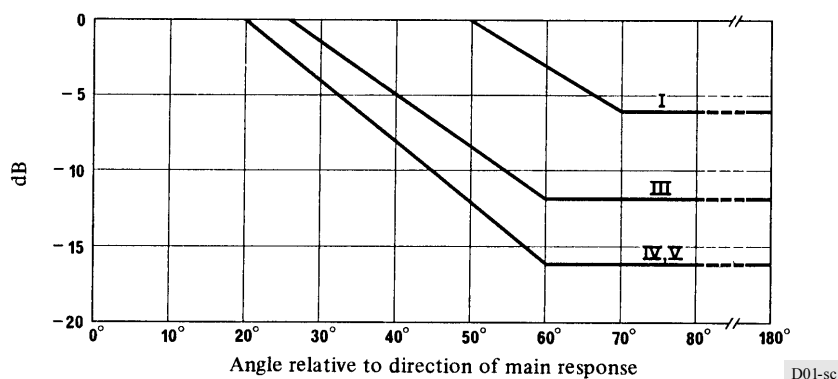


Figure 1.2: Directivity of receiving antennas for bands I, III and IV/V

Fixed antenna reception also offers the possibility to take advantage of polarisation discrimination. According to Rec. ITU-R BT.419-3 median values of 13 dB to 18 dB can be expected.

1.3 Portable antenna reception

Portable antenna reception is defined as:

- Class A (outdoor) being reception where a portable receiver with an attached or built-in antenna is used outdoors at no less than 1.5 m above ground level;
- Class B (ground floor, indoor) being reception where a portable receiver with an attached or built-in antenna is used indoors at no less than 1.5 m above floor level in rooms:
 - on the ground floor;
 - with a window in an external wall.

Portable indoor reception at the first or higher floors will be regarded as class B reception with signal level corrections applied, but indoor ground floor reception is likely to be the most common case.

The conditions for portable reception differ from fixed reception in the:

- absence of receiving antenna gain and directivity;
- no feeder loss;
- generally lower reception height;
- building penetration loss in the case of indoor reception.

It has been assumed that a portable receiver and a receiver for fixed reception have the same receiver noise figure, that is, 7 dB.

1.4 Mobile antenna reception

Mobile reception is defined as being the reception of a DVB-T signal while in motion, using a non-directional antenna situated at no less than 1.5 metres above the ground level.

Motion in this case can be anything from quasi static (a slowly walking pedestrian) to a high speed train.

In this context the receiving conditions can be subdivided into 3 classes:

- reception in MFN in urban areas
- reception in MFN in rural areas
- reception in SFN's in all environments (most favourable receiving conditions)

The potential for mobile reception is expected to be enhanced by the use of diversity receiving antennas, advanced channel estimation etc.

1.4.1 Considerations on Quality of Service for mobile reception

The DVB-T standard defines the Quasi Error Free (QEF) criterion, corresponding to "less than one uncorrected error event per hour". In the stationary reception cases, QEF is equivalent to a residual BER of $2 \cdot 10^{-4}$ after Viterbi decoding. The QEF criterion, meaning effectively perfect "Quality of Transmission", is unfortunately not suitable in the mobile environment due to the fast channel variations. In mobile cases, as QEF shows unstable values, its usage could imply a severe underestimation of the DVB-T mobile capabilities.

It is to be expected that there are rapid changes in reception in a moving vehicle as a result of the changing propagation channel. If the vehicle is moving rapidly, compared with the wavelength of the received signal, then these changes will also occur rapidly. It is thus inappropriate to use any quality assessment criterion, such as a BER of $2 \cdot 10^{-4}$, which is relevant to static reception. For this reason, quality assessments are to be made using the criterion of no more than one visible impairment in any 20 second period. This is also the criterion proposed by the ITU-R when making protection ratio measurements using a subjective assessment method with a limited number of observers.

1.5 Coverage area

In defining the coverage area for each reception condition a three level approach is taken.

Level 1: Receiving location

The smallest unit is a receiving location. A receiving location is regarded as being covered if the level of the wanted signal is high enough to overcome noise and interference for a given percentage of the time. A value of 99% of time is recommended.

Level 2: Small area coverage

The second level is a "small area" (typically 200 m by 200 m). In this small area the percentage of covered locations is indicated.

The coverage of this small area is classified as:

“**Good**” if at least 95% of receiving locations within it are covered;

“**Acceptable**” if at least 70% of locations within it are covered.

Level 3: Coverage area

The coverage area of a transmitter, or a group of transmitters, is made up of the sum of the individual small areas in which a given percentage (70% or 95%) of coverage is achieved.

2. Field strength prediction

Prediction of the coverage provided by a given transmitting station (or a group of stations in an SFN) is normally done on the basis of the field strength for the wanted signal predicted for 50% of time, which is assumed to be very close to that for 99% of time. Field strengths for unwanted (interfering) signals are predicted for a higher percentage of time. When the wanted signal is a digital signal, 1% of time is often used for the unwanted signals due to the rapid failure characteristic of digital broadcast systems near the minimum $C/(N + I)$ value.

2.1 Rec. ITU-R P.370

Rec. ITU-R P.370 is a commonly agreed field strength prediction method.

The propagation curves, given in this Recommendation, represent field-strength values in the VHF and UHF bands as a function of various parameters; some curves refer to land paths, others refer to sea paths. The land path curves were prepared from data obtained mainly from temperate climates and 'rolling terrain' as encountered in Europe and North America. The sea path curves were prepared from data obtained mainly from the Mediterranean and the North Sea regions, referred to as 'warm' and 'cold' seas, respectively.

The propagation curves represent the field-strength values exceeded at 50% of the locations (within any area of approximately 200 m by 200 m) for different percentages of time. They correspond to different transmitting antenna heights and a receiving antenna height of 10 m. The land path curves refer to a value of $\Delta h = 50$ m which generally applies to rolling terrain commonly found in Europe and North America.

For location probabilities other than 50% a correction may be applied (see § 3.2).

In case of mixed land – sea paths a coast line model is also needed. The Recommendation describes methods dealing with mixed paths, but does not provide any coastline information.

The Recommendation can be used without taking the actual terrain into account. It is, however, also possible to take account of the terrain near the receiving site by means of the Terrain Clearance Angle.

By agreement other, for example terrain data bank based, methods can be used in coordination between administrations on a bi-lateral basis.

It is to be noted that the ITU-R has adopted new Rec. P.1546 which which replaces Rec. ITU-R P.370 and some other ITU-R Recs. (in particular 529 and 1146). Further information may be found in Annex 2, § A2.1.

2.2 Terrain data bank

Terrain data banks with a horizontal resolution of 500 metres or better are available for national network planning in most countries. Such data banks are expensive and are often not used when interference from transmitters in neighbouring countries is calculated.

There is, however, one terrain data bank available at modest cost on CD-ROM from the US government agency NOAA and freely available on the Internet - GTOPO30 (except for the large download time). This has a horizontal resolution of 30 seconds of arc by 30 seconds of arc, corresponding to approximately 1 km by 1 km at the equator and smaller east-west distances north or south of the equator. Experience has shown that if this data bank is used for the countries

surrounding the country for which planning is undertaken (and for which a more detailed data bank is assumed available) the calculated interference contributions are sufficiently correct.

Where relevant and if possible the use of terrain data under the Vienna Agreement might be helpful.

ANNEX to Chapter 2: Revision of Rec. ITU-R P.370

A2.1 ITU-R work on a replacement for Rec. 370

For some time now it has been known that there were some discrepancies between the, so-called, point-to-area propagation prediction methods available within the ITU-R. In particular, differences have developed between Rec. ITU-R P.529, used by the mobile services and Rec. ITU-R P.370 used by the broadcasting service. In addition, neither of these Recs. dealt adequately with the whole frequency range 30 to 3000 MHz nor with the whole distance range from 1km to (about) 1000 km. It was thus decided to try to combine the various available methods for point-to-area propagation predictions (actually much better described as path-general methods), including Recs. ITU-R P.370, P.529 and P.1146 and use the result to produce a new, more general method which could be used by both mobile and broadcasting services.

It must be stressed that no miracles should be expected. In the absence of detailed path profile information, there are definite limits with regard to the accuracy of a method based, essentially, on the statistically summed results of a large number of measurements.

Work is going on in parallel to develop improved prediction methods based on path profiles. However, even this approach has its limits. A common measure of the "quality" of a prediction method is the standard deviation of the difference between measurement and prediction. Rec. ITU-R P.370, using a terrain clearance correction and excluding any delta H correction, provides a "quality" of about 12 dB. The best terrain profile methods achieve a "quality" of about 10 dB. There have been claims of "quality" of some 3 dB from some methods, but investigation has, so far, always shown this to be the result of fortunate circumstances in specific areas or a particular approach to the comparison of measurement and prediction.

A2.2 Basis of new ITU approach

NEW RECOMMENDATION ITU-R P.1546. Method for point-to-area predictions for terrestrial services in the frequency range 30 to 3 000 MHz.

The new method is still based on curves of field strength versus distance but tabulated values will also be available. The latter is been done to avoid the situation of having different interpretations of the curves. These curves/tables are for three discrete frequencies, 100, 600 and 2000 MHz, and interpolation/extrapolation is used to provide results for other frequencies.

A major change from the existing approach of Recs. 370 and 529 is that the curves/tables give results for a "representative" height. This is, in effect, the height of the ground cover local to the receiving location, subject to a minimum value of 10m. Explicit formulas are given for signal level variation as a function of receiving antenna height. The result of this is that in rural areas, the field strength values given are close to those of Rec. 370, at the reference frequencies. In an urban area with a roof level height of 20m, the results for a receiving antenna height of 1.5 m are close to those given by the Okamura formula. It is hoped that this approach will avoid the problems inherent in the current version of Rec. 370 of giving the same field strength at 10 m above ground level in a town as in a rural area.

To avoid some of the "interpretations" of Rec. 370 which have appeared in the past, there is a specific sequence of instructions regarding the application of the method and, in particular, the various interpolations needed (for example between discrete distance values, transmitting antenna height values and frequencies).

One result of the application of the new method, if adopted for DVB-T planning, is that there will be some field strength differences across the UHF band - a fact long familiar to anyone who has made measurements. The magnitude of the difference will be about zero for distances up to about 10 km and will increase for greater distances becoming about 2 dB at 60 to 100 km (dependent upon transmitting antenna height to some extent). At first sight, this difference is not enough to explain known coverage effects, but it has to be remembered that receiving antenna gain and feeder loss also come into the overall assessment. As an approximation, the overall difference across the UHF band would be some 6 dB.

Of course, in addition to wanted signal level differences, there will also be differences in the required co-channel separation distances, which will thus decrease (a little) as the frequency increase, at least for paths over land.

3. Signal levels for DVB-T

Due to the very rapid transition from near perfect to no reception, it is necessary that the minimum required signal level is achieved at a high percentage of locations. These percentages have been set at 95 for "good" and 70 for "acceptable" reception. Corresponding minimum median signal levels may be derived, taking account of propagation elements, to ensure that the minimum values are achieved at the specified percentage of locations. The figures are derived assuming a receiver noise figure of 7 dB.

The minimum median signal levels have been calculated for:

- 8 MHz channels. For 7 MHz channels, 0.6 dB should be subtracted from the relevant results given in the tables of minimum median equivalent field strength;
- four different receiving conditions:
 - fixed antenna reception;
 - portable outdoor reception (Class A);
 - portable indoor reception at ground floor (Class B);
 - mobile reception (no diversity condition);
- frequencies representing Band III and Band IV/V: 200 and 500 MHz;
- representative C/N ratios: 2, 8, 14, 20, 26 and 32 dB, including an implementation margin of 3 dB.

Representative C/N values are used for these examples. Results for any chosen DVB-T system variant (see Table 3.1) may be obtained by interpolation between relevant representative values.

All minimum median equivalent field strength values are for coverage by a single transmitter only, not for Single Frequency Networks.

3.1 Minimum receiver input level

The minimum receiver input signal level depends on three elements:

- the receiver noise figure;
- the bandwidth of the signal
- the system variant

Typical C/N results from laboratory tests are about 3 dB higher than the values given in Table 3.1. Therefore an implementation margin of 3 dB should be added to the values given in Table 3.1 before they are used to calculate the minimum equivalent field strengths or to perform the interpolation between C/N values needed for the application of Table 3.2 and Tables 3.8, 3.9, 3.10, 3.11 and 3.12.

3.1.1 DVB-T system variants

			Required C/N for BER=2. 10 ⁻⁴ after Viterbi decoder (quasi error-free after Reed-Solomon decoder*)			Net bit rate (Mbit/s)			
System Variant	Modulation	Code Rate	Gaussian Channel	Ricean Channel	Rayleigh Channel	D/T _U = 1/4	D/T _U = 1/8	D/T _U = 1/16	D/T _U = 1/32
A1	QPSK	1/2	3.1	3.6	5.4	4.98	5.53	5.85	6.03
A2	QPSK	2/3	4.9	5.7	8.4	6.64	7.37	7.81	8.04
A3	QPSK	3/4	5.9	6.8	10.7	7.46	8.29	8.78	9.05
A5	QPSK	5/6	6.9	8.0	13.1	8.29	9.22	9.76	10.05
A7	QPSK	7/8	7.7	8.7	16.3	8.71	9.68	10.25	10.56
B1	16-QAM (M1 **)	1/2	8.8	9.6	11.2	9.95	11.06	11.71	12.06
B2	16-QAM	2/3	11.1	11.6	14.2	13.27	14.75	15.61	16.09
B3	16-QAM	3/4	12.5	13.0	16.7	14.93	16.59	17.56	18.10
B5	16-QAM	5/6	13.5	14.4	19.3	16.59	18.43	19.52	20.11
B7	16-QAM	7/8	13.9	15.0	22.8	17.42	19.35	20.49	21.11
C1	64-QAM (M2 **)	1/2	14.4	14.7	16.0	14.93	16.59	17.56	18.10
C2	64-QAM (M3 **)	2/3	16.5	17.1	19.3	19.91	22.12	23.42	24.13
C3	64-QAM	3/4	18.0	18.6	21.7	22.39	24.88	26.35	27.14
C5	64-QAM	5/6	19.3	20.0	25.3	24.88	27.65	29.27	30.16
C7	64-QAM	7/8	20.1	21.0	27.9	26.13	29.03	30.74	31.67

Notes: (*) Quasi error-free means less than one uncorrected error event per hour, corresponding to BER = 1. 10⁻¹¹ at the input of the MPEG-2 demultiplexer.

(**) System modes adopted by ITU-R as representative for protection ratio assessments.

Table 3.1: Required C/N (dB) for non-hierarchical transmission to achieve a BER = 2. 10⁻⁴ after the Viterbi decoder for all combinations of coding rates and modulation types. The net bit rates after the Reed-Solomon decoder are also listed.

To describe the number of carriers and the guard interval ratio, D/T_U, the designators given in Table 3.2 should be used.

Designator	Number of carriers	Guard interval ratio
A	2k	1/32
B	2k	1/16
C	2k	1/8
D	2k	1/4
E	8k	1/32
F	8k	1/16
G	8k	1/8
H	8k	1/4

Table 3.2: Designators for Guard Interval ratios and number of carriers

3.1.2 Representative minimum receiver input signal levels

The minimum receiver input signal level, based on the receiver noise figure and the bandwidth of the DVB-T signal, can be calculated using the following formulas:

$$P_n = F + 10 \log (k \cdot T_0 \cdot B)$$

$$P_{s \text{ min}} = P_n + C/N$$

$$U_{s \text{ min}} = P_{s \text{ min}} + 120 + 10 \log (Z_i)$$

where:

- k : Boltzmann's Constant = $1.38 \cdot 10^{-23}$ Ws/K
- T₀ : Absolute temperature = 290 K
- B : Receiver noise bandwidth {Hz}
- C/N : RF signal to noise ratio required by the system {dB}
- F : Receiver noise figure {dB}
- P_n : Receiver noise input power {dBW}
- P_{s min} : Minimum receiver signal input power {dBW}
- U_{s min} : Minimum equivalent receiver input voltage into Z_i {dBμV}
- Z_i : Receiver input impedance (75Ω)

Frequency Band III and IV/V – 8 MHz channels							
Equivalent noise band width	B {Hz}	7.6*10 ⁶	7.6*10 ⁶	7.6*10 ⁶	7.6*10 ⁶	7.6*10 ⁶	7.6*10 ⁶
Receiver noise figure	F {dB}	7	7	7	7	7	7
Receiver noise input power	P _n {dBW}	-128.2	-128.2	-128.2	-128.2	-128.2	-128.2
Representative minimum RF signal/noise ratio	C/N {dB}	2	8	14	20	26	32
Min. receiver signal input power	P _{s min} {dBW}	-126.2	-120.2	-114.2	-108.2	-102.2	-96.2
Min. equivalent receiver input voltage, 75 Ω	U _{s min} {dBμV}	13	19	25	31	37	43

Table 3.3: Minimum equivalent receiver input signal level for a representative set of C/N ratios for the 8 MHz version, based on a receiver noise figure of 7 dB.

3.2 Location variation of the received signal

Within a small area, say 200 m by 200 m, there will be a more-or-less random variation of the received signal level with location which is due to terrain irregularities. The statistics of this variation are characterised by a log-normal distribution.

For calculating the location correction C_l used when other than 50% locations are to be considered, a log-normal distribution of the received signal is assumed.

The location correction can be calculated by the formula:

$$C_l = \mu + \sigma \{dB\}$$

where:

- μ is the distribution factor, see Table 3.4 below;
- σ is the standard deviation.

In the following sections location probabilities of 70% and 95% are used to calculate minimum median equivalent field strengths.

Location probability in %	Distribution factor μ
0	$-\infty$
1	-2.32692
5	-1.64476
10	-1.18147
15	-1.04637
20	-0.84161
25	-0.67453
30	-0.52443
35	-0.38527
40	-0.25338
45	-0.12570
50	0.0
55	0.12570
60	0.25338
65	0.38527
70	0.52443
75	0.67453
80	0.84161
85	1.04637
90	1.18147
95	1.64476
99	2.32692
100	$+\infty$

Table 3.4: Distribution factors for various location probabilities

3.3 Calculation of minimum median equivalent field strength

The minimum median equivalent field strength can be calculated using the following formulas:

P_n	$= F + 10 \log_{10} (k T_0 B)$	
$P_{s \min}$	$= C/N + P_n$	
A_a	$= G + 10 \log_{10} (1.64\lambda^2/4\pi)$	
ϕ_{\min}	$= P_{s \min} - A_a + L_f$	for fixed antenna reception
ϕ_{\min}	$= P_{s \min} - A_a$	for portable reception
E_{\min}	$= \phi_{\min} + 120 + 10 \log_{10} (120\pi)$	
	$= \phi_{\min} + 145.8$	
E_{med}	$= E_{\min} + P_{\text{mmn}} + C_l$	for fixed antenna reception
E_{med}	$= E_{\min} + P_{\text{mmn}} + C_l + L_h$	for portable outdoor reception
E_{med}	$= E_{\min} + P_{\text{mmn}} + C_l + L_h + L_b$	for portable indoor reception

where:

P_n	: Receiver noise input power {dBW}
F	: Receiver noise figure {dB}
k	: Boltzmann's Constant ($k= 1.38 \cdot 10^{-23}$ {Ws/K})
T_0	: Absolute temperature ($T_0 = 290$ {K})
B	: Receiver noise bandwidth ($B=7.61 \cdot 10^6$ {Hz})
$P_{s \min}$: Minimum receiver input power {dBW}
C/N	: RF signal to noise ratio at the receiver input required by the system {dB}
A_a	: Effective antenna aperture {dBm ² }
G	: Antenna gain related to half dipole {dB}
λ	: Wavelength of the signal {m}
ϕ_{\min}	: Minimum power flux density at receiving place {dBW/m ² }
L_f	: Feeder loss {dB}
E_{\min}	: Equivalent minimum field strength at receiving place {dB μ V/m}
E_{med}	: Minimum median equivalent field strength, planning value {dB μ V/m}
P_{mmn}	: Allowance for man made noise {dB}
C_l	: Location correction {dB}
L_h	: Height loss (10 m agl to 1.5 m agl) {dB}
L_b	: Building penetration loss {dB}

In the tables showing the minimum median equivalent field strength for fixed, portable and mobile reception only two frequencies have been used, 200 MHz and 500 MHz.

The values for 200 MHz can be taken to represent all channels in Band III.

Within Bands IV and V, the minimum median equivalent field strength (E_{med}) for a given frequency may be calculated by the semi-empirical formula:

$$E_{\text{med } f} = E_{\text{med } 500 \text{ MHz}} + 20 \log_{10}(f / 500)$$

where:

f is the actual frequency in MHz being considered;

and $470 \text{ MHz} < f < 862 \text{ MHz}$.

3.4 Fixed reception

3.4.1 Signal level variation

Measurements of digital signals have shown that the standard deviation (σ) of the distribution will be about 5.5 dB. The standard deviation for analogue television signals interfering with DVB-T is also taken as 5.5 dB.

Applying the multiplying values for 95% and 70% locations from Table 3.4 gives the location corrections for fixed antenna reception shown in Table 3.5.

Coverage target (location probability)	Location variation VHF and UHF
> 95%	9.0 dB
> 70%	2.9 dB

Table 3.5: Location variation for fixed antenna reception

3.4.2 Antennas for fixed reception

The antenna diagrams (directivity) to be used for terrestrial television planning are given in Rec. ITU-R BT.419 (see § 1.2). The antenna gains (relative to half wave dipole) used in the derivation of the minimum median wanted signal levels are given in Table 3.6:

200 MHz	500 MHz	800 MHz
7 dB	10 dB	12 dB

Table 3.6: Assumed antenna gains for fixed reception

These values are considered as realistic minimum values.

The associated feeder losses used in the derivation of the minimum wanted signal levels are given in Table 3.7:

200 MHz	500 MHz	800 MHz
2 dB	3 dB	5 dB

Table 3.7: Assumed feeder losses for fixed reception

These values are considered as realistic examples of what is achieved in practice. Of course, there will be many cases where feeder losses are much higher than the values quoted, for example because of damage to the feeder, but such values should not be used for planning purposes.

Within Bands IV and V, the variation of antenna gain as well as feeder loss with frequency may be taken into account by the addition of an empirical correction term:

$$\text{Corr} = 10 \log_{10} (f_A / f_R) \text{ {dB}}$$

where:

f_A is the actual frequency being considered;

f_R is the relevant reference frequency quoted above.

Data for antenna gain and feeder loss must be taken corresponding to the reference frequency f_R .

It should be noted that the sum of antenna gain and feeder loss is 7 dB across the whole of Bands IV and V and may be taken to be 5 dB across Band III.

3.4.3 Minimum median equivalent field strength

The tables below give the minimum median equivalent field strength for 70% and 95% of location probability calculated for 200 MHz and 500 MHz. These tables are expressed in terms of representative minimum C/N value required by the system. C/N values taken from Table 3.1

should be increased by an implementation margin of 3 dB before they are used when interpolating between the values given in Tables 3.8 and 3.9.

For 7 MHz channels, 0.6 dB is to be subtracted from the input signal voltage and field strength values given in Tables 3.8 and 3.9.

For frequencies in Bands IV and V other than 500 MHz, the field strength correction formula:

$$E_{\text{med } f} = E_{\text{med } 500 \text{ MHz}} + 20 \log_{10}(f / 500)$$

where:

f is the actual frequency in MHz being considered;

and $470 \text{ MHz} < f < 862 \text{ MHz}$,

may be used. For further information, see § 3.3.

Frequency	f {MHz}	200					
Representative Minimum C/N ratio	{dB}	2	8	14	20	26	32
Min. equivalent receiver input voltage, 75 Ω	$U_{s\ min}$ {dB μ V}	13	19	25	31	37	43
Feeder loss	L_f {dB}	2					
Antenna gain rel. to half wave dipole	G_D {dB}	7					
Effective antenna aperture	A_a {dBm ² }	1.7					
Min equivalent field strength at receiving place	E_{min} {dB μ V/m}	20	26	32	38	44	50
Allowance for man made noise	P_{mnn} {dB}	1					

Location probability: 70%

Location correction	C_l {dB}	2.9					
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	24	30	36	42	48	54

Location probability: 95%

Location correction	C_l {dB}	9					
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	30	36	42	48	54	60

Table 3.8: Minimum median equivalent field strength in Band III for fixed antenna reception.

Frequency	f {MHz}	500					
Representative Minimum C/N ratio	{dB}	2	8	14	20	26	32
Min. equivalent receiver input voltage, 75 Ω	$U_{s\ min}$ {dB μ V}	13	19	25	31	37	43
Feeder loss	L_f {dB}	3					
Antenna gain rel. to half wave dipole	G_D {dB}	10					
Effective antenna aperture	A_a {dBm ² }	-3.3					
Min equivalent field strength at receiving place	E_{min} {dB μ V/m}	26	32	38	44	50	56
Allowance for man made noise	P_{mnn} {dB}	0					

Location probability: 70%

Location correction	C_l {dB}	2.9					
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	29	35	41	47	53	59

Location probability: 95%

Location correction	C_l {dB}	9					
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	35	41	47	53	59	65

Table 3.9: Minimum median equivalent field strength in Band IV for fixed antenna reception.

3.5 Portable reception

3.5.1 Signal level variation

Field strength variations can be divided into macro-scale and micro-scale variations. Micro-scale variations relate to areas with dimensions in the order of a wavelength and are mainly caused by multipath reflections from nearby objects. As the position of the receiving antenna for portable reception can be optimised within the order of a wavelength, micro-scale variations will not be significant for planning purposes.

The macro-scale variations relate to areas with linear dimensions of 200 m to 200 m or more and are mainly caused by shadowing and multipath reflections from distant objects. Macro-scale variations of the field strength are very important for coverage assessment. In general, a high target percentage for coverage is required to compensate for the rapid failure rate of digital television signals.

Location variations at outdoor locations (macro-scale)

Rec. ITU-R P.370 gives a standard deviation for wide band signals of 5.5 dB. Although it is to be expected that there will be some dependency on the environment surrounding an outdoor portable receiver this value is used here for determining the location variation at outdoor locations.

This location variation for macro-scale variations are thus the same as that given in Table 3.5 for fixed antenna reception.

3.5.2 Antennas for portable reception

It is assumed that the antenna of a portable receiver is non-directional and that the gain (relative to a $\lambda/2$ dipole) is 0 dB for a UHF antenna and -2.2 dB for a VHF[Band III] antenna. A portable receiver can be assumed to have 0 dB feeder loss in all bands.

Generally, no polarisation discrimination is expected from this type of portable reception antenna.

3.5.3 Height loss for received signal

For portable reception, the antenna height of 10 m above ground level generally used for planning purposes is not realistic and a correction needs to be introduced based on a receiving antenna near ground floor level. For this reason a receiving antenna height of 1.5 m above ground level (outdoor) or above floor level (indoor) has been assumed.

The propagation prediction method of Rec. ITU-R P.370 uses a receiving height of 10 m. To correct the predicted values for a receiving height of 1.5 m above ground level a correction called "height loss" has been introduced. At UHF, a height loss of 12 dB is used, based on measurements in the Netherlands. For VHF, a height loss of 10 dB is used, taken from Rec. ITU-R 1203.

3.5.4 Building penetration loss

Definition

The mean building penetration loss is the difference in dB between the mean field strength inside a building at a given height above ground level and the mean field strength outside the same building at the same height above ground level. A large spread of building penetration losses is to be expected.

Building penetration loss values

Results of measurements carried out at VHF in the UK to investigate in-house reception of T-DAB have been reported in Rep. ITU-R 1203. The results indicate a median value of building penetration loss of 8 dB with a standard deviation of 3 dB.

For UHF measurements have been carried out in the Netherlands and in the UK. Based on these results building penetration loss for planning purposes is given in Table 3.10.

Band	Median value	Standard deviation
VHF	8 dB	3 dB
UHF	7 dB	6 dB

Table 3.10: Building penetration loss

Location distribution indoors

The variation at indoor locations is the combined result of the outdoor variation and the variation due to building penetration attenuation. These distributions are expected to be uncorrelated. The standard deviation of the indoor field strength distribution can therefore be calculated by taking the root of the sum of the squares of the standard deviations for the outdoor and building penetration variations. At VHF, where the macro-scale standard deviations are 5.5 dB and 3 dB respectively, the combined value is 6.3 dB. At UHF, where the macro-scale standard deviations are 5.5 dB and 6 dB respectively, the combined value is 8.1 dB.

For planning purposes, the location variation at indoor locations is given in Table 3.11.

Coverage target (location probability)	Location variation	
	VHF	UHF
Not less than 95%	10.4 dB	13.4 dB
Not less than 70%	3.3 dB	4.2 dB

Table 3.11: Location variation for portable indoor reception

3.5.5 Minimum median equivalent field strength

The tables below give the minimum median equivalent field strength for location probabilities of 70% and 95% in Band III and 500 MHz. These tables are expressed in terms of representative minimum C/N value required by the system. C/N values taken from Table 3.1 should be increased by an implementation margin of 3 dB before they are used when interpolating between the values given in Tables 3.12 to 3.15.

For 7 MHz channels, 0.6 dB is to be subtracted from the input signal voltage and field strength values given in Tables 3.12, 3.13, 3.14 and 3.15.

For frequencies in Bands IV and V other than 500 MHz, the field strength correction formula:

$$E_{\text{med } f} = E_{\text{med } 500 \text{ MHz}} + 20 \log_{10}(f / 500)$$

where:

f is the actual frequency in MHz being considered;

and $470 \text{ MHz} < f < 862 \text{ MHz}$,

may be used. For further information, see § 3.3.

Frequency	f {MHz}	200					
Representative Minimum C/N ratio	{dB}	2	8	14	20	26	32
Min. equivalent receiver input voltage, 75 Ω	$U_{s\ min}$ {dB μ V}	13	19	25	31	37	43
Antenna gain rel. to half wave dipole	G_D {dB}	-2.2					
Effective antenna aperture	A_a {dBm ² }	-7.5					
Min equivalent field strength at receiving place	E_{min} {dB μ V/m}	27	33	39	45	51	57
Allowance for man made noise	P_{mmn} {dB}	1					
Height loss	L_h {dB}	10					

Location probability: 70%

Location correction	C_i {dB}	2.9					
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	41	47	53	59	65	71

Location probability: 95%

Location correction	C_i {dB}	9					
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	47	53	59	65	71	77

Table 3.12: Minimum median equivalent field strength in Band III for portable outdoor reception (Class A)

Frequency	f {MHz}	500					
Representative Minimum C/N ratio	{dB}	2	8	14	20	26	32
Min. equivalent receiver input voltage, 75 Ω	$U_{s\ min}$ {dB μ V}	13	19	25	31	37	43
Antenna gain rel. to half wave dipole	G_D {dB}	0					
Effective antenna aperture	A_a {dBm ² }	-13.3					
Min equivalent field strength at receiving place	E_{min} {dB μ V/m}	33	39	45	51	57	63
Allowance for man made noise	P_{mmn} {dB}	0					
Height loss	L_h {dB}	12					

Location probability: 70%

Location correction	C_i {dB}	2.9					
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	48	54	60	66	72	78

Location probability: 95%

Location correction	C_i {dB}	9					
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	54	60	66	72	78	84

Table 3.13: Minimum median equivalent field strength at 500 MHz for portable outdoor reception (Class A)

Frequency	f {MHz}	200					
Representative Minimum C/N ratio	{dB}	2	8	14	20	26	32
Min. equivalent receiver input voltage, 75Ω	$U_{s \min}$ {dB μ V}	13	19	25	31	37	43
Antenna gain rel. to half wave dipole	G_D {dB}	-2.2					
Effective antenna aperture	A_a {dBm ² }	-7.5					
Min equivalent field strength at receiving place	E_{\min} {dB μ V/m}	27	33	39	45	51	57
Allowance for man made noise	P_{mnn} {dB}	1					
Height loss	L_h {dB}	10					
Building penetration loss	L_b {dB}	8					

Location probability: 70%

Location correction	C_l {dB}	3.3					
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	49	55	61	67	73	79

Location probability: 95%

Location correction	C_l {dB}	10.4					
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	56	62	68	74	80	86

Note: Minimum median equivalent field strength values at 10 m agl for 50% of time and 50% of locations are estimated to be:

- dB lower than the values shown if reception is required in rooms at the first floor;
- 10 dB lower than the values shown if reception is required in rooms higher than the first floor.

Table 3.14: Minimum median equivalent field strength in Band III for portable indoor reception at ground floor (Class B)

Frequency	f {MHz}	500					
Representative Minimum C/N ratio	{dB}	2	8	14	20	26	32
Min. equivalent receiver input voltage, 75Ω	$U_{s \min}$ {dB μ V}	13	19	25	31	37	43
Antenna gain rel. to half wave dipole	G_D {dB}	0					
Effective antenna aperture	A_a {dBm ² }	-13.3					
Min equivalent field strength at receiving place	E_{\min} {dB μ V/m}	33	39	45	51	57	63
Allowance for man made noise	P_{mnn} {dB}	0					
Height loss	L_h {dB}	12					
Building penetration loss	L_b {dB}	7					

Location probability: 70%

Location correction	C_l {dB}	4.2					
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	56	62	68	74	80	86

Location probability: 95%

Location correction	C_l {dB}	13.4					
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	66	72	78	84	90	96

Note: Minimum median equivalent field strength values at 10 m agl for 50% of time and 50% of locations are estimated to be:

- 6 dB lower than the values shown if reception is required in rooms at the first floor,
- 12 dB lower than the values shown if reception is required in rooms higher than the first floor.

Table 3.15: Minimum median equivalent field strength at 500 MHz for portable indoor reception at ground floor (Class B)

3.6 Mobile reception

Mobile reception of DVB-T signals is being studied. It is still in an early phase of development.

The values given in this section do not take account of improvements which are expected to be achieved by the use of diversity reception.

3.6.1 Location variation

The field strength is assumed to show a log-normal distribution with a standard deviation of 5.5 dB as for fixed and portable reception.

For mobile reception it may be necessary to plan for a location probability of 99%.

Coverage target (location probability)	Location variation VHF and UHF
Not less than 99%	12.8 dB
Not less than 95%	9.0 dB
not less than 70%	2.9 dB

Table 3.16: Location variation for mobile reception

3.6.2 Antennas for mobile reception

It is assumed that the antenna of a mobile receiver is non-directional and that the gain (relative to a $\lambda/2$ dipole) is 0 dB for a UHF antenna and -2.2 dB for a VHF Band III antenna.

A mobile receiver can be assumed to have a low feeder loss in all bands. The value is initially set to 0 dB.

Generally, no polarisation discrimination is expected from antennas for mobile reception.

It is expected that the use of diversity antenna systems will reduce the rather high C/N values used in the following calculations.

Antenna diversity is a key technique for future mobile and portable DVB-T compliant broadband multimedia receivers.

In mobile reception conditions, antenna diversity is expected to reduce transmitted power (by 7 to 8 dB) for the same coverage, but it should also allow an increase in the mobile's maximum speed for correct reception which will act in the opposite direction.

The potential advantages of using antenna diversity for portable reception are considerable. This is especially important for the 8k modes in DVB-T, which are more sensitive to the Doppler effects caused by people moving near the receiving antenna or by (slow) movement of that antenna when the receiver is being used by a pedestrian.

As for low speed mobile reception, a 7 to 8 dB gain in robustness is expected. This should lead to an improved robustness against variations of reception quality due to people moving around the receiver or to changing channel.

Additionally since the signal is received on 2 antennas, and indoor reception conditions are known to vary rapidly with location, it should be much easier to find an accurate position for

good reception with a portable receiver featuring antenna diversity than with a single antenna receiver (the probability of having deep or flat fades on 2 antennas is much lower than on one single antenna).

3.6.3 Height loss for received signal

For mobile reception the same height losses are assumed as for portable reception, see § 3.5.3, that is for VHF (Band III) 10 dB and for UHF 12 dB.

3.6.4 Doppler effect and speed limitations

Figures for mobile reception are given in Tables 3.17 and 3.18 for the typical channel profile - TYPICAL URBAN. Table 3.17 shows values for the minimum C/N ratio, the critical Doppler frequency and the corresponding speed limits in the **non-diversity** case. Table 3.18 contains the corresponding values for the **diversity** case. The speed limits are given for three frequencies (200 MHz, 500 MHz and 800 MHz).

The figures apply to the case of MFN coverage. Simulations show that in the SFN case, where large echo delays reduce the probability of flat fading, smaller figures for C/N are needed. Moreover, the figures for C/N as well as for the Doppler frequencies are to be regarded as preliminary. Improvements may be achieved with receivers particularly designed for mobile reception.

Modulation	Bitrate {Mbit/s}	Code Rate	C/N theoretical Rayleigh {dB}	C/N minimum {dB}	2k mode			8k mode				
					Critical Doppler frequency f_D (Hz)	Equivalent speed {km/h}			Critical Doppler frequency f_D (Hz)	Equivalent speed {km/h}		
						200 MHz	500 MHz	800 MHz		200 MHz	500 MHz	800 MHz
QPSK	6.03	1/2	5.4	14.5	520	2808	1123	702	130	702	281	176
QPSK	8.04	2/3	8.4	17.0	460	2484	994	621	115	621	248	155
16QAM	12.06	1/2	11.2	20.5	304	1641	657	410	76	410	164	103
16QAM	16.09	2/3	14.2	23.5	212	1144	458	286	53	286	114	72
64QAM	18.10	1/2	16.0	25.5	168	907	363	227	42	227	91	57
64QAM	24.13	2/3	19.3	30.0	104	561	225	140	26	140	43	35

Table 3.17: C/N, Doppler frequency f_D and equivalent speeds for mobile reception with the 'TYPICAL URBAN' profile for the **non-diversity** case.

Modulation	Bitrate {Mbit/s}	Code Rate	C/N theoretical Rayleigh {dB}	C/N minimum {dB}	2k mode			8k mode				
					Critical Doppler frequency f_D (Hz)	Equivalent speed {km/h}			Critical Doppler frequency f_D (Hz)	Equivalent speed {km/h}		
						200 MHz	500 MHz	800 MHz		200 MHz	500 MHz	800 MHz
QPSK	6.03	1/2	5.4	8.5								
QPSK	8.04	2/3	8.4	14.0								
16QAM	12.06	1/2	11.2	16.5	560	3024	1210	756	140	756	302	189
16QAM	16.09	2/3	14.2	18.5	480	2592	1037	648	120	648	259	162
64QAM	18.10	1/2	16.0	21.0	388	2095	838	524	97	524	210	131
64QAM	24.13	2/3	19.3	22.0	260	1404	562	351	65	351	140	88

Table 3.18: C/N, Doppler frequency f_D and equivalent speeds for mobile reception with the 'TYPICAL URBAN' profile for the **diversity** case.

Higher code rates than 1/2 and 2/3 are less suitable for mobile reception.

The values for the bit rate correspond to the shortest guard interval 1/32 which is the least critical case in terms of Doppler. In SFN networks a short guard interval may increase the risk of self interference.

It can be seen from the Tables 3.17 and 3.18 that lower frequencies allow for a higher speed of the vehicle and also that 2k variants allow for higher speed than 8k variants.

3.6.5 Minimum median equivalent field strength

The tables below give the minimum median equivalent field strength for location probabilities of 70%, 95% and 99% in Band III and at 500 MHz. These tables are expressed in terms of representative minimum C/N value required by the system. C/N values taken from Table 3.17 or 3.18 should be increased by an implementation margin of 3 dB before they are used when interpolating between the values given in Tables 3.19 to 3.20.

For 7 MHz channels, 0.6 dB is to be subtracted from the input signal voltage and field strength values given in Tables 3.19 and 3.20.

For frequencies in Bands IV and V other than 500 MHz, the field strength correction formula:

$$E_{\text{med } f} = E_{\text{med } 500 \text{ MHz}} + 20 \log_{10}(f / 500)$$

where:

f is the actual frequency in MHz being considered;

and $470 \text{ MHz} < f < 862 \text{ MHz}$,

may be used. For further information, see § 3.3.

It is to be noted that the following two Tables are for the **non-diversity** case and that the use of diversity reception is expected to reduce the minimum equivalent field strength requirements by some 7 to 8 dB. The representative C/N values are those applicable for mobile reception (see Tables 3.17 and 3.18) increased by the implementation margin of 3 dB.

Frequency	f {MHz}	200					
Representative Minimum C/N ratio	{dB}	2	8	14	20	26	32
Min. receiver signal input power	$P_{s\ min}$ {dBW}	-126.2	-120.2	-114.2	-108.2	-102.2	-96.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\ min}$ {dB μ V}	13	19	25	31	37	43
Antenna gain rel. to half wave dipole	G_D {dB}	-2.2					
Effective antenna aperture	A_a {dBm ² }	-7.5					
Min power flux density at receiving place	ϕ_{min} {dBW/m ² }	-118.7	-112.7	-106.7	-100.7	-94.7	-88.7
Min equivalent field strength at receiving place	E_{min} {dB μ V/m}	27	33	39	45	51	57
Allowance for man made noise	P_{mnn} {dB}	1					
Height loss	L_h {dB}	10					

Location probability: 70%

Location correction	C_l {dB}	2.9					
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} {dBW/m ² }	-104.8	-98.8	-92.8	-86.8	-80.8	-74.8
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	41	47	53	59	65	71

Location probability: 95%

Location correction	C_l {dB}	9					
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} {dBW/m ² }	-98.7	-92.7	-86.7	-80.7	-74.7	-68.7
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	47	53	59	65	71	77

Location probability: 99%

Location correction	C_l {dB}	12.8					
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} {dBW/m ² }	-94.7	-88.7	-82.7	-76.7	-70.7	-64.7
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dB μ V/m}	51	57	63	69	75	81

Table 3.19: Minimum median power flux density and equivalent minimum median field strength in Band III for 70%, 95% and [99]% location probability, mobile reception.

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Frequency	f [MHz]	500					
Representative Minimum C/N ratio	[dB]	2	8	14	20	26	32
Min. receiver signal input power	$P_{s\ min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2	-96.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\ min}$ [dB μ V]	13	19	25	31	37	43
Antenna gain rel. to half wave dipole	G_D [dB]	0					
Effective antenna aperture	A_a [dBm ²]	-13,3					
Min power flux density at receiving place	ϕ_{min} [dBW/m ²]	-112.9	-106.9	-100.9	-94.9	-88.9	-82.9
Min equivalent field strength at receiving place	E_{min} [dB μ V/m]	33	39	45	51	57	63
Allowance for man made noise	P_{mmn} [dB]	0					
Height loss	L_h [dB]	12					

Location probability: 70%

Location correction	C_{lc} [dB]	2.9					
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} [dBW/m ²]	-98	-92	-86	-80	-74	-68
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dB μ V/m]	48	54	60	66	72	78

Location probability: 95%

Location correction	C_{lc} [dB]	9					
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} [dBW/m ²]	-91.9	-85.9	-79.9	-73.9	-67.9	-61.9
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dB μ V/m]	54	60	66	72	78	84

Location probability: 99%

Location correction	C_{lc} [dB]	12.8					
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} [dBW/m ²]	-87.9	-81.9	-75.9	-69.9	-63.9	-59.9
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dB μ V/m]	58	64	70	76	82	88

Table 3.20: Minimum median power flux density and equivalent minimum median field strength at 500 MHz for 70%, 95% and [99]% location probability, mobile reception.

4. Transmitter spectrum masks for DVB-T

DVB-T transmitters operating in frequency bands, shared with other services, may have to respect a defined spectrum mask.

The out-of-band signal radiated in any 4 kHz band should be constrained by one of the two symmetrical spectrum masks given in Figure 4.1 and Table 4.1.

Case 1: the mask having a shoulder attenuation of 40 dB is intended for non-critical cases

Case 2: the mask with a shoulder attenuation of 50 dB is intended for sensitive cases.

The mask for non-critical cases should also be used for measurements of protection ratios for analogue television interfered with by DVB-T.

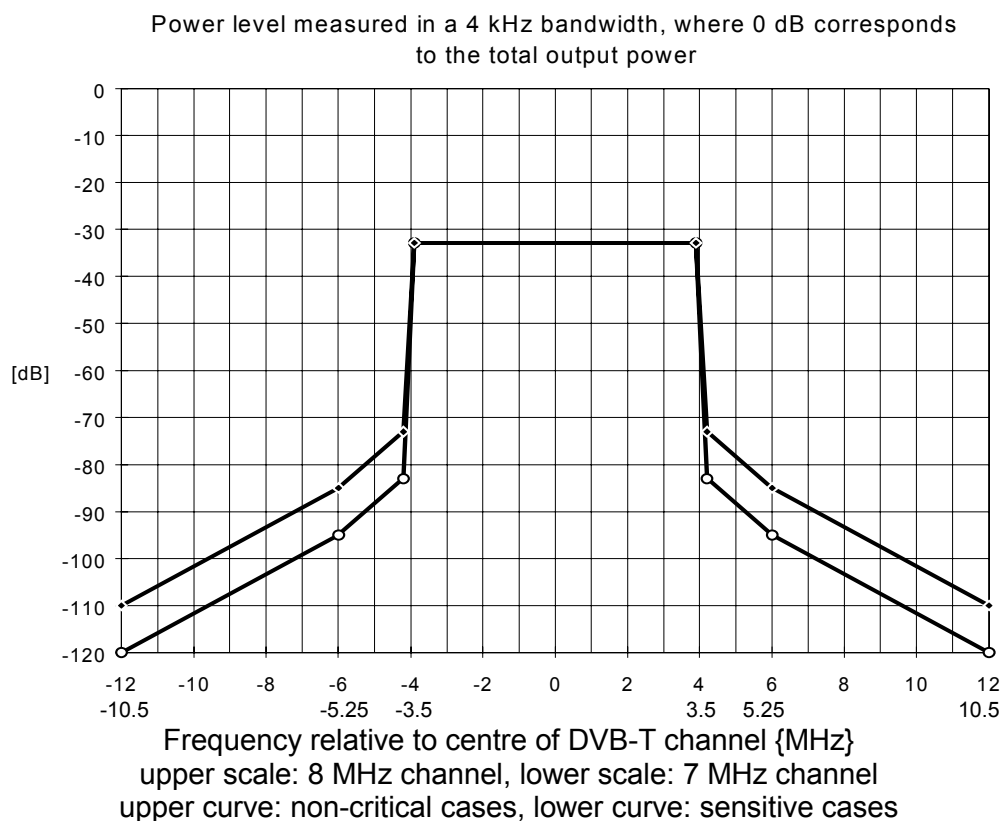


Figure 4.1: Symmetrical spectrum masks for non-critical and for sensitive cases

Breakpoints					
8 MHz channels			7 MHz channels		
Relative Frequency MHz	Non-critical cases	Sensitive cases	Relative Frequency MHz	Non-critical cases	Sensitive cases
	Relative Level dB	Relative Level dB		Relative Level dB	Relative Level DB
-12.0	-110.0	-120.0	-10.5	-110.0	-120.0
-6.0	-85.0	-95.0	-5.25	-85.0	-95.0
-4.2	-73.0	-83.0	-3.7	-73.0	-83.0
-3.9	-32.8	-32.8	-3.4	-32.8	-32.8
+3.9	-32.8	-32.8	+3.4	-32.8	-32.8
+4.2	-73.0	-83.0	+3.7	-73.0	-83.0
+6.0	-85.0	-95.0	+5.25	-85.0	-95.0
+12.0	-110.0	-120.0	+10.5	-110.0	-120.0

Table 4.1: Breakpoints used in Figure 4.1

5. Protection ratios

The reference power for protection ratio evaluation is:

- for DVB-T, the average signal power (heating) of the COFDM signal measured in the system bandwidth
- for analogue television, generally, the RMS power of the vision signal at the sync peak, but in the case of SECAM L, the peak white level.

The protection ratios relevant to a given interference are evaluated without noise or other interference, at the relevant quality target, and are expressed in dB.

5.1 DVB-T interfered with by DVB-T

For a wanted DVB-T signal the required protection ratios are preferably measured for no more than one visible impairment in any 20 second period. In the case of a digital signal as the wanted signal, the same protection ratio values relate to both tropospheric and continuous interference.

5.1.1 Co-channel

Modulation	Code Rate	ITU-mode	Protection ratio		
			Gaussian (*)	Ricean (**)	Rayleigh (**)
QPSK	1/2		5	7	8
QPSK	2/3		7		
QPSK	3/4				
16QAM	1/2	M1	13	13	14
16QAM	2/3				
16QAM	3/4		14	16	20
64QAM	1/2	M2		18	19
64QAM	2/3	M3	19	20	22
64QAM	3/4				

(*) Measurement results, IF loop, 2K mode; (**) Extrapolated result

Table 5.1: Co-channel protection ratios for DVB-T interfered with by DVB-T (the protection ratios given for the different transmission channels do not show the same difference as the required C/N values for the corresponding system variants)

Protection ratios are given for three types of propagation channels (i.e. Gaussian, Ricean and Rayleigh). For fixed and portable reception, the values relevant to the Ricean and Rayleigh channels respectively should be adopted.

The same protection ratios should be applied for DVB-T systems with 7 and 8 MHz bandwidth. Protection ratios are rounded to the nearest integer.

5.1.2 Overlapping channels

For overlapping channel, in absence of measurement information the protection ratio should be extrapolated from the co-channel ratio figure as follows.

$$PR = CCI + 10 \log_{10}(BO/BW)$$

where:

CCI: co-channel protection ratio

BO: bandwidth (MHz) in which the two DVB-T signals are overlapping

BW: bandwidth (MHz) of the wanted signal

PR = -30 dB should be used when the above formula gives *PR* < -30 dB.

5.1.3 Adjacent channels

Unwanted DVB-T signal in channel	N - 1	N + 1
Protection ratio (dB)	-30	-30

Table 5.2: Protection ratios for a DVB-T signal interfered with by a DVB-T signal in the lower (*N* - 1) and upper (*N* + 1) adjacent channels (Information concerning the dependence of the DVB-T system variant is not available.)

The protection ratios are given in dB and apply to both continuous and tropospheric interference.

The values are given for the case where the wanted and unwanted DVB-T signals have the same channel width.

5.1.4 Other channels, except adjacent channels but including the image channel

Unwanted DVB-T signal in channel	Other channels
Protection ratio (dB)	-40

Table 5.3: Protection ratio for a DVB-T signal interfered with by a DVB-T signal in the other channels than the adjacent channels (Information concerning the dependence of the DVB-T system variant is not available.)

5.2 DVB-T interfered with by analogue television

5.2.1 Co-channel

Modulation	Protection ratio														
	QPSK					16QAM					64QAM				
Code rate	1/2	2/3	3/4	5/6	7/8	1/2	2/3	3/4	5/6	7/8	1/2	2/3	3/4	5/6	7/8
Unwanted analogue television PAL / SECAM ⁽¹⁾	-12	-8	-4	3	9	-8	-3	3	9	16	-3	3	9	15	20

(1) With teletext and sound carriers.

Table 5.4: Co-channel protection ratios (dB) for DVB-T 7 MHz and 8 MHz systems interfered with by analogue television (non-controlled frequency condition) systems. (The differences between the individual values are larger than between the corresponding min. C/N values in Table 3.1)

NOTE 1 – The PAL/SECAM values are valid for the following sound carrier modes:

- MONO FM with a single sound carrier at - 10 dB referred to the vision carrier;
- DUAL FM and FM + NICAM with two sound carriers at - 13 dB and - 20 dB level;
- AM + NICAM with two sound carriers at respectively - 10 dB and - 27 dB level.

According to the available measurements, the same protection ratio values are applicable for 2k and 8k modes.

In all tables the so-called non-controlled conditions are used.

Actual measurements of protection ratio values will reflect the cyclic variation that occurs when the offset between a wanted DVB-T signal and an unwanted analogue signal is varied over a frequency range equivalent to the spacing between carriers

of coded orthogonal frequency division multiplex (COFDM) systems. The protection ratios given represent a conservative, but realistic, value that covers the expected offset performance of existing receivers. The adoption of fine offset between COFDM signals and interfering analogue TV signals will permit the achievement of up to 3 dB improvement in protection ratio. The required transmitter frequency stability is similar to the analogue precision offset, that means in a range of some Hz.

5.2.2 Overlapping channels

DVB-T 8 MHz 64-QAM code rate 2/3													
Δf (MHz)	- 9.75	- 9.25	- 8.75	- 8.25	- 6.75	- 3.95	- 3.75	- 2.75	- 0.75	2.25	3.25	4.75	5.25
PR (dB)	- 37	- 14	- 8	- 4	- 2	1	3	3	3	2	- 1	- 29	- 36

The frequency difference Δf is the vision carrier frequency of the analogue television signal minus the centre frequency of the DVB-T signal.

Table 5.5: Protection ratios (dB) for a DVB-T 8 MHz system interfered with by an overlapping PAL B signal including sound. (A relation to other DVB-T variants is needed)

DVB-T 7 MHz 64-QAM code rate 2/3														
Δf (MHz)	- 9.25	- 8.75	- 8.25	- 7.75	- 6.25	- 3.45	- 3.25	- 2.25	- 1.25	0	1.75	2.75	4.25	4.75
PR (dB)	- 35	- 12	- 11	- 5	- 3	- 1	4	1	0	2	- 5	- 5	- 36	- 38

The frequency difference Δf is the vision carrier frequency of the analogue television signal minus the centre frequency of the DVB-T signal.

Table 5.6: Protection ratios (dB) for a DVB-T 7 MHz system interfered with by an overlapping 7 MHz analogue TV system including sound. (A relation to other DVB-T variants is needed)

DVB-T 8 MHz 64-QAM Code rate 2/3														
Δf (MHz)	- 10.25	- 9.75	- 9.25	- 8.75	- 7.25	- 3.45	- 3.25	- 2.25	- 1.25	0	1.75	2.75	4.25	4.75
PR (dB)	- 35	- 12	- 11	- 5	- 3	- 1	4	1	0	2	- 5	- 5	- 36	- 38

The frequency difference Δf is the vision carrier frequency of the analogue television signal minus the centre frequency of the DVB-T signal.

Table 5.7: Protection ratios (dB) for a DVB-T 8 MHz system interfered with by an overlapping 8 MHz analogue TV system including sound. (A relation to other DVB-T variants is needed).

5.2.3 Adjacent channels

Wanted signal		Unwanted signal					
Modulation	Code rate	PAL B	PAL B1, G	PAL I	PAL D, K	SECAM L	SECAM D, K
QPSK	1/2						
QPSK	2/3	-44					
QPSK	3/4						
16QAM	1/2			-43			
16QAM	2/3	-42					
16QAM	3/4						
64QAM	1/2			-38			
64QAM	2/3	-35		-34		-35	
64QAM	3/4						

Table 5.8: Protection ratios (dB) for DVB-T systems (7 MHz and 8 MHz) interfered with by analogue television in the lower adjacent channel (N - 1)

Wanted DVB-T signal		Unwanted analogue signal
Modulation	Code rate	PAL / SECAM
QPSK	1/2	
QPSK	2/3	-47
QPSK	3/4	
16QAM	1/2	
16QAM	2/3	-43
16QAM	3/4	
64QAM	1/2	
64QAM	2/3	-38
64QAM	3/4	

Table 5.9: Protection ratios (dB) for DVB-T systems (7 MHz and 8 MHz) interfered with by an analogue television signal in the upper adjacent channel (N + 1). (It is not known whether there is a dependency on the width of the lower side band of the analogue signal)

5.2.4 Image channel

Wanted signal				Interfering signal					
System	BW	Modulation	Code rate	PAL B	PAL G,B1	PAL I	PAL D,K	SECAM L	SECAM D,K
DVB-T	8 MHz	16QAM	1/2			-58			
		64QAM	1/2			-50			
		64QAM	2/3			-46			

Note: the protection ratios in this table will depend on the intermediate frequency of the receiver.

Table 5.10: Protection ratios (dB) for DVB-T interfered with by analogue television in the image channel

5.3 Analogue television interfered with by DVB-T

5.3.1 Co-channel

Wanted analogue system	Unwanted signal: DVB-T 8 MHz	
	Tropospheric interference	Continuous interference
B, B1, D, D1, G, H, K / PAL	34	40
I / PAL	37	41
B, D, K, L / SECAM	35	41

Table 5.11: Protection ratios (dB) for an analogue vision signal interfered with by a DVB-T 8 MHz system

Wanted analogue system	Unwanted signal: DVB-T 8 MHz	
	Tropospheric interference	Continuous interference
B / PAL, B / SECAM	35	41

Table 5.12: Protection ratios (dB) for an analogue vision signal interfered with by a DVB-T 7 MHz system

Protection ratio related to the wanted sound carrier		Unwanted signal	
Wanted sound signal		DVB-T 7 MHz	DVB-T 8 MHz
FM	Tropospheric	6	5
	Continuous	16	15
AM	Tropospheric	21	20
	Continuous	24	23
NICAM (PAL B / G)	Tropospheric	5	4
	Continuous	6	5
NICAM (System I)	Tropospheric		
	Continuous		
NICAM (System L)	Tropospheric	12	11
	Continuous	13	12

Table 5.13: Protection ratios (dB) for a wanted sound signal interfered with by a DVB-T signal

5.3.2 Overlapping channels

Centre frequency of the unwanted DVB-T signal minus the vision carrier frequency of the wanted analogue television signal (MHz)	Protection ratio (dB)	
	Tropospheric Interference	Continuous interference
-7.75	-16	-11
(N - 1) -4.75	-9	-5
-4.25	-3	4
-3.75	13	21
-3.25	25	31
-2.75	30	37
-1.75	34	40
-0.75	35	41
(N) 2.25	35	41
4.25	35	40
5.25	31	38
6.25	28	35
7.25	26	33
8.25	6	12
(N + 1) 9.25	-9	-5
12.25	-9	-5

Table 5.14: Protection ratios (dB) for analogue B, B1, D, D1, G, H, K/PAL vision signals ⁽¹⁾ interfered with by a DVB-T 7 MHz system (overlapping channels)

(1) For all SECAM systems similar values are expected. The values are still under study.

Centre frequency of the unwanted DVB-T signal minus the vision carrier frequency of the wanted analogue television signal (MHz)	Protection ratio (dB)	
	Tropospheric interference ⁽¹⁾	Continuous Interference ⁽¹⁾
-8.25	-16	-11
(N - 1) -5.25	-9	-5
-4.75	-4	3
-4.25	12	20
-3.75	24	30
-3.25	29	36
-2.25	33	39
-1.25	34	40
(N) 2.75	34	40
4.75	34	39
5.75	30	37
6.75	27	34
7.75	25	32
8.75	5	11
(N + 1) 9.75	-9	-5
12.75	-9	-5

(1) The values for tropospheric and continuous interference have been arrived at from Table 5.15 by calculation.

(2) (2) For all SECAM systems similar values are expected. The values are still under study.

Table 5.15: Protection ratios (dB) for analogue B, D, D1, G, H, K/PAL vision signals ⁽²⁾ interfered with by a DVB-T 8 MHz system (overlapping channels)

Protection ratio related to the wanted sound carrier	Frequency of the DVB-T signal relative to an FM carrier	Frequency of the 3 dB point of the DVB-T signal minus sound carrier frequency						
		-500 kHz	-250 kHz	-50 kHz	0 kHz	50 kHz	250 kHz	500 kHz
Tropospheric	DVB-T below FM	0	0	0	5	5	6	6
Continuous	DVB-T below FM	9	9	9	14	14	15	16
Tropospheric	DVB-T above FM	5	5	4	3	-9	-22	-32
Continuous	DVB-T above FM	15	15	14	12	-6	-16	-27

Table 5.16: Protection ratios (dB) for a wanted FM sound carrier interfered with by a DVB-T 7 MHz signal

5.3.3 Adjacent channels

Wanted analogue system	Tropospheric Interference	Continuous Interference
B, B1, D, D1, G, H, I, K / PAL	-9	-5
B, D, K, L / SECAM	-6	-1

Table 5.17: Protection ratios (dB) for an analogue vision signal interfered with by DVB-T 7 MHz and 8 MHz systems in the lower adjacent channel

Wanted analogue system	Tropospheric interference	Continuous Interference
B, B1, D, D1, G, H, I, K / PAL and SECAM	-9	-5

Table 5.18: Protection ratios (dB) for an analogue vision signal interfered with by DVB-T 7 MHz and 8 MHz systems in the upper adjacent channel

Protection ratio related to the wanted sound carrier	Centre frequency of the DVB-T signal minus sound carrier frequency		
	With negative DVB-T offset	No offset	With positive DVB-T offset
	4.250 – 0.166 MHz = 4.084 MHz	4.250 MHz	4.250 + 0.166 MHz = 4.416 MHz
Tropospheric	-1	-2	-4
Continuous	+1	0	-2

Table 5.19: Protection ratios (dB) for a wanted AM sound signal interfered with by a DVB-T 8 MHz system for different frequency offsets for the DVB-T (in the upper adjacent channel)

5.3.4 Image channel

Wanted analogue television system	Unwanted DVB-T channel	Tropospheric interference	Continuous Interference
D1, G / PAL	N + 9	-19	-15
I / PAL	N + 9		
L / SECAM ⁽¹⁾	N + 9	-24	-22
D, K / SECAM ⁽¹⁾	N + 8, N + 9	-16	-11
D, K / PAL	N + 8, N + 9		

Note: (1) Provisional values, still under study

Table 5.20: Protection ratios (dB) for an analogue vision signal interfered with by a DVB-T 8 MHz system in the image channel

5.4 DVB-T interfered with by T-DAB

DVB-T 8 MHz, 64 QAM, Code rate 2/3 (ITU-R mode M3)									
Δf = Centre frequency of T-DAB minus centre frequency of DVB-T									
Δf (MHz)	-5	-4.2	-4	-3	0	3	4	4.2	5
Protection ratio (dB)	-30	-6	-5	28	29	28	-5	-6	-30

Table 5.21: Protection ratios (dB) for a DVB-T 8 MHz interfered with by T-DAB (see Annex 1)

DVB-T 7 MHz, 64 QAM, Code rate 2/3 (ITU-R mode M3)									
Δf = Centre frequency of T-DAB minus centre frequency of DVB-T									
Δf (MHz)	-4.5	-3.7	-3.5	-2.5	0	2.5	3.5	3.7	4.5
Protection ratio (dB)	-30	-6	-5	28	29	28	-5	-6	-30

Table 5.22: Protection ratios (dB) for a DVB-T 7 MHz interfered with by T-DAB (see Annex 1)

5.5 T-DAB interfered with by DVB-T

DVB-T 8 MHz, 64 QAM, Code rate 2/3 (ITU-R mode M3)									
Δf = Centre frequency of DVB-T minus centre frequency of T-DAB									
Δf (MHz)	-5	-4.2	-4	-3	0	3	4	4.2	5
Protection ratio (dB)	-50	-1	0	1	1	1	0	-1	-50

Table 5.23: Protection ratios (dB) for T-DAB interfered with by DVB-T 8 MHz

DVB-T 7 MHz, 64 QAM, Code rate 2/3 (ITU-R mode M3)									
Δf = Centre frequency of DVB-T minus centre frequency of T-DAB									
Δf (MHz)	-4.5	-3.7	-3.5	-2.5	0	2.5	3.5	3.7	4.5
Protection ratio (dB)	-49	0	1	2	2	2	1	0	-49

Table 5.24: Protection ratios (dB) for T-DAB interfered with by DVB-T 7 MHz

5.6 DVB-T interfered with by other services

(Information to come from SE27)

5.7 Other services interfered with by DVB-T

(Information to come from SE27)

6. Calculation of interference

Most television transmitters provide a coverage limited by interference. The level of interference is determined by the nuisance field from each interfering transmitter.

The nuisance field is the sum of the interfering field strength and the relevant protection ratio.

If applicable the nuisance field is corrected by the properties of an assumed receiving antenna (see § 1.2).

The sum of the individual nuisance fields can be calculated by means of several methods of which the most important are described below.

6.1 Combination of signal levels for coverage assessments

One of the questions to be answered is how to combine interfering signals when there is more than one and how to take into account the effect of noise. Some of the calculation methods to deal with this question are presented below. They are all statistical methods which require computer processing and they use models of the real situation. In all the methods, except the power sum method, it is assumed that field strengths have a log-normal distribution with location.

The first method is a numerical approach which is capable of providing the required accuracy but at the expense of a large amount of computer time. The remaining methods are approximations which are presented in order of growing complexity and this increasing complexity corresponds to an increasing computer processing time.

It should be noted that though there may exist some correlation between the individual signals, wanted as well as unwanted signals, none of the methods described below include the treatment of correlation in their original form. However some of them can be extended to include correlation. The effect of correlation varies with the reception situation. It can produce either an increase or a decrease of coverage depending upon the particular correlation situation.

6.1.1 The Monte-Carlo method

Apart from a deterministic (numerical integration) method, the Monte-Carlo approach is the most accurate method available to evaluate the coverage probability. With the mean value and the standard deviation of the distribution of each signal it is possible to simulate the situation for a large number of reception locations in a small area (say, 200 m x 200 m). This is done by generating one random value of the wanted field and one random value of each interferer. For each combination it is possible to check if the reception location is served or unserved by comparing the power of the useful signal with the sum of the powers of the noise and the nuisance fields. By repeating this simulation for a large number of combinations of wanted and unwanted signals, the coverage probability for a given small area may be derived. The higher the number of combinations, the more accurate the method becomes but this can lead to very lengthy computer processing times. In addition, the process must be repeated for a large number of small areas in order to represent the overall coverage area.

6.1.2 Power sum method

A description of the power sum method as applied to analogue television is given in EBU doc. Tech 3254. This method has been used for the assessment of multiple interference at several ITU conferences. The sum of the signal levels is calculated by a non statistical summation of the individual signal powers. For the unwanted signal, the powers of the mean values of the in

dividual nuisance fields are added to the power of the minimum field strength (representing the noise contribution). For the wanted signal in an SFN, the powers of the individual useful fields are added. A 50% location coverage is obtained if the sum of the unwanted signal levels equals the sum of the wanted signal levels.

For digital television, a margin must be added to the resulting nuisance field in order to cover more than 50% of the locations. This margin is related to the target percentage of locations. Its value is not derived by the power sum method. Usually a value derived from the standard deviation of a single signal is used.

The method gives acceptable results for a 50% locations target but shows a poor behaviour for higher percentages due to its non-statistical character. Detailed formulas are given in Annex 6.1.

6.1.3 Simplified multiplication method

The simplified multiplication method is a statistical computation procedure which has also been used for the assessment of multiple interference, for instance at the Regional VHF/FM Broadcasting Conference (Geneva, 1984).

It gives the coverage probability in the presence of several interfering signals which are assumed to be log-normally distributed with known mean values and standard deviations. The coverage area can be determined by calculating the probability for different locations. The contour of the coverage area is made up of the set of locations where the coverage probability achieves the required value.

As the effect of noise is not taken into account in the statistical treatment, over-estimation of the coverage can be expected when the levels of the interferers are low. However, it is possible to add the effect of noise at the end of the calculation process.

This method is explained in detail in the Final Acts the Regional VHF/FM Broadcasting Conference (Geneva, 1984) as well as in the EBU doc. Tech 3254, but it must be noted that it is not applicable to SFNs since it cannot deal with multiple useful signals.

6.1.4 Log-normal method

The log-normal method is an approximation method for the statistical computation of the sum distribution of several log-normally distributed variables. In a coverage calculation it gives the coverage probability of the small area under consideration. The method is based on the assumption that the resulting sum distributions of the wanted and unwanted fields are also log-normal. It is composed of several steps. First the distributions of the composite wanted (C) and unwanted (NF) fields are calculated. Then the corresponding distributions of C/NF and C/N are evaluated. Finally, the combination of these distributions gives the coverage probability. To some extent, the LNM is able to cope with different standard deviations of the single field distributions.

To improve the accuracy of the LNM in the high probability region (that is, a high coverage value) a correction factor can be introduced. This version of the LNM is called k-LNM.

Detailed formulas of standard LNM and k-LNM are given in Appendix 6.2. A simplified version of standard LNM is described in ITU-R Rep. 945. (This is not to be confused with the so-called 'simplified log-normal method' which is applicable only for 50% coverage calculations and therefore of no use for digital television planning).

6.1.5 The t-LNM method

The t-LNM method is a numerical approximation method for the statistical computation of the sum distribution of several log-normally distributed variables. Its structure is similar to that of the standard LNM and it is based on the same idea, i.e. that the sum distribution of two log-normal variables is also log-normal. However, the parameters of the sum distribution are calculated in a different way and, as a consequence, are different from those of the standard LNM.

This approach leads to a higher accuracy in the high probability region (that is, a high coverage value) compared to the standard and k-LNM approaches but this must be paid for with higher mathematical complexity. The t-LNM method is able to process different standard deviations of the single fields with few restrictions. The specific case of noise may be regarded as an interference signal with a standard deviation of 0 dB.

A description of the method is given in Annex 6.3.

6.1.6 Schwartz and Yeh method

The Schwartz and Yeh method is an iterative method for calculation of the characteristics of the resultant of N interferers. It makes the assumption that the combination of two log-normal variables also has a log-normal distribution (this is a common approximation) and it gives the formulas to calculate the resultant of two variables. For more than two signals an iterative process is applied. Its general approach is very similar to that of t-LNM and the accuracy of both methods is comparably high; for this reason, no further details are given here.

ANNEX 1 to Chapter 6: POWER SUM METHOD

The power sum method is a procedure for the approximate calculation of the mean value of a sum field. If the mean value of the (logarithmic) field strength of a single signal is denoted by \bar{F} and is expressed in dB(μ V/m), its power P (in arbitrary units) is given by

$$P = 10^{\frac{\bar{F}}{10}} .$$

For n individual fields the respective powers are added:

$$P_{\Sigma} = \sum_{i=1}^n P_i .$$

and the mean value \bar{F}_{Σ} of the (logarithmic) sum field strength is calculated as:

$$\bar{F}_{\Sigma} = 10 \times \log_{10}(P_{\Sigma})$$

ANNEX 2 to Chapter 6: STANDARD LNM AND k-LNM

The approach is based on the idea to describe the distribution of the sum of two log-normally distributed statistical variables by a new log-normal distribution, the parameters of which are determined by the prescription that the mean value and standard deviation of the new, approximative, distribution have to be identical with those of the true sum distribution:

$$M_{power}^{approx.} = M_{power}^{true} , \quad S_{power}^{approx.} = S_{power}^{true} ,$$

where M and S denote the mean value and standard deviation of the respective distributions.

Since the resulting approximative sum distribution is taken to be log-normal, it can be combined again with a third log-normal distribution, and so on, thus enabling the construction of an approximative distribution of n log-normally distributed statistical variables. This procedure can be performed analytically.

Suppose there are given:

n logarithmic fields \bar{F}_i with gaussian distribution (parameters $\bar{F}_i, \sigma_i, i=1\dots n$).

The task is to find the parameters of the approximative log-normal sum distribution:

1. Transform $\bar{F}_i, \sigma_i, i=1\dots n$, from dB scale to Neper scale (this avoids nasty constants in the calculation):

$$X_{Neper} = \frac{1}{10 \log_{10}(e)} * X_{dB} .$$

2. Evaluate the mean values M_i and the variances S_i^2 of the n fields:

$$M_i = e^{\bar{F}_i + \frac{\sigma_i^2}{2}} , \quad S_i^2 = e^{2\bar{F}_i + \sigma_i^2} * (e^{\sigma_i^2} - 1) , \quad i=1\dots n$$

3. Determine the mean value M and variance S^2 of the sum field strength distribution:

$$M = \sum_{i=1}^n M_i , \quad S^2 = \sum_{i=1}^n S_i^2 ,$$

4. Determine the distribution parameters σ_Σ and \bar{F}_Σ of the approximative log-normal sum distribution:

$$\sigma_\Sigma^2 = \log_e \left(k \frac{S^2}{M^2} + 1 \right) , \quad \bar{F}_\Sigma = \log_e(M) - \frac{\sigma_\Sigma^2}{2} , \quad i=1\dots n$$

where k is a correction factor in the range 0...1.

5. Transform \bar{F}_Σ and σ_Σ from Neper scale to dB scale:

$$X_{dB} = 10 \log_{10}(e) * X_{Neper} .$$

The k-LNM method suffers from the drawback that the correction factor k depends on the number, the powers and the variances of the involved fields. To obtain optimal results, an interpolation table would be necessary, but this is not suitable for an heuristic approach like k-LNM. Therefore, to keep the simple and analytic character of the approximation, only an average value of k can be chosen, extracted from a sample of representative field configurations. This simplicity has to be paid for with an inaccuracy which amounts to some dBs for the 1%-fractile for some, fairly typical, configurations. For the summation of fields with standard deviations between 6 and 10 dB the value k=0.5 seems to represent a fair compromise. For smaller standard deviations a higher value for k should be used, e.g. k = 0.7. If k is set to 1.0, k-LNM is identical with the standard LNM approach as described in ITU-R Rep. 945.

ANNEX 3 to Chapter 6: t-LNM (V2)

1. Introduction

This annex describes a method of computing the sum field from component field parameters (mean, variance) which provides a reduction of computational load compared to earlier versions of t-LNM. The principal structure of computing the sum field by combining the n-th component field with the sum of the fields 1 to n-1 by means of interpolation tables has been retained. By exploiting the properties of a suitably chosen analytical approximation of the expression for the sum of two fields it has become possible to compute the interpolation tables at run time and to replace the two tri-linear interpolation steps by three bilinear interpolations, which cuts down the number of necessary operations to almost 1/2 of the double tri-linear version t-LNM (V1).

2. The t-LNM(V2) Algorithm

Let f_1 and f_2 be the (uncorrelated and normally distributed) intensity levels of the two fields to be combined. The corresponding sum field level is given by:

$$f = \log_e(e^{f_1} + e^{f_2}), \quad (1)$$

which can be written in the form

$$f = \frac{1}{2}(f_1 + f_2) + \log_e\left(e^{\frac{x}{2}} + e^{-\frac{x}{2}}\right), \quad (2)$$

where

$$x = f_1 - f_2. \quad (3)$$

From (2) it follows that the mean value $\langle f \rangle$ of the sum field level f has the form

$$\langle f \rangle = \frac{1}{2}(\langle f_1 \rangle + \langle f_2 \rangle) + U(\bar{x}, \sigma_x), \quad (4)$$

where $\langle f_1 \rangle$ and $\langle f_2 \rangle$ are the mean values of f_1 and f_2 , respectively and

$$U(\bar{x}, \sigma_x) := \langle \log_e(e^{\frac{x}{2}} + e^{-\frac{x}{2}}) \rangle. \quad (5)$$

For convenience, \bar{f} is used in place of $\langle f \rangle$ in some of the following equations.

Clearly $U(\bar{x}, \sigma_x)$ depends on the parameters of the distribution of x only; by proposition, x is normally distributed with mean $\bar{x} = \bar{f}_1 - \bar{f}_2$ and variance $\sigma_x^2 = \sigma_1^2 + \sigma_2^2$. The variance of f can be written in the form

$$\langle f^2 \rangle - \langle f \rangle^2 = \frac{1}{4}\sigma_x^2 + V(\bar{x}, \sigma_x) - [U(\bar{x}, \sigma_x)]^2 + \tilde{W}(\bar{x}, \sigma_1, \sigma_2), \quad (6)$$

where

$$V(\bar{x}, \sigma_x) = \left\langle \left[\log_e \left(e^{\frac{x}{2}} + e^{-\frac{x}{2}} \right) \right]^2 \right\rangle \quad (7)$$

and

$$\tilde{W}(\sigma_1, \sigma_2) = \langle (f_1 - \bar{f}_1 + f_2 - \bar{f}_2) \times \log_e \left(e^{\frac{x}{2}} + e^{-\frac{x}{2}} \right) \rangle. \quad (8)$$

With suitably chosen coefficients A, B, and C the term $\ln(e^{\frac{x}{2}} + e^{-\frac{x}{2}})$ can be approximated by

$$\log_e \left(e^{\frac{x}{2}} + e^{-\frac{x}{2}} \right) = \frac{1}{2} |x| + C e^{-A|x| - Bx^2}. \quad (9)$$

Both absolute and relative approximation errors are less than 7×10^{-3} with maximum errors occurring for x in the interval $[-4, 4]$ when $A = 0.685437037$, $B = 0.08198801$ and $C = 0.686850632$. When the approximation (9) is inserted into the expressions (5), (7) and (8) the mean values can be evaluated. It turns out that

$$\begin{aligned} U(\bar{x}, \sigma_x) = & \bar{x} \left[\Phi\left(\frac{\bar{x}}{\sigma_x}\right) - \frac{1}{2} \right] + \frac{\sigma_x}{\sqrt{2\pi}} e^{-\frac{\bar{x}^2}{2\sigma_x^2}} \\ & + \frac{C e^{-\frac{\bar{x}^2}{2\sigma_x^2}}}{\sqrt{1 + 2B\sigma_x^2}} \left[e^{\frac{K_+^2}{2}} \Phi(-K_+) + e^{\frac{K_-^2}{2}} \Phi(K_-) \right], \end{aligned} \quad (10)$$

where

$$K_{\pm} = \frac{\bar{x} / \sigma_x \pm A \sigma_x}{\sqrt{1 + 2B\sigma_x^2}} \quad (11)$$

and where $\Phi(y) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^y dm e^{-\frac{m^2}{2}}$ is the cumulated normalised normal distribution.

V is given by

$$\begin{aligned}
 V(\bar{x}, \sigma_x) &= \frac{1}{4}(\bar{x}^2 + \sigma_x^2) + \frac{C\sigma_x}{1+2B\sigma_x^2} e^{-\frac{\bar{x}^2}{2\sigma_x^2}} \times \\
 &\left[\sqrt{\frac{2}{\pi}} - K_+ e^{\frac{K_+^2}{2}} \Phi(-K_+) + K_- e^{\frac{K_-^2}{2}} \Phi(K_-) \right] + \frac{C^2}{\sqrt{1+4B\sigma_x^2}} e^{-\frac{-2B\bar{x}^2+2A^2\sigma_x^2}{1+4B\sigma_x^2}} \times \\
 &\left[e^{\frac{2A\bar{x}}{1+4B\sigma_x^2}} \Phi\left(-\frac{\bar{x}/\sigma_x + 2A\sigma_x}{\sqrt{1+4B\sigma_x^2}}\right) + e^{\frac{-2A\bar{x}}{1+4B\sigma_x^2}} \Phi\left(\frac{\bar{x}/\sigma_x - 2A\sigma_x}{\sqrt{1+4B\sigma_x^2}}\right) \right]. \quad (12)
 \end{aligned}$$

\tilde{W} finally can be written as

$$\tilde{W} = (\sigma_1^2 - \sigma_2^2) W(\bar{x}, \sigma_x), \quad (13)$$

where

$$\begin{aligned}
 W(\bar{x}, \sigma_x) &= \Phi\left(\frac{\bar{x}}{\sigma_x}\right) - \frac{1}{2} + C e^{-\frac{\bar{x}^2}{2\sigma_x^2}} \times \\
 &\left\{ \frac{1}{\sigma_x(1+2B\sigma_x^2)} \left[K_+ e^{\frac{K_+^2}{2}} \Phi(-K_+) + K_- e^{\frac{K_-^2}{2}} \Phi(K_-) \right] \right. \\
 &\left. - \frac{\bar{x}}{\sigma_x^2 \sqrt{1+2B\sigma_x^2}} \left[e^{\frac{K_+^2}{2}} \Phi(-K_+) + e^{\frac{K_-^2}{2}} \Phi(K_-) \right] \right\}. \quad (14)
 \end{aligned}$$

Once the functions U, V and W have been tabulated (which due to the many similarities of the terms appearing in (10), (12) and (14) consumes only a moderate amount of computing time) the combination of two fields can very simply be accomplished by first computing \bar{x} and σ_x , then finding the corresponding values of the functions U, V and W by bilinear interpolation in the respective tables, and finally computing the mean sum field level by formula (4) and the variance as

$$\langle f^2 \rangle - \langle f \rangle^2 = \frac{1}{4} \sigma_x^2 + V(\bar{x}, \sigma_x) - [U(\bar{x}, \sigma_x)]^2 + (\sigma_1^2 - \sigma_2^2) W(\bar{x}, \sigma_x). \quad (15)$$

7. Frequency bands and channels

7.1 TV-channel rasters in the European Broadcasting Area

7.1.1 Frequencies for implementation of DVB-T

The frequency bands for implementation of DVB-T in the European Broadcasting Area are 174 to 230 MHz and 470 to 862 MHz. However, the CEPT considers the frequency band 216 to 230 MHz as the core band for T-DAB in VHF.

7.1.2 Analogue television channel rasters

In Band III, different television channel rasters are used across Europe. In Eastern Europe, France and Ireland, channels are 8 MHz wide but the rasters are aligned differently. In other countries the channel width is 7 MHz. In addition, there are different channel rasters in some countries using 7 MHz channels (e.g. Italy). This means that in the VHF Bands there are many cases where channels overlap.

Within Bands IV and V, there is a single channel raster of 8 MHz, with the upper and lower edges, and vision carrier, of each channel being the same for all countries in Europe.

7.1.3 Frequencies for television channels in the European Broadcasting Area

Information concerning the frequencies for television channels in Bands III, IV and V, in the European Broadcasting Area are given in Tables 7.1 to 7.9.

Note that following the CEPT T-DAB Planning Meeting (Wiesbaden 1995) the upper part of Band III, above 216 MHz, is now allocated to T-DAB services in many CEPT countries.

Channel	Channel boundaries MHz		Vision carrier MHz	Sound carrier MHz	Dual FM Second Sound carrier MHz	NICAM carrier MHz
5	174	181	175.25	180.75	180.99	181.1
6	181	188	182.25	187.75	187.99	188.1
7	188	195	189.25	194.75	194.99	195.1
8	195	202	196.25	201.75	201.99	202.1
9	202	209	203.25	208.75	208.99	209.1
10	209	216	210.25	215.75	215.99	216.1
11	216	223	217.25	222.75	222.99	223.1
12	223	230	224.25	229.75	229.99	230.1

Table 7.1: VHF System B

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Channel	Channel boundaries MHz		Vision carrier MHz	Sound carrier MHz	Dual FM Second Sound carrier MHz
D	174.00	181.00	175.25	180.75	180.99
E	182.50	189.50	183.75	189.25	188.49
F	191.00	198.00	192.25	197.75	197.99
G	200.00	207.00	201.25	206.75	206.99
H	209.00	216.00	210.25	215.75	215.99
H1	216.00	223.00	217.25	222.75	222.99
H2	223.00	230.00	224.25	229.75	229.99

Table 7.2: VHF System B (Italy)

Channel	Channel boundaries MHz		Vision carrier MHz	Sound carrier MHz
M4	162	169	163.25	168.75
M5	170	177	171.25	176.75
M6	178	185	179.25	184.75
M7	186	193	187.25	192.75
M8	194	201	195.25	200.75
M9	202	209	203.25	208.75
M10	210	217	211.25	216.75
M11	218	225	219.25	224.75

Table 7.3: VHF System B (Morocco)

Channel	Channel boundaries MHz		Vision carrier MHz	Sound carrier MHz	Dual FM Second Sound carrier MHz	(NICAM carrier) MHz
R6	174	182	175.25	180.75	180.99	181.1
R7	182	190	183.25	188.75	188.99	189.1
R8	190	198	191.25	196.75	196.99	197.1
R9	198	206	199.25	204.75	204.99	205.1
R10	206	214	207.25	212.75	212.99	213.1
R11	214	222	215.25	220.75	220.99	221.1
R12	222	230	223.25	228.75	228.99	229.1

Table 7.4: VHF System B1

Channel	Channel boundaries MHz		Vision carrier MHz	Sound carrier MHz	(NICAM carrier) MHz
R6	174	182	175.25	181.75	181.10
R7	182	190	183.25	189.75	189.10
R8	190	198	191.25	197.75	197.10
R9	198	206	199.25	205.75	205.10
R10	206	214	207.25	213.75	213.10
R11	214	222	215.25	221.75	221.10
R12	222	230	223.25	229.75	229.10

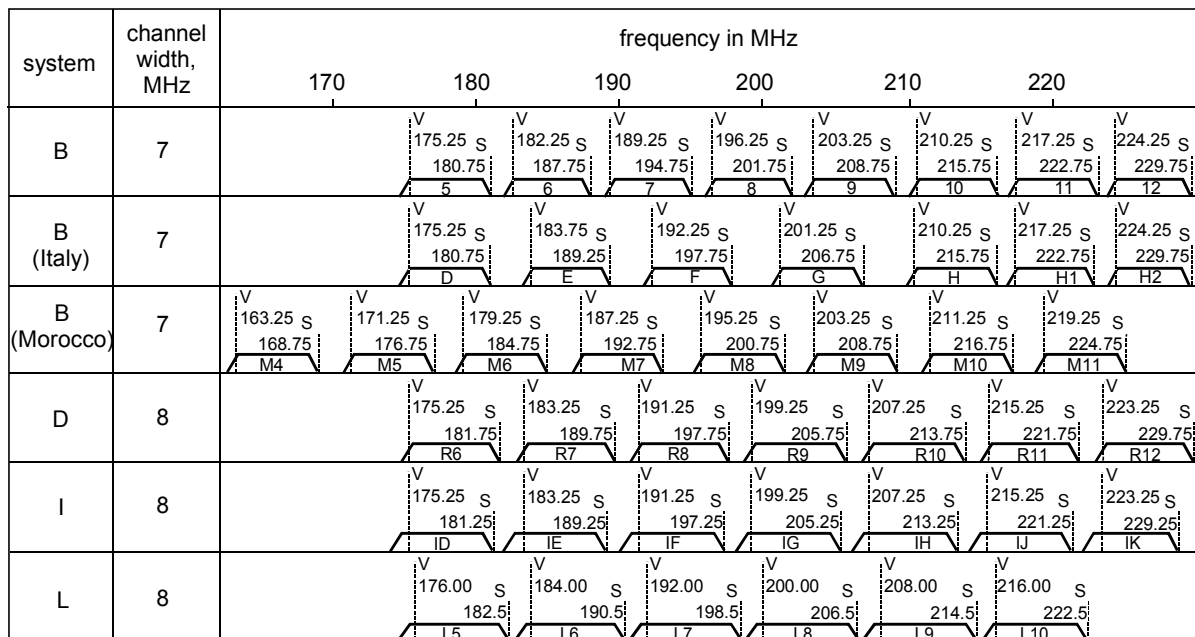
Table 7.5: VHF Systems D and D1

Channel	Channel boundaries MHz		Vision carrier MHz	Sound carrier MHz	NICAM carrier MHz
ID	174	182	175.25	181.25	181.80
IE	182	190	183.25	189.25	189.80
IF	190	198	191.25	197.25	197.80
IG	198	206	199.25	205.25	205.80
IH	206	214	207.25	213.25	213.80
IJ	214	222	215.25	221.25	221.80
IK	222	230	223.25	229.25	229.80

Table 7.6: VHF System I

Channel	Channel boundaries MHz		Vision carrier MHz	Sound carrier MHz	NICAM carrier MHz
L5	174.25	182.75	176.00	182.50	181.85
L6	182.75	190.75	184.00	190.50	189.85
L7	190.75	198.75	192.00	198.50	197.85
L8	198.75	206.75	200.00	206.50	205.85
L9	206.75	214.75	208.00	214.50	213.85
L10	214.75	222.75	216.00	222.50	221.85

Table 7.7: VHF System L



* Note that the sound carrier is 1 MHz lower in frequency for System B1

Figure 7.1: Channel positions for analogue television in Band III

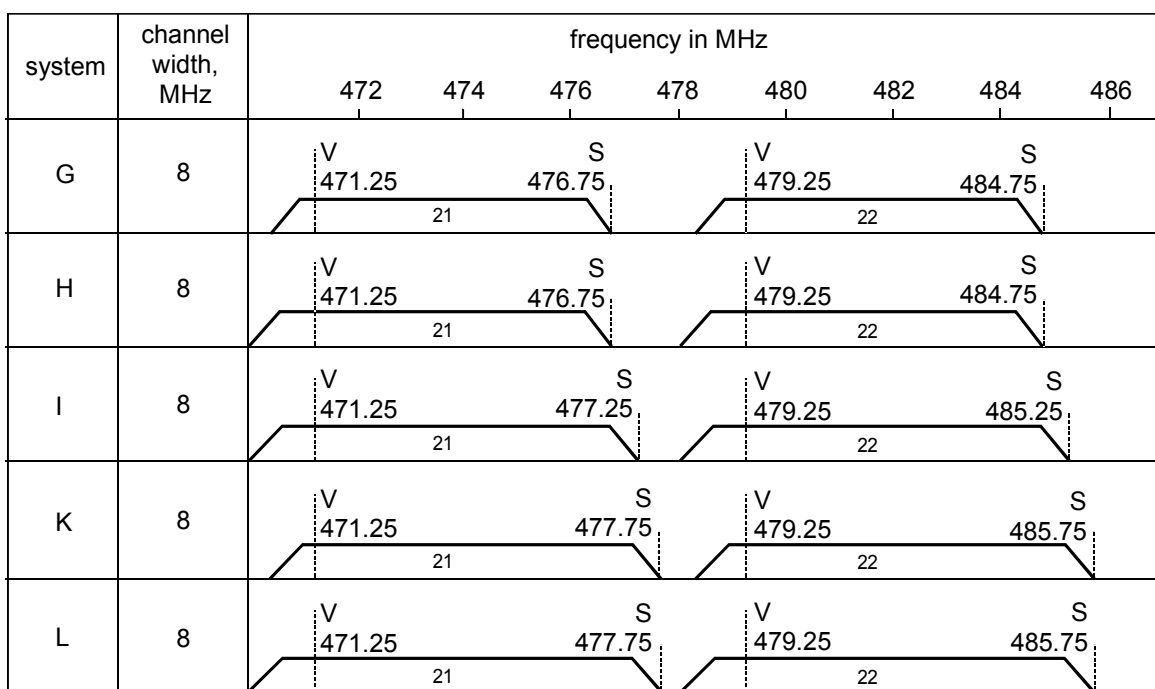


Figure 7.2: Channel positions in television Bands IV & V

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Channel	Channel boundaries		Vision carrier MHz	System G System H	System G	System G System H System L (System K) NICAM carrier MHz	System I	System K System L	System I
	MHz			Sound carrier MHz	Dual FM Second Sound car- rier MHz	Sound carrier MHz	Sound carrier MHz	Sound carrier MHz	NICAM carrier MHz
21	470	478	471.25	476.75	476.99	477.1	477.25	477.75	477.8
22	478	486	479.25	484.75	484.99	485.1	485.25	485.75	485.8
23	486	494	487.25	492.75	492.99	493.1	493.25	493.75	493.8
24	494	502	495.25	500.75	500.99	501.1	501.25	501.75	501.8
25	502	510	503.25	508.75	508.99	509.1	509.25	509.75	509.8
26	510	518	511.25	516.75	516.99	517.1	517.25	517.75	517.8
27	518	526	519.25	524.75	524.99	525.1	525.25	525.75	525.8
28	526	534	527.25	532.75	532.99	533.1	533.25	533.75	533.8
29	534	542	535.25	540.75	540.99	541.1	541.25	541.75	541.8
30	542	550	543.25	548.75	548.99	549.1	549.25	549.75	549.8
31	550	558	551.25	556.75	556.99	557.1	557.25	557.75	557.8
32	558	566	559.25	564.75	564.99	565.1	565.25	565.75	565.8
33	566	574	567.25	572.75	572.99	573.1	573.25	573.75	573.8
34	574	582	575.25	580.75	580.99	581.1	581.25	581.75	581.8
35	582	590	583.25	588.75	588.99	589.1	589.25	589.75	589.8
36	590	598	591.25	596.75	596.99	597.1	597.25	597.75	597.8
37	598	606	599.25	604.75	604.99	605.1	605.25	605.75	605.8
38	606	614	607.25	612.75	612.99	613.1	613.25	613.75	613.8
39	614	622	615.25	620.75	620.99	621.1	621.25	621.75	621.8
40	622	630	623.25	628.75	628.99	629.1	629.25	629.75	629.8
41	630	638	631.25	636.75	636.99	637.1	637.25	637.75	637.8
42	638	646	639.25	644.75	644.99	645.1	645.25	645.75	645.8
43	646	654	647.25	652.75	652.99	653.1	653.25	653.75	653.8
44	654	662	655.25	660.75	660.99	661.1	661.25	661.75	661.8
45	662	670	663.25	668.75	668.99	669.1	669.25	669.75	669.8
46	670	678	671.25	676.75	676.99	677.1	677.25	677.75	677.8
47	678	686	679.25	684.75	684.99	685.1	685.25	685.75	685.8
48	686	694	687.25	692.75	692.99	693.1	693.25	693.75	693.8
49	694	702	695.25	700.75	700.99	701.1	701.25	701.75	701.8
50	702	710	703.25	708.75	708.99	709.1	709.25	709.75	709.8
51	710	718	711.25	716.75	716.99	717.1	717.25	717.75	717.8
52	718	726	719.25	724.75	724.99	725.1	725.25	725.75	725.8
53	726	734	727.25	732.75	732.99	733.1	733.25	733.75	733.8
54	734	742	735.25	740.75	740.99	741.1	741.25	741.75	741.8
55	742	750	743.25	748.75	748.99	749.1	749.25	749.75	749.8
56	750	758	751.25	756.75	756.99	757.1	757.25	757.75	757.8
57	758	766	759.25	764.75	764.99	765.1	765.25	765.75	765.8
58	766	774	767.25	772.75	772.99	773.1	773.25	773.75	773.8
59	774	782	775.25	780.75	780.99	781.1	781.25	781.75	781.8
60	782	790	783.25	788.75	788.99	789.1	789.25	789.75	789.8
61	790	798	791.25	796.75	796.99	797.1	797.25	797.75	797.8
62	798	806	799.25	804.75	804.99	805.1	805.25	805.75	805.8
63	806	814	807.25	812.75	812.99	813.1	813.25	813.75	813.8
64	814	822	815.25	820.75	820.99	821.1	821.25	821.75	821.8
65	822	830	823.25	828.75	828.99	829.1	829.25	829.75	829.8
66	830	838	831.25	836.75	836.99	837.1	837.25	837.75	837.8
67	838	846	839.25	844.75	844.99	845.1	845.25	845.75	845.8
68	846	854	847.25	852.75	852.99	853.1	853.25	853.75	853.8
69	854	862	855.25	860.75	860.99	861.1	861.25	861.75	861.8

Table 7.8: UHF Systems D1, G, H, I, K and L

7.2 T-DAB blocks in Band III

Table 7.9 shows the adopted harmonised channelling plan for T-DAB in Band III (174 – 230 MHz). This is based on tuning increments of 16 kHz and guard bands of at least 176 kHz between adjacent T-DAB frequency blocks.

Within each 7 MHz television channel, four T-DAB frequency blocks have been accommodated, giving common centre frequencies for T-DAB frequency blocks, irrespective of the TV system used.

To enhance compatibility with analogue TV sound (System B), the guard bands for T-DAB frequency blocks A in Channel N and block D in Channel N-1 are between 320 kHz and 336 kHz.

T-DAB block number	Centre frequency (MHz)	Block bandwidth (MHz)	Lower guard band (kHz)	Upper guard band (kHz)	Frequency range ¹ (MHz)
5A	174.928	174.160 - 175.696	160	176	174.0 - 181.0
5B	176.640	175.872 - 177.408	176	176	
5C	178.352	177.584 - 179.120	176	176	
5D	180.064	179.296 - 180.832	176	336	
6A	181.936	181.168 - 182.704	336	176	181.0 - 188.0
6B	183.648	182.880 - 184.416	176	176	
6C	185.360	184.592 - 186.128	176	176	
6D	187.072	186.304 - 187.840	176	320	
7A	188.928	188.160 - 189.696	320	176	188.0 - 195.0
7B	190.640	189.872 - 191.408	176	176	
7C	192.352	191.584 - 193.120	176	176	
7D	194.064	193.296 - 194.832	176	336	
8A	195.936	195.168 - 196.704	336	176	195.0 - 202.0
8B	197.648	196.880 - 198.416	176	176	
8C	199.360	198.592 - 200.128	176	176	
8D	201.072	200.304 - 201.840	176	320	
9A	202.928	202.160 - 203.696	320	176	202.0 - 209.0
9B	204.640	203.872 - 205.408	176	176	
9C	206.352	205.584 - 207.120	176	176	
9D	208.064	207.296 - 208.832	176	336	
10A	209.936	209.168 - 210.704	336	176	209.0 - 216.0
10B	211.648	210.880 - 212.416	176	176	
10C	213.360	212.592 - 214.128	176	176	
10D	215.072	214.304 - 215.840	176	320	
11A	216.928	216.160 - 217.696	320	176	216.0 - 223.0
11B	218.640	217.872 - 219.408	176	176	
11C	220.352	219.584 - 221.120	176	176	
11D	222.064	221.296 - 222.832	176	336	
12A	223.936	223.168 - 224.704	336	176	223.0 - 230.0
12B	225.648	224.880 - 226.416	176	176	
12C	227.360	226.592 - 228.128	176	176	
12D	229.072	228.304 - 229.840	176	176	

Table 7.9: T-DAB frequency blocks in Band III

¹ The frequency ranges given are the channels for System B which are 7 MHz wide. They have no other significance.

Table 7.10 gives the scenarios for the 7 MHz raster. Examination of Figure 7.3 shows that the scenarios in Table 7.11 (assuming 8 MHz DVB-T channels and a contiguous allocation of channels to T-DAB) can also give good spectrum usage – i.e., there would be little “waste” spectrum resulting from the retention of the existing T-DAB block arrangements

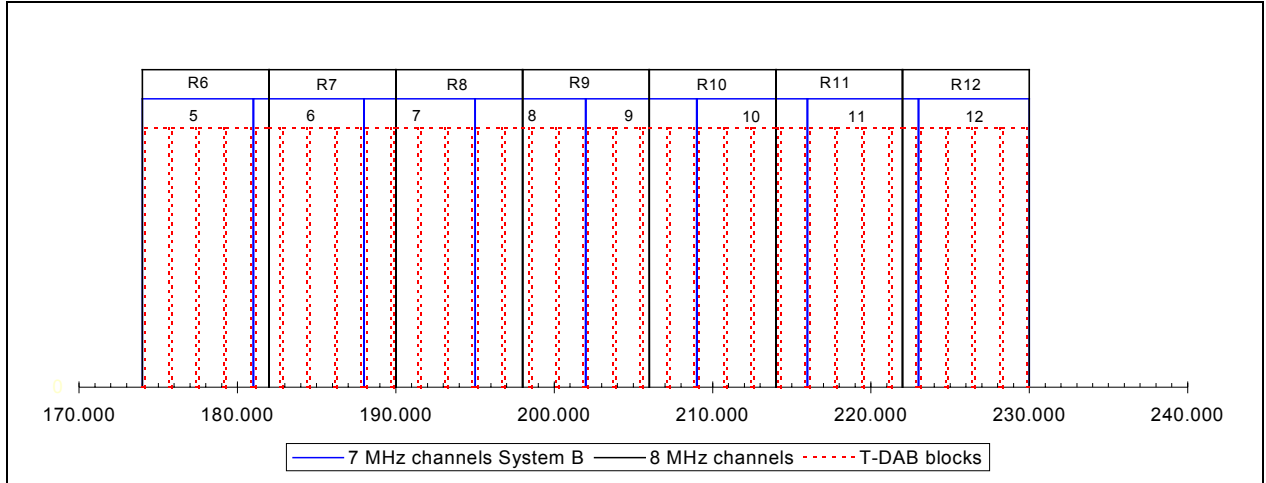


Figure 7.3: Band III rasters

Number of 7 MHz TV channels allocated to T-DAB	Number of T-DAB blocks	Number of DVB-T channels
0	0	8
1	4	7
2	8	6
3	12	5
4	16	4
5	20	3
6	24	2
7	28	1
8	32	0

Table 7.10: Apportionment of Band III between T-DAB and DVB-T for 7 MHz channels

Number of 8 MHz TV channels allocated to T-DAB	Number of T-DAB blocks	Number of DVB-T channels
0	0	7
2	9	5
4	18	3
7	32	0

Table 7.11: Apportionment of Band III between T-DAB and DVB-T – 8 MHz channels

7.3 Channel distribution schemes

If the plan produced by the conference is to be based on lattice planning principle then a channel distribution scheme, optimised for DVB-T by taking into account the typical performance of DVB-T receivers, should probably be developed similar to what has been done for other broadcasting planning conferences.

Annex to Chapter 7: Lattice Planning

In broadcasting, lattice planning is generally understood to be the development of geometrical regular lattices having linear channel distributions. However, in the case of digital television, it is normally assumed that the effects of interference other than co-channel can be neglected. The lattice based theoretical studies described below therefore take no account of the absolute channel distribution.

A7.1 MFN case

The basic idea of lattice based theoretical MFN studies is that the planning area under consideration can be represented as a semi-infinite plane covered by a network of equally spaced transmitters. This arrangement implies that the transmitter sites form equilateral triangles with each transmitter on a different channel (Figure A7.1). A similar set of transmitters, with larger spacing, represents the sources of co-channel interference (Figure A7.2) and is the basic geometric structure which is used by the different calculation methods. (Strictly speaking, the sites do not need to form equilateral triangles, but this is a convenient starting point for the studies.)

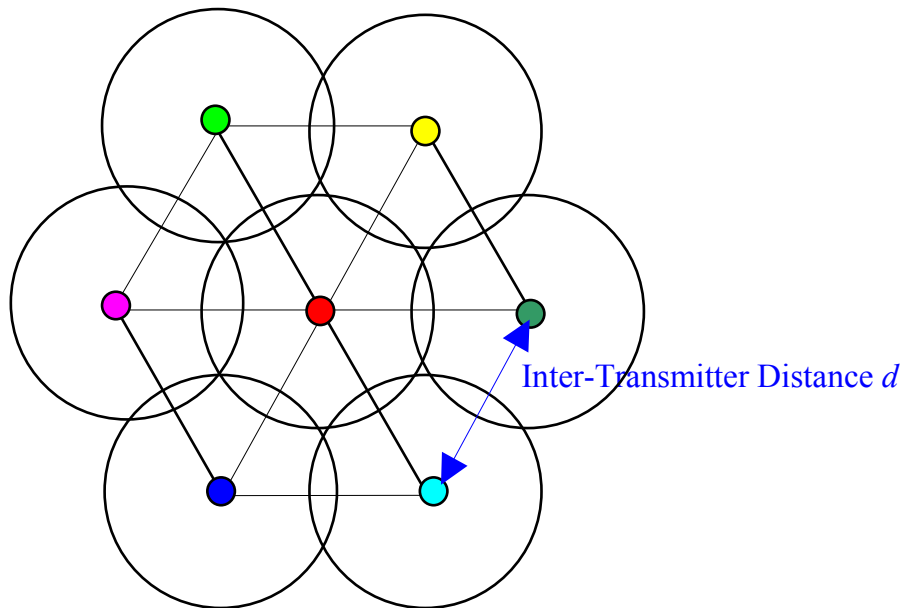


Figure A7.1: Hexagonal structure of MFN coverage showing inter-transmitter distance.

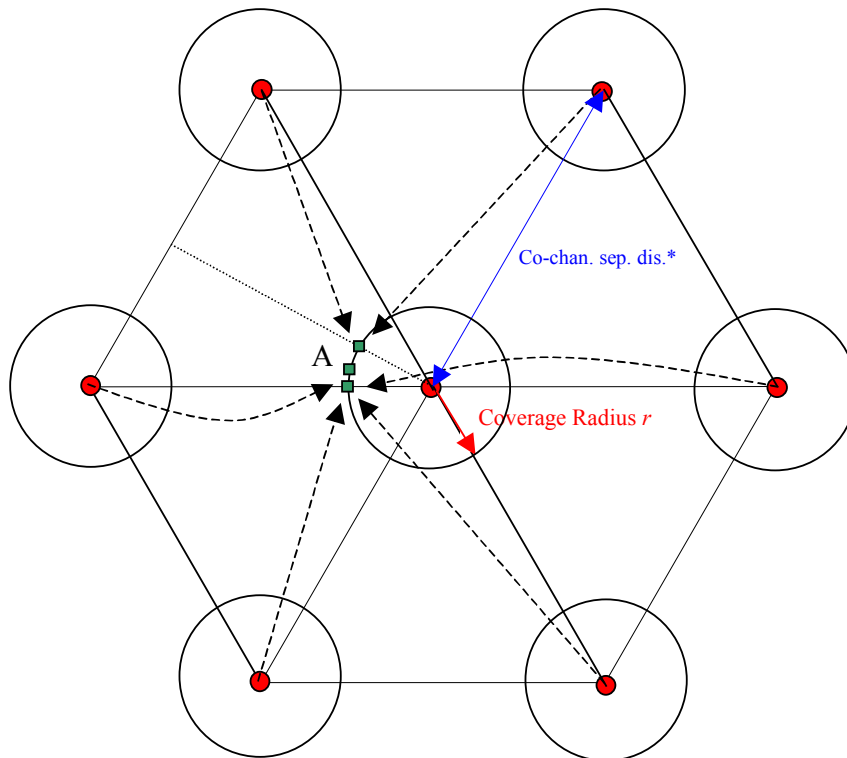


Figure A7.2: Multiple co-channel interference at points A.
(* co-channel separation distance)

A2.2 SFN case

Similar ideas can be used for theoretical SFN studies (Figure A7.3); the primary difference is that the basic unit providing coverage is a group of transmitters acting as an SFN, rather than a single transmitter. The other major difference is that it is the spacing between individual co-frequency SFNs which determines the spectrum requirement, rather than the spacing between the sites of co-frequency transmitters.

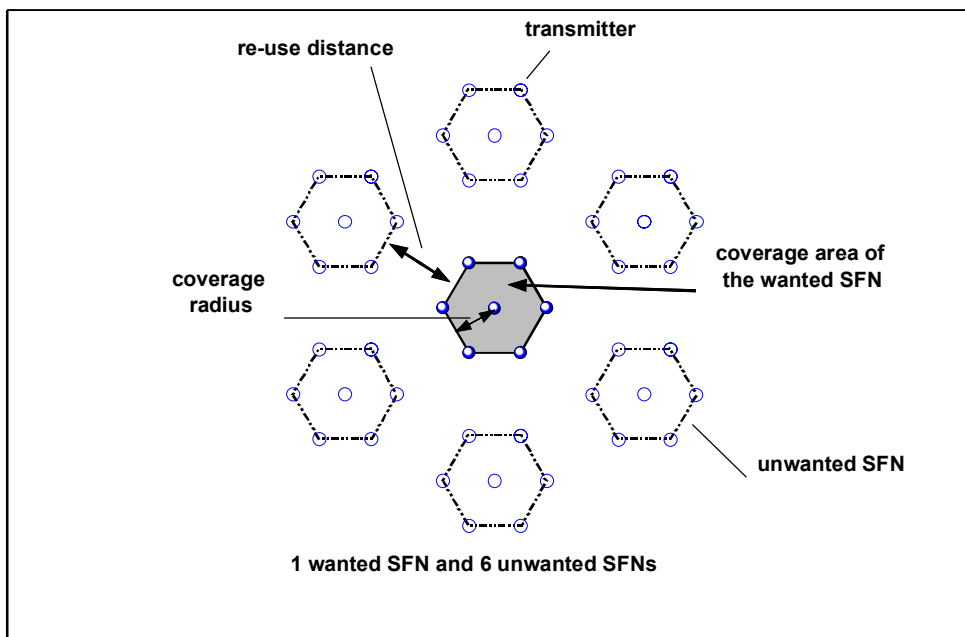


Figure A7.3: A model of SFN configuration.

8. Co-ordination distances

In order to facilitate co-ordination of new television stations a set of tables containing agreed co-ordination distances is needed.

For the co-ordination of analogue television stations a set of tables is given in ST61. For the co-ordination of DVB-T stations a corresponding set is given in CH97.

In both cases the co-ordination distances have been based on the (by then) latest version of Rec. ITU-R P.370. This Recommendation is expected to be replaced by a new recommendation in the near future (2001). It may therefore be expected that a new Planning Conference will decide upon new co-ordination distances based on the new recommendation.