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ERC/EBU Report

on

Planning and Introduction of Terrestrial Digital Television (DVB-T) in Europe

Izmir, December 1997

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Overall introduction

The February 1995 meeting of the CEPT FM Working Group established a new Project Team, PT24, chaired by Mr. Whittingham, to address the subject of digital terrestrial TV planning and implementation in Europe.

PT24 recognised the advantage of working closely with other organisations in the field of digital terrestrial TV (DVB-T), and representatives of such organisations were active participants in the work, namely from the DVB Project, the EBU, and the Validate Project.

Working Groups were established to address the four main areas of work identified as follows:

WGA	System studies	Chaired by Dr. Morello
WGB	Planning factors	Chaired by Mr. Hunt
WGC	Co-ordination issues	Chaired by Mr. Doeven
WGD	Implementation studies	Chaired initially by Mr. Müller, later by Mr. Laflin

This report is divided into four sections, A, B, C and D representing the considerations of each of the Working Groups identified above, extended as appropriate by taking into account the results of Chester 97 and information available from the EBU and the Validate project. A summary of the contents of each of these sections is given overleaf. Each of the sub-sections of the four sections is indexed individually.

In the early years of DVB-T, it is likely that for economic reasons, primary attention will be given to the re-use of existing transmission sites. A limited number of additional sites may, however, be required to extend coverage to high-population-density areas which can not be covered by digital television from existing sites, as a result, for example, of spectrum constraints.

Clearly there is still much to be done in taking forward digital terrestrial television in Europe in a way that adequately satisfies all those concerned. A good deal of co-operation has been shown hitherto, and such co-operation will become paramount in the future. It is expected that the remaining parts of this text will support the results of Chester 97 and facilitate the process of introducing DVB-T in Europe.

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A0. AN OVERVIEW OF THE DVB SPECIFICATION

The DVB-T system[1] was designed originally for the 8 MHz UHF channel spacing used in Europe, and the calculations and many of the numerical values in the subsequent sections of §A are for systems for 8 MHz channels. An adaptation of the specification for 7 MHz VHF channels can be achieved by scaling down all system parameters by changing the system clock rate by 7/8 from 64/7 MHz to exactly 8 MHz. This allows the re-use of the integrated circuits in the IRD. Protection ratio values for both the 8 MHz and 7 MHz variants are given in §A5.

An OFDM modulation system with concatenated error correcting coding and a guard interval has been used so that the system can cope with short "natural" echoes due to multipath propagation, as well as with the relatively long "artificial" echoes due to the self-interference which occurs in SFNs. The system also provides good protection against high levels of co-channel interference (CCI) and adjacent channel interference (ACI) emanating from analogue PAL/SECAM television services. OFDM also has excellent inherent frequency spectrum shaping which will allow DVB-T to be accommodated in channels adjacent to those used for analogue television services while causing minimum interference to these services.

Two modes of operation are defined: a "2k mode" and a "8k mode". The "2k mode" is suitable for single transmitter operation and for small single frequency networks (SFN) with limited transmitter distances (up to about 20 km). The "8k mode" can be used both for single transmitter operation and for large SFNs (with transmitter distances up to about 80 km). The inter-transmitter distance in an SFN depends on transmitter power, on the guard interval and on the modulation/coding mode chosen. To allow optimum trade off between network topology and frequency efficiency, four guard intervals are specified for each "mode".

The specification allows three different levels of QAM modulation and five different code rates to be used to trade bit rate versus ruggedness. The specification also covers two level hierarchical channel coding and modulation, including uniform and multi-resolution constellations. To guarantee that the signals emitted by such hierarchical systems may be received by a simple receiver, the hierarchical nature is restricted to hierarchical channel coding and modulation without the use of hierarchical source coding. A programme service could thus be 'simulcast' as a low-bit-rate, reduced definition, rugged version and also at a higher bit-rate, better definition, but less rugged version. Alternatively, entirely different programmes could be transmitted on the two levels of the hierarchy with different ruggedness. In either case, the receiver requires only one set of the inverse elements: inner de-interleaver, inner decoder, outer de-interleaver, outer decoder and multiplex adaptation.

To maximise the commonality with Satellite and Cable DVB-ETSI Specifications[2], the outer coding and outer interleaving are common, and the inner coding is common with the Satellite specification.

Annex A0.1 describes some of the principles of operation of a DVB-T receiver.

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[1]

[2] ETSI: EN300421: "Digital Video Broadcasting (DVB).: Framing structure, channel coding and modulation for 11/12 GHz satellite services".

A0.1 Modulation, code rates and system capacity

The parameters that can be varied by the broadcaster in order to allow optimisation of the service capacity, coverage or multipath/SFN performance are:

- number of carriers Choice of nominal 2k (1705 actual) or 8k (6817 actual);
- inner code rate (R_C) Choice of R_C = 1/2, 2/3, 3/4, 5/6 or 7/8:
- normalised Guard interval length (Δ/T_g) Choice of Δ/T_g = 1/4, 1/8, 1/16 or 1/32;
- modulation mode Choice of QPSK, 16 QAM or 64 QAM;
- hierarchical modes Choice of QPSK/16 QAM or QPSK/64 QAM.

The useful bit-rate in MBit/s for all combinations of guard interval, modulation type and code rate for non-hierarchical and hierarchical systems is given in **Tables A.2 a, b** and **c**.

A0.2 OFDM frame structure

The transmitted signal is organised in "frames". Each frame has a duration of T_f , and consists of 68 OFDM "symbols" which are numbered from 0 to 67. All symbols contain data and

Each symbol is constituted by a set of K = 6817 carriers in the 8k mode and K = 1705 carriers in the 2k mode which are transmitted simultaneously with a symbol duration T_S. The symbol is composed of two parts: a "useful" part with duration T_U , and a "guard interval" with a duration Δ inserted in front of T_U as a cyclic continuation of T_U .

Not all of the 6817 (or 1705) carriers are modulated with data. Some of them (the "pilot carriers" or "pilots") are used to transmit reference information required by the receiver to demodulate the OFDM signal. There are three types of pilots:

- scattered pilots;
- continual pilots;
- TPS pilots.

The pilots are used for frame synchronisation, frequency synchronisation, time synchronisation, channel estimation, transmission mode identification and can also be used to follow the phase noise.

Since the OFDM signal comprises many separately-modulated carriers, each symbol can in turn be considered to be divided into "cells", each corresponding to the modulation carried on one carrier during one symbol.

Table A0.1 shows some numerical values for the OFDM parameters for the 8K and 2K modes.

Table A0.1

Parameter	8K mode	2K mode
Number of carriers	6817	1705
Useful symbol duration T_u	896 µs	224 µs
Carrier spacing 1/Tu	1116 Hz	4464 Hz
Spacing between first and last carriers	7.61 MHz	7.61 MHz

A0.3 Spectrum characteristics

An OFDM symbol consists of an "ensemble" of 6817 (or 1705) equally-spaced orthogonal carriers.

The power spectral density $P_k(f)$ of each carrier at frequency:

$$f_k = f_c + \frac{k}{T_U} \quad ; \qquad (K_{min} \leq k \leq K_{max})$$

is defined by the following expression:

$$P_k(f) = \left[\frac{\sin \pi.(f - f_k).T_S}{\pi.(f - f_k).T_S} \right]^2$$

where T_u is the useful symbol time,
T_S is the sum of the useful symbol time and the guard interval,
k is the number of the carrier.

The overall power spectral density of the modulated data cell carriers is the sum of the power spectral densities of all these carriers. A theoretical DVB transmission signal spectrum is illustrated in the DVB-T Specification[3]. Because the OFDM symbol duration is larger than the inverse of the carrier spacing, the main lobe of the power spectral density of each carrier is narrower than twice the carrier spacing. Therefore the spectral density is not constant within the nominal bandwidth (7.60888 MHz for the 8k mode and 7.615584 MHz for the 2k mode).

The level of the spectrum at frequencies outside the nominal bandwidth can be reduced by applying an appropriate IF filtering. The signal emitted by the transmitter consists of the theoretical spectrum produced by the OFDM modulator plus its IF filtering, distorted by non linear effects in the transmitters and limited by the transmitter RF output filters.

[3] ETS 300 744 § 4.8.1, Figure 12

The spectrum shaping and out-of channel rejection directly affects the protection ratios for the adjacent channels and overlapping channel cases. A number of fixed spectrum shaping limiting masks are defined in the DVB-T Specification[4] to allow the protection ratios to be determined. When measuring protection ratios with a spectrum analyser, the settings of the analyser must be agreed and standardised if consistent results are to be obtained.
The nominal centre frequency f_c of the RF signal is given by:

$$470 \text{ MHz} + 4 \text{ MHz} + i_1 * 8 \text{ MHz}, \; i_1 = 0, 1, 2, 3, ...$$

This is exactly the centre frequency of the UHF channel in use. This centre frequency may be offset to improve spectrum sharing, in appropriate cases.

[4] ETS 300 744 § 4.8.2, Figures 13, 14 and Tables 20, 21

ANNEX A01: DVB-T RECEIVER PRINCIPLES OF OPERATION

The model used for network planning of the T-DAB system for terrestrial digital audio broadcasting is based on the following principles[5].

T-DAB receiver model

For T-DAB, it is assumed that the system always operates in a "Rayleigh" multipath propagation environment, since the receiver makes use of a non-directive antenna. Therefore the required *C/N* (for any given system variant) at the service threshold is the one obtained by computer simulations and by laboratory tests with multiple echoes and without a line-of-sight path. Furthermore it is assumed that the system performance under "Rayleigh" conditions is quite independent of the echo configuration (number of echoes, amplitude, phase, delay) within the guard interval. Therefore a single figure for the required *C/N* is used for planning T-DAB in MFN and SFN. For a given value of "dominant" signal, the system model performance improves in the presence of multiple echoes within the guard interval, since they increase the available *C/N* without modifying the required *C/N*.

For an MFN the planner usually cannot predict the level of each individual natural echo, and therefore only the field strength of the main path is taken into account, and the assumption is made that the chosen guard interval is long enough to cover all the natural echo delays. Conversely, for a SFN the planner can evaluate the delay and amplitude on the various contributions from the other synchronised transmitters (artificial echoes), whereas he cannot estimate the natural echoes associated with each of these artificial echoes or those for the main signal.

In SFN planning for T-DAB, the power of all the echoes received within a window of duration T_g (guard interval width) is considered as useful, and contributes positively to the global available signal power. Outside the guard interval, a part of the echo power is associated with the same OFDM symbol as the zero delay signal, and therefore contributes positively to the global useful signal power. Another part of the echo power is associated to the previous OFDM symbol and produces Inter-Symbol-Interference (ISI) which has a similar effect as an uncorrelated Gaussian noise interference. In addition to the ISI, a loss of orthogonality in the OFDM carriers is induced by the echoes, producing Inter-Carrier-Interference (ICI). Therefore, by progressively increasing the echo delay outside the guard interval, the useful contribution decreases and the ISI and ICI interference increases with a quadratic law, so that the echo power becomes full interference when the delay is larger than or equal to one OFDM symbol (**Figure Annex A0.1.1**).

[5] M. Meilhoc, "Interfering effect in COFDM", CCETT contribution to EBU R1/DIG, 1992

Mathematically, the rule for splitting the echo power into a useful component C, and an interfering component I is expressed as follows:

$$C = \begin{cases} 0 & \text{if } t \le -T_s \\ \left(\dfrac{T_s + t}{T_s}\right)^2 & \text{if } -T_s < t \le 0 \\ 1 & \text{if } 0 < t \le T_g \\ \left(\dfrac{T_s - t + T_g}{T_s}\right)^2 & \text{if } T_g < t < T_s + T_g \\ 0 & \text{if } t \ge T_s + T_g \end{cases}$$

$$I = 1 - C$$

The guard interval window position depends on the receiver synchronisation strategy. The best algorithm should place the window so that the global useful power is maximised with respect to the global interfering power, max $[\sum C_i / \sum I_i]$. Simplified receivers could place the first received signal exceeding a given level (or even the strongest signal) at the beginning of the guard interval, but these methods risk leaving some disturbing echoes outside the guard interval.

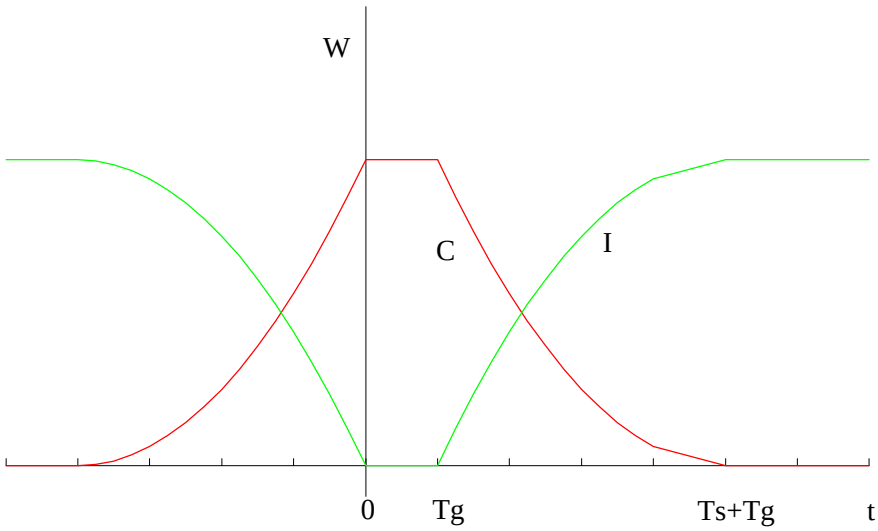

Figure Annex A0.1.1: T-DAB model for SFN - Splitting of the echo power (W) into useful (C) and interfering (I) components

DVB-T receiver model

Simulation and hardware tests of DVB-T systems have shown that, depending on the adopted receiver algorithms, this T-DAB model may not represent the system performance with sufficient accuracy. The main reason is due to the different demodulation strategy of the two systems:

- the T-DAB system is based on differential demodulation of differential QPSK;
- the DVB-T system is based on coherent demodulation of QPSK or QAM signals.

To achieve coherent demodulation, the DVB-T system equalises the amplitude and phase of the various carriers by dividing the received samples (after FFT) by the estimated channel frequency response. This channel estimation, not needed for the T-DAB system, can be performed in the DVB-T system through various algorithms with different advantages and disadvantages, for example:

- through time and frequency interpolation of the "pilot carriers", regularly inserted in the transmitted OFDM symbols;
- by using Phase Locked Loops (PLLs);
- by exploiting the bit-stream after Viterbi decoding in a feedback loop (CD3 algorithm).

In the following, the description of some algorithms is given to justify the proposed system model, but other algorithms could be adopted in the future with different performance trade-offs.

The OFDM symbol structure is given in **Figure Annex A0.1.2**. Pilots are inserted in the spectrum with a density of 1/12 in the frequency domain (D_f) and 1/4 in the time domain (D_t), and their amplitude is "boosted" by 2.5 dB to improve the channel estimation in the presence of noise.

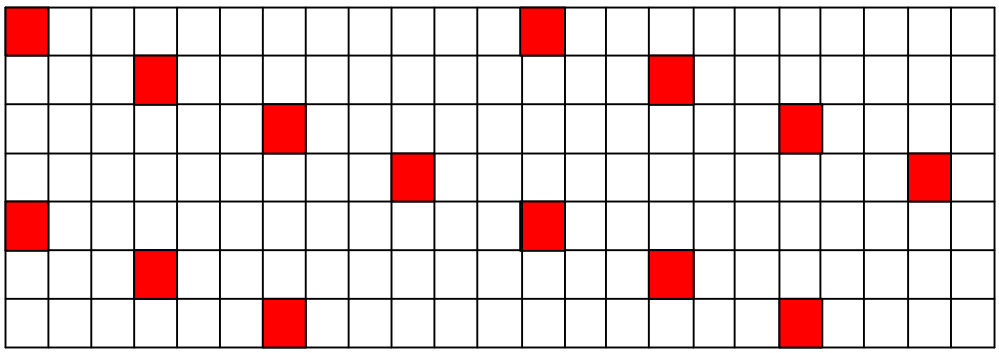

Figure Annex A0.1.2 OFDM symbol structure for the DVB-T system.

The channel estimation is easily performed on the pilot cells, since the transmitted vector is known "a priori" by the receiver, and is then extended on the cells carrying useful data through an interpolation process. Two interpolation algorithms for the pilots have been proposed within the RACE dTTb project:

- **2-D**(two dimensional): four OFDM symbols are stored in the receiver, then a linear time-domain interpolation of the pilots is applied, followed by a frequency-domain interpolation;
- **1-D**(one dimensional): the pilots are stored in a buffer, and are up-dated by the new pilots once they are received (every fourth symbol). Frequency domain interpolation is applied on the pilots at every OFDM symbol.

The 2D-channel estimation is relevant to complex receivers and allows very fast channel tracking capability, while the 1D-channel estimation is relevant to simpler receivers.

Time- and frequency-domain interpolation also allows a small noise reduction on the estimated channel response. A possible example of the transfer function of the frequency-domain interpolation filter is given in **Figure Annex A0.1.3**. The curve is normalised with respect to the useful symbol duration T_u, and the guard interval is located between 0 and -0.25. This frequency domain interpolation process allows the estimation of the channel response provided that all the echoes are within the pass-band T_F of the frequency interpolator filter. It should be noted that even for an ideal rectangular frequency interpolation filter, the passband T_F is limited to $T_u/3$, in order to filter-out the aliasing effect produced by the pilot subsampling in the frequency domain (one pilot out of three carriers). For echoes outside T_F, the frequency interpolator introduces an attenuation and the estimated channel impulse response, *for those particular echoes*, is distorted. This is the reason why echoes outside the guard interval are not equalised and are to be considered as pure interference, producing a rapid performance degradation. Furthermore, for echo delays longer than T_u /3, the system performance can show an additional degradation due to the aliasing effect on the channel estimation.

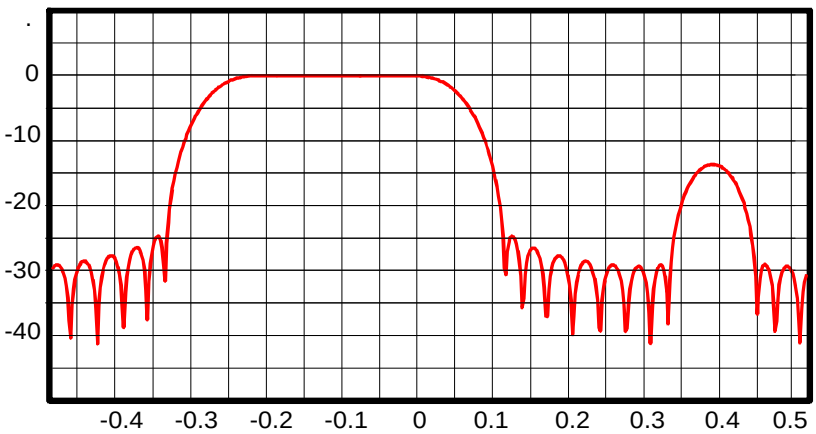

Figure Annex A0.1.3 Example of frequency-domain interpolation filter transfer function

In the cases of shorter guard intervals ($T_g = T_u/8$, $T_u/16$, $T_u/32$) the same interpolator filter can be used as for $T_g=T_u/4$, and a smoother system failure characteristic can be achieved similar to that of T-DAB (up to $\tau = T_F$). However, short guard intervals are of little interest for SFNs.

On the contrary, the CD3 algorithm[6] does not suffer from the aliasing effect, since the channel estimation is performed in each frequency position, over the data carriers as well as over the pilots. Therefore the frequency-domain filter passband T_F can be extended (for example up to $T_u/2$). A possible algorithm to *lock-in* CD3 (on the DVB-T signal, without an OFDM reference symbol) in the presence of echoes outside T_g is described[7]. This latter algorithm, performing an average over some tens of OFDM symbols, allows *lock-in* for quasi-static channels only, and therefore is not applicable to mobile reception.

The failure of the equalisation algorithm after T_F adds to the ISI and ICI effects (which also happen in T-DAB), to produce a more rapid performance degradation versus the echo delay than in T-DAB. The T-DAB model (see **Figure Annex A1.1**) that splits the echo power into a useful and an interfering contribution is thus only applicable for echo delays up to T_F, with the echoes outside T_F tending to contribute only to the interfering power, independent of their delay.

On the basis of the above tutorial description, the following model is proposed to compute the equivalent available C/I ratio for a DVB-T system:

- an echo inside the guard interval Δ adds to the power of the useful signals
- an echo outside the guard interval Δ, but within the interval of correct equalisation T_F, is split into a useful component and an interfering component (ISI / ICI)
- an echo outside T_F contributes as pure interference

$$w_i = \begin{cases} 0 & \text{if } t \le 0 \\ 1 & \text{if } 0 < t \le T_g \\ \left(\dfrac{T_u - t + T_g}{T_u} \right)^2 & \text{if } T_g < t \le T_F \\ 0 & \text{if } t > T_F \end{cases}$$

$$C = \sum_i w_i \, C_i$$

$$I = \sum_i (1 - w_i) \, C_i$$

[6] V. Mignone, A. Morello: "CD3-OFDM: a novel demodulation scheme for fixed and mobile receivers" IEEE Transactions on Communications, Vol., No., September 1996

[7] V. Mignone, A. Morello, M. Visintin: "An improved receiver algorithm to extend coverage in SFN" IBC'97 Conference, Amsterdam.

where:

C_i is the power contribution from the i-th echo (natural or artificial) at the receiver input
C is the total power of the effective useful signal
I is the total effective interfering power
w_i is the weighting coefficient for the i-th component
T_F is the interval of correct equalisation

The performance of an ideal DVB-T receiver on typical multipath channels is given in **Tables A1.1, A1.3 and A1.4**. These data are derived from computer simulations and do not take into account system implementation losses.

As derived by a theoretical study**,** the loss due to channel estimation noise is given by the expression:

$$g_{CE} = 10 \log \left(1 + \frac{Wk}{\alpha D}\right) = \begin{cases} 1.8 \text{ dB for 1D} \\ 1.3 \text{ dB for 2D} \end{cases}$$

where W (assumed equal to 0.3 for a guard interval of 1/4) is the noise equivalent bandwidth of the frequency interpolator (normalised with respect to T_u), α the boosting level of the pilots (16/9), D the density of the pilots after time interpolation (D = 1/3 for DVB-T) and k is the gain of time-domain interpolation filter (equal to 1 for the 1D-channel estimation and to 11/16 for the 2D-channel estimation).

The loss due to the boosted pilots is:

$$g_P = 10 \text{ Log } \left[\eta_P (1 - \alpha) + \alpha\right] = 0.33 \text{ dB}$$

where η_P (equal to 6116/6817) is the boosted pilot efficiency.

The CD3 channel estimation algorithm is characterised by a C/N loss which depends on the bandwidths of the frequency and time-domain filters. Typical figures are comparable to the performance of 2D channel estimation.

A1. THEORETICAL C/N RATIO REQUIREMENTS DERIVED FROM SIMULATIONS2

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A1. THEORETICAL C/N RATIO REQUIREMENTS DERIVED FROM SIMULATIONS

A1.1 Channel Characteristics

The characteristics of the DVB-T channel are random variables depending:

- on the receiving location;
- on the receiving antenna;
- on time.

In fact the number of echoes, their amplitude, delay and phase vary from place to place and from time to time. Therefore in each location the frequency response of the channel (the channel characteristic) is different .

A1.2 Differences in planning for T-DAB and DVB-T

In T-DAB planning, a single figure for the required C/N was adopted since the T-DAB receiver is always assumed to have a non-directional aerial and to be operating in a severe multipath environment (Rayleigh channel).

DVB-T planning is more complex, as the receiver may be connected to a fixed aerial at roof-top level or may have a set-top aerial with limited directivity and low height. In the first case, the channel has essentially Ricean characteristics, whereas for the second the channel has Rayleigh characteristics. In addition, the DVB-T Specification offers a wide choice of combinations of modulation type and inner code rate.

A1.3 Required C/N at the input to the receiver - effect of the modulation type and inner code rate

Even when the echo delays are within the guard interval, the input carrier to noise ratio (*C/N)* required by the DVB-T system [1] depends on the channel characteristics (see **Tables A1.1, A1.3 and A1.4**). The presence of echoes produces frequency selective attenuations (notches) within the signal bandwidth; the depth and frequency position of the notches depend on the echo amplitude and phase. The reason for the system sensitivity to the channel characteristics is due to the fact that the notches heavily attenuate some OFDM carriers (while the noise level remains constant), increasing their un-coded BER. However, the use of powerful inner codes (e.g. coding rates 1/2, 2/3 or 3/4) allows good recovery of the information of the attenuated carriers by means of the information carried by the other carriers, and thus the use of these coding rates reduces the system sensitivity to the channel characteristics.

[1] to achieve a final signal "quality" (e.g. BER<10^{-11} after Reed-Solomon decoding)

Since a statistical characterisation of the system in the various reception environments is too complex, only two "representative" channels have been chosen in the specification[2] for computer simulations, one for the fixed reception with directive antenna (F1, Ricean channel) and one for portable reception (P1, Rayleigh channel). It should be noted:

- that these channels are not a worse case, since a single 0 dB echo could introduce stronger degradations;
- that these channels include only relatively short natural echoes (up to 5.4 μs), well within the shortest guard interval, and thus do not represent an SFN situation.

As described in **Annex A0.1**, when an echo delay exceeds the correct equalisation interval T_F, a steep transition occurs and the echo effect becomes similar to, or even worse than, that of un-correlated Gaussian noise interference. For MFN planning, the echo delay configuration cannot usually be precisely evaluated in each receiving location, and the guard interval is chosen according to the typical echo delay that is expected in the service area or in the network. Therefore MFN planning exercises assume that all the echoes fall within the guard interval.

The noise margin loss between the Gaussian channel and the Rayleigh channel is between 2 to 9 dB, depending on the echo characteristics and on the inner coding rate.

The theoretical C/N values for non-hierarchical transmission for all system variants, that is all combinations of coding rates and modulation types are given in **Table A1.1**, taken from Annex A of the DVB-T system specification. **Table A1.3** and **A1.4** report similar results for the hierarchical modes. The *C/N* figures assume perfect channel estimation and do not include a receiver implementation margin. The net bit rates after the Reed-Solomon decoder are also listed.

[2] DVB-T Specification - EN 300 744, Annex A

Table A1.1

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.

			Required C/N for BER=2. 10^{-4} after Viterbi (quasi error-free after Reed-Solomon, *)			Net bit rate (MBit/s)			
System variant	Modulation	Code Rate	Gaussian channel	Ricean channel (F_1)	Rayleigh channel (P_1)	Δ/T_U =1/4	Δ/T_U =1/8	Δ/T_U =1/16	Δ/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

To account for the number of carriers and the guard interval ratio, Δ/T_u, the designators given in **Table A1.2** should be used. See also **Table B3.2** (digital television transmitter database structure).

Table A1.2

Designator	Number of carriers	Δ/T_g =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 A1.3

Required C/N for hierarchical transmission to achieve a BER = 2 * 10^{-4} after the Viterbi decoder for some combinations of coding rates and modulation types - Ideal Receiver. The net bit-rates after the Reed-Solomon decoder are also listed.

			Required C/N for BER=2·10^{-4} after Viterbi; QEF after Reed-Solomon (IDEAL RECEIVER)			Bit rate (MBit/s)			
Modulation	**Code Rate**	**a**	**Gaussian Channel**	**Ricean Channel (F_1)**	**Rayleigh Channel (P_1)**	**Δ/T_U =1/4**	**Δ/T_U =1/8**	**Δ/T_U =1/16**	**Δ/T_U =1/32**
QPSK in Non-uniform 16-	1/2	2	4.8	5.4	6.9	4.98	5.53	5.85	6.03
	2/3		7.1	7.7	9.8	6.64	7.37	7.31	8.04
	3/4		8.4	9.0	11.8	7.46	8.29	8.78	9.05
						+			
	1/2		13.0	13.3	14.9	4.98	5.53	5.85	6.03
	2/3		15.1	15.3	17.9	6.64	7.37	7.31	8.04
	3/4		16.3	16.9	20.0	7.46	8.29	8.78	9.05
	5/6		16.9	17.8	22.4	8.29	9.22	9.76	10.05
	7/8		17.9	18.7	24.1	8.71	9.68	10.25	10.56
QPSK in Non-uniform 16-	1/2	4	3.8	4.4	6.0	4.98	5.53	5.85	6.03
	2/3		5.9	6.6	8.6	6.64	7.37	7.31	8.04
	3/4		7.1	7.9	10.7	7.46	8.29	8.78	9.05
						+			
	1/2		17.3	17.8	19.6	4.98	5.53	5.85	6.03
	2/3		19.1	19.6	22.3	6.64	7.37	7.31	8.04
	3/4		20.1	20.8	24.2	7.46	8.29	8.78	9.05
	5/6		21.1	22.0	26.0	8.29	9.22	9.76	10.05
	7/8		21.9	22.8	28.5	8.71	9.68	10.25	10.56

Table A1.4

Required C/N for hierarchical transmission to achieve a BER = 2 * 10^{-4} after the Viterbi decoder for some combinations of coding rates and modulation types - Ideal Receiver.

The net bit-rates after the Reed-Solomon decoder are also listed.

			Required C/N for BER=2·10^{-4} after Viterbi QEF after Reed-Solomon (IDEAL RECEIVER)			**Bit rate (MBit/s)**			
Modulation	Code rate	**a**	**Gaussian Channel**	**Ricean Channel (F_1)**	**Rayleigh Channel (P_1)**	**Δ/T_U =1/4**	**Δ/T_U =1/8**	**Δ/T_U =1/16**	**Δ/T_U =1/32**
QPSK in Uniform 64-QAM	1/2	1	8.9	9.5	11.4	4.98	5.53	5.85	6.03
	2/3		12.1	12.7	14.8	6.64	7.37	7.31	8.04
	3/4		13.7	14.3	17.5	7.46	8.29	8.78	9.05
						+			
	1/2		14.6	14.9	16.4	9.95	11.06	11.71	12.06
	2/3		16.9	17.6	19.4	13.27	14.75	15.61	16.09
	3/4		18.6	19.1	22.2	14.93	16.59	17.56	18.10
	5/6		20.1	20.8	25.8	16.59	18.43	19.52	20.11
	7/8		21.1	22.2	27.6	17.42	19.35	20.49	21.11
QPSK in Non-uniform 64-QAM	1/2	2	6.5	7.1	8.7	4.98	5.53	5.85	6.03
	2/3		9.0	9.9	11.7	6.64	7.37	7.31	8.04
	3/4		10.8	11.5	14.5	7.46	8.29	8.78	9.05
						+			
	1/2		16.3	16.7	18.2	9.95	11.06	11.71	12.06
	2/3		18.9	19.5	21.7	13.27	14.75	15.61	16.09
	3/4		21.0	21.6	24.5	14.93	16.59	17.56	18.10
	5/6		21.9	22.7	27.3	16.59	18.43	19.52	20.11
	7/8		22.9	23.8	29.6	17.42	19.35	20.49	21.11

A1.4 Multipath reception and statistical gain

OFDM can exploit the power contained in multiple echoes in the sense that the available *C/N* at the receiver input can increase, due to power summation of the carrier (*C)* contributions. However, at the same time the receiver performance can degrade due to the increase in the required *C/N*. As a result of these two effects, there can be a net performance gain or loss with multipath reception and contributions from other transmitters in SFNs. Except for the low spectrum efficiency modes (e.g., those with coding rate 1/2, see **Table A1.1**, a channel with a single line-of-sight contribution (Gaussian channel) can give a better global performance than one with two 0-dB echoes (Rayleigh channel). Conversely, when the number of 0-dB echoes is larger than two, the required C/N for the Rayleigh channel does not increase further, but the total carrier power available at the receiver increases (higher C/N), thus improving the global performance.

In addition to the above considerations, the space diversity due to the presence of multi-path propagation or SFN echoes increases the probability that at least one contribution exceeds the required threshold of the receiver. This “statistical gain” is very important in obstructed areas and in SFNs.

It should be noted that in the simulations and laboratory tests *C* is the total power of the received signal (including echoes) at the receiver input. This definition of *C* separates the problems related to the system performance (variation of the required *C/N* due to the distortions introduced by the frequency selective channel) from the statistics of the received field strength (available *C/N* which is to be taken into account by the frequency planner).

A1.5 System implementation losses

Due to the lack of information about consumer tuner and integrated receiver/decoder (IRD) characteristics, it is not possible at present to precisely characterise DVB-T receivers. Nevertheless, on the basis of the available theoretical and laboratory test results (see **Annexes A1** and **A3**), "typical" system implementation losses have been agreed, and are summarised in **Table A1.5**. For simplicity, the dependence of the implementation loss on the transmission mode (e.g. modulation and coding rate) has been neglected.

Table A1.5

Typical system implementation losses (DB)

	2D-channel estim. or CD3	1D-channel estim.
Channel estimation noise & boosted pilots	1.6	2.1
Tuner phase noise	0.5	0.5
Demodulator Implementation	0.6	0.6
Transmitter linear and non-linear distortions)	0.3	0.3
Total system implementation loss Δ_1	3	3.5

A1.6 Effective Protection Target

In DVB-T planning exercises the C/N required by the system must be predicted by a suitable law taking into account the echo configuration (MFN or SFN). In general, not only noise, but also interference and delayed signals outside the guard interval may be present at the receiver input. Therefore, instead of the required C/N ratio, a new system parameter is introduced, the "***Effective Protection Target***" (EPT) which is the ratio between the total power of the wanted signals and the sum of the powers of noise and effective interference at the receiver input.

In principle the *EPT* required by the DVB-T system is a random variable depending on the channel response and on the adopted transmission mode (coding rate, modulation and guard interval), and is different for MFN and SFN network configurations.

A2. DVB-T SYSTEM MODEL FOR MFN PLANNING 2

A2. DVB-T SYSTEM MODEL FOR MFN PLANNING

In MFN planning, it is assumed that a DVB-T system can operate satisfactorily at a given location when the available C/N is larger than or equal to the required effective protection target EPT:

$$C/N \Big|_{\text{Available}} \geq EPT \qquad \textbf{(A2.1)}$$

The required EPT depends on the system parameters and on the characteristics of the echoes inside and outside the guard interval, which determine the *criticality* of the channel (its frequency selectivity). Since the echo distribution cannot be usually controlled by the planner, it is assumed that in an MFN all the echoes fall within the guard interval. The *EPT* is assumed to be relevant to the F1 Ricean channel for fixed reception and to the P1 Raleigh channel for portable receivers. It is calculated by adding the total system implementation loss Δ_1 (**Table A1.5**) to the appropriate C/N value for an ideal receiver (**Tables A1.1, A1.3 and A1.4**).

$$EPT = \begin{cases} C/N\big|_F + \Delta_1 & \text{for fixed reception} \\ C/N\big|_P + \Delta_1 & \text{for portable reception} \end{cases} \qquad \textbf{(A2.2)}$$

A3. SFN PLANNING (ACTIVE ECHOES) 2

A3.1 DVB-T system model for SFN planning 2

ANNEX A3.1: SFN MODEL: Computer simulation results 5

ANNEX A3.2: LABORATORY TEST RESULTS ON GAUSSIAN AND MULTIPATH CHANNELS 8

A3. SFN PLANNING (ACTIVE ECHOES)

While for MFNs the amplitude and delay characteristics of the natural echoes in each location cannot be evaluated by the planner, in SFNs the characteristics of the "artificial" echoes from the various transmitters can be evaluated with a good approximation. Each SFN contribution is also affected by “natural echoes” due to reflections on the propagation path.

A3.1 DVB-T system model for SFN planning

From the computer simulations results of **Annex A3.1** and from the laboratory test results of **Annex A3.2**, the DVB-T system can be represented in first approximation by a simple model, as described in the following.

The required *EPT* depends on the system parameters and on the characteristics of the echoes inside and outside the guard interval, which determine the *criticality* of the channel (its frequency selectivity).

For fixed reception, the Ricean channel (F_1) is used for the main transmitter contribution. The *EPT* depends on the amplitude of the artificial echoes from the other transmitters, and can vary from $C/N|_F$ (single transmitter, Ricean channel (F_1), see **Table A1.1**) for low artificial echoes to $C/N|_P$ (single transmitter, Rayleigh channel (P_1), see **Table A1.1**) for high artificial echoes. The number and the delay of artificial echoes within the guard interval does not affect significantly the system performance, but their total power compared to the power of the main path has an important effect on the channel *criticality*. A parameter, K_A, has been identified as the “channel criticality due to artificial echoes” and is the ratio (in dB) between the power received from the main transmitter and the total power of the artificial echoes inside the interval of correct equalisation T_F. It should be noted that K_A = 0 dB corresponds to the most critical channel.

For portable reception, the Rayleigh channel (P_1) is adopted for each transmitter contribution (natural echoes), and the computer simulations have indicated that *EPT* is not significantly affected by the presence of the other SFN transmitters (in fact the channel model is of Rayleigh type also with a single transmitter).

Neglecting other interference sources, the equivalent total available *(C/N+I)* [dB] in a given location of the service area can be estimated by using formula **(A3.2)**, as derived in **Annex A0.1**.

$$w_i = \begin{cases} 0 & \text{if } t \le 0 \\ 1 & \text{if } 0 < t \le \Delta \\ \left(\dfrac{T_u - t + \Delta}{T_u}\right)^2 & \text{if } \Delta < t \le T_F \\ 0 & \text{if } t > T_F \end{cases}$$

$$C = \sum_i w_i \, C_i \qquad \textbf{(A3.2)}$$

$$I = \sum_i (1 - w_i) \, C_i$$

where:

C_i is the power contribution from the i-th echo (natural or artificial) at the receiver input;
C is the total power of the effective useful signal;
I is the total effective interfering power;
w_i is the weighting coefficient for the i-th component;
T_F is the interval of correct equalisation.

The system can operate satisfactorily in a given location when the aggregate available *C/N+I* is larger or equal to the required effective protection target *EPT*:

$$C/N+I \Big|_{\text{Available}} \equiv \frac{1}{(C/N)^{-1} + (C/I)^{-1}} \ge EPT \qquad \textbf{(A3.3)}$$

The computer simulation results reported in **Annex A2** can be approximated by an empirical expression proposed by RAI, where the required Effective Protection Target is given by (all the items are expressed in dB):

$$EPT = \begin{cases} C/N\big|_F + \left(C/N\big|_P - C/N\big|_F\right)\left(\dfrac{0.5}{\left(C/N\big|_P - C/N\big|_F\right)}\right)^{\frac{K_A}{10}} + \Delta_1 + \Delta_2 & \text{for fixed reception} \\ C/N\big|_P + \Delta_1 + \Delta_2 & \text{for portable reception} \end{cases} \qquad \textbf{(A3.4)}$$

where:

EPT is the required system effective protection target in a particular SFN echo environment;

C/N|F is the carrier to noise ratio required by the system on the F_1 channel (single transmitter, Rice channel, see **Table A1.1**);

C/N|P is the carrier to noise ratio required by the system on the P_1 channel (single transmitter, Rayleigh channel, see **Table A1.1**);

K_A **"***channel criticality due to artificial echoes"* is the ratio (in dB) between the power received from the main transmitter and the total power of the artificial echoes inside the interval of correct equalisation T_F; (if K_A<0 dB, then K_A is set to 0 dB);

Δ_1 total *"system implementation loss"* is given in the last line of **Table A1.5**;

Δ_2 is an aggregate performance loss due to the echoes outside $T_u/3$ which produce aliasing and noise increase on the channel estimation (this effect is not present in the case of CD3 channel estimation). It depends on the echo delay, phase and amplitude, and is still under investigation. As regards the echo phase, the worst case should be considered. Pending other results, Δ_2 should be set equal to 0 dB.

ANNEX A3.1: SFN MODEL: Computer simulation results

A computer simulation investigation has been carried out at the RAI on the DVB-T system in two operational modes:

- QPSK with coding rate ½
- 64 QAM with coding rate 2/3).

Complete 1-D channel estimation and equalisation algorithms have been simulated. A single frequency network environment has been reproduced, considering a number of SFN echoes (a main signal and one or two artificial SFN echoes), with different combinations of amplitudes and delays (within and outside the guard interval). Each contribution from a transmitter was affected by 20 natural echoes, with independently generated Ricean (fixed reception, channel F_1, Ricean factor K_n=10 dB) or Rayleigh (portable reception, channel P_1) amplitude distributions.

Figures Annex A3.1.1, Annex A3.1.2 and **Annex A3.1.3** show the good agreement of the simulation results with the approximated formulae described in **§A3.1**. To match with the computer simulations, **formula A3.4** is used with Δ_1 relevant to 1-D channel estimation without receiver and transmitter implementation losses (i.e., Δ_1 is taken from the first line in **Table A1.5**). The simulation results refer to echo delays for which Δ_2 can be assumed equal to 0 dB. In **Figure Annex A3.1.4** the theoretical model is compared to the laboratory test results on the STERNE modem (non fully compliant with the DVB-T specification). The peak loss of the system is worse than that indicated by the formula, since in the tests a more critical channel was used (single echo at 0 dB, instead of a number of echoes as in the simulations). In this case **formula A3.4** is used with Δ_1 relevant to 2-D channel estimation (as implemented in the modem), including the receiver and transmitter implementation losses (i.e., last line in **Table A1.5)**.

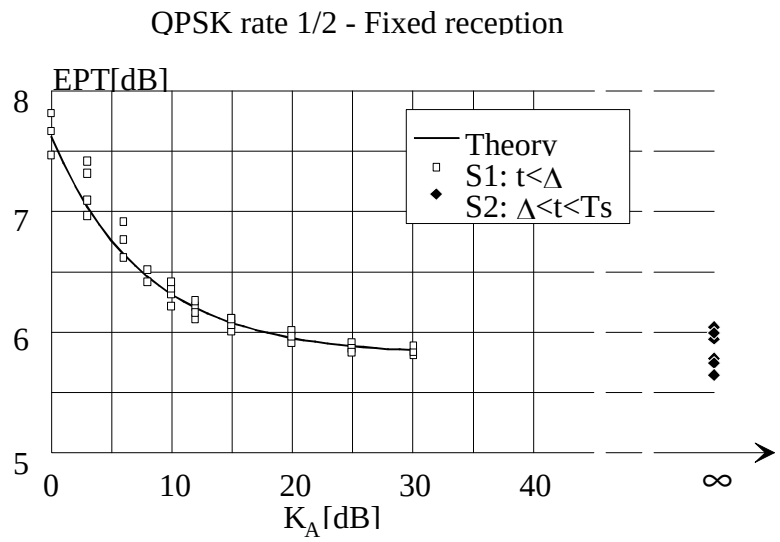

Figure Annex A3.1.1 Comparison between the simulation results and the proposed model

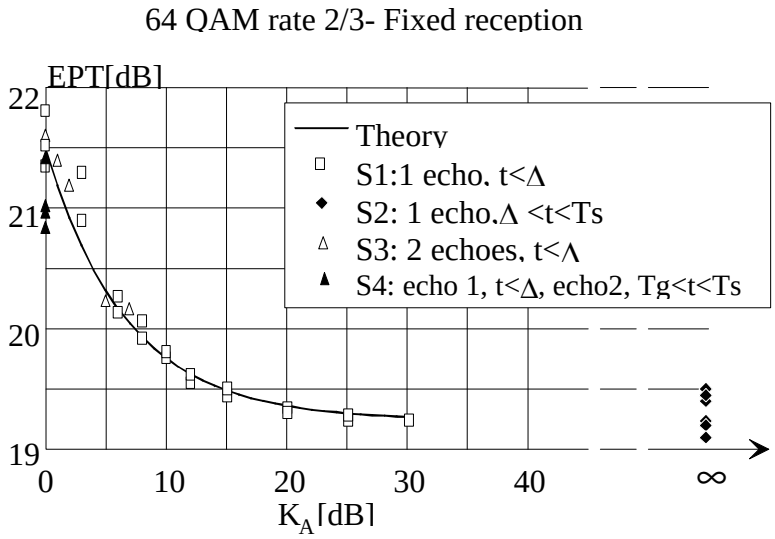

Figure Annex A3.1.2 Comparison between the simulation results and the proposed model

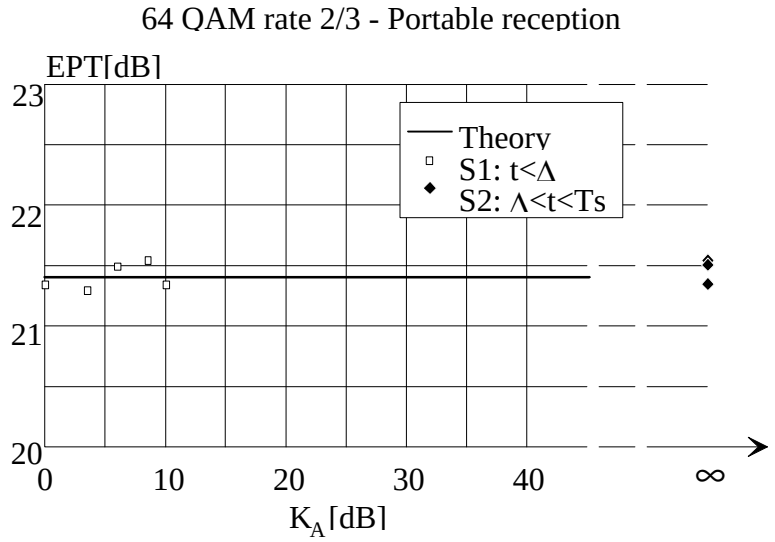

Figure Annex A3.1.3 Comparison between the simulation results and the proposed model

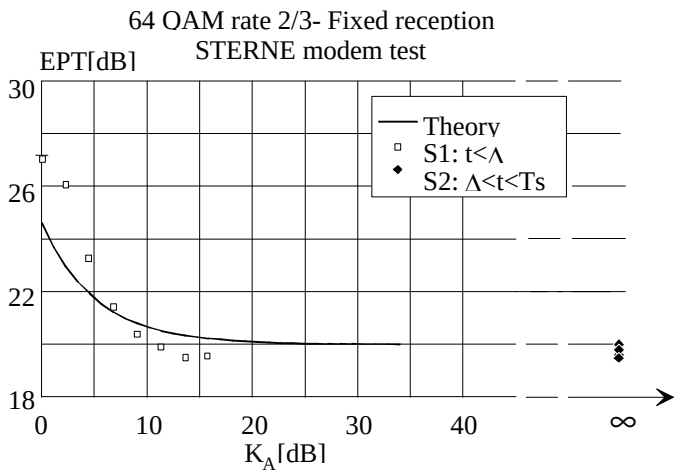

Figure Annex A3.1.4 Comparison between the results of laboratory tests and the proposed model

Figure Annex A3.1.5 compares the performance of a CD3 receiver[1] with correct equalisation interval $T_F=2T_u$ with that of a conventional pilot-based receiver (with $T_F=\Delta$), in the case of 8K, $\Delta = T_u/4$, 64 QAM modulation with code rate 2/3. The curves give the maximum echo level [2], γ dB, to achieve BER=$2\cdot10^{-4}$ after Viterbi decoding without noise, as a function of the normalised echo delay τ/Δ. The performance predicted by the theoretical model of formulae (1) and (5), with $T_F=2T_u$, is also given as a reference. The performance of CD3 is similar to that of the theoretical formulae for the echoes outside the guard interval, achieving approximately a gain in terms of γ from 12 dB to 7 dB compared to a receiver based on pilot tones, for delays in the range 1.3Δ to 2Δ.

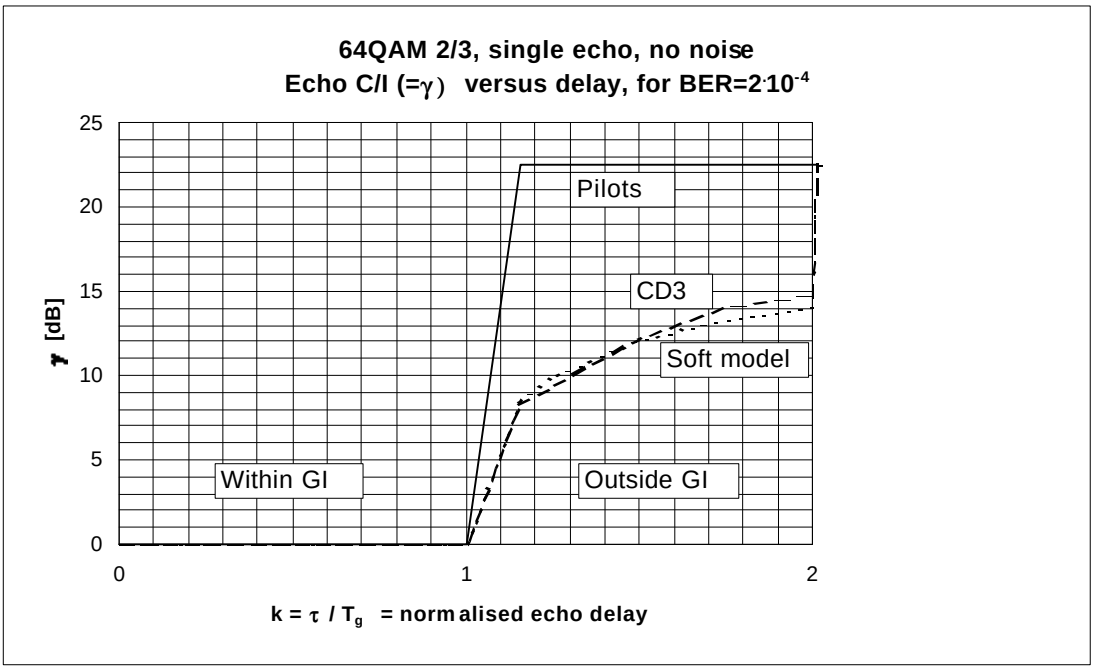

Figure Annex A3.1.5 Simulated performance of pilot-based and CD3 channel estimation for echoes outside Δ**.**

[2] = power of the echoes inside the guard interval/power of the echoes outside the guard interval

ANNEX A3.2: LABORATORY TEST RESULTS ON GAUSSIAN AND MULTIPATH CHANNELS

A first estimation of the losses due to tuner phase noise, demodulator implementation and transmitter linear and non-linear distortions has been derived from preliminary studies within the RACE dTTb project, the tests in the AHG/DAPSK group[3] , TCE/CCETT[4] and HD-DIVINE[5] .
In the TCE/CCETT document, the loss due to tuner phase noise was estimated in the range of 0.5 dB for a "pseudo-8K" mode, while in the D-DIVINE document a figure of 0.1 dB was given.

Gaussian channel

In the framework of the activities of the ACTS VALIDATE Project, in December 1996 the RAI has carried out a number of laboratory tests and a real transmission trial on the dTTb-2 demonstrator. The dTTb-2 modem is the first one implementing both the 2K and 8K FFT modes. A complete DVB-T chain was set-up, including real time MPEG-2 encoder/decoder (for three programmes), a multiplexer/demultiplexer, the dTTb-2 C-OFDM modem, an RF transmitter on UHF channel 28 and a “quasi-consumer” tuner developed by Thomson. The dTTb-2 modem can implement QPSK, 16 QAM and 64 QAM modulations and a variety of guard intervals and coding rates.

In order to identify the system implementation margins, the BER versus C/N (in 7.6 MHz) curves after Viterbi decoding have been measured in various configurations, as given in **Table Annex A3.2.1**. The receiver intermediate frequency (IF) is 35.5 MHz while the radio-frequency (RF) is 530 MHz (UHF channel 28).

Table Annex A3.2.1 gives the measured additional C/N losses, due to system implementation, to be added to the theoretical figures given in the DVB-T specification (Annex A, Gaussian Channel). The system under test was based on 2-D channel estimation.

TABLE Annex A3.2.1 System implementation losses ΔC/N over AWGN channel at BER=2·10^{-4} after Viterbi decoding

			ΔC/N [dB]		
Modulation	Rate	FFT	IF-IF (note 1)	Tuner (note 2)	Total RF-RF (note 3)
QPSK	1/2	2K	1.7	0.0	
		8K	1.6	0.0	2.0
16 QAM	3/4	2K	1.6	0.0	
		8K	1.5	0.1	2.0
64 QAM	2/3	2K	2.4	0.0	
		8K	2.3	0.3	3.0

Note (1): measurement configuration: IF transmitter output, IF receiver input. The theoretical degradation for channel estimation and pilot boosting is 1.6 dB (2-D algorithm) and 2.1 dB (1-D algorithm)
Note (2): measurement configuration: IF transmitter output, RF receiver input

[3] DVB-TM, Doc. 1562
[4] DVB-TM, Doc. 1381
[5] DVB-TM, Doc. 1494

Note (3): measurement configuration: RF transmitter output, RF receiver input. HPA producing spectrum shoulders of the order of -38 dB

During these tests, the dTTb-2 demonstrator operated reliably without synchronisation problems even at high BER levels after Viterbi decoding (about BER=10^{-2}).

From the above figures the following conclusions can be drawn:

- the 2K and 8K systems show similar implementation margins;
- **IF-IF loop**: for QPSK 1/2 and 16 QAM 3/4, the degradation is at the limit of the theoretical figure relevant to 2-D channel estimation and pilot boosting, while for 64 QAM 2/3 an additional implementation margin of about 0.8 dB is required;
- **IF-RF loop**: the "quasi-consumer" tuner introduces a very small degradation on the system performance, and the 8K mode is not penalised by the tuner phase noise (0.3 dB degradation with 64 QAM 2/3);
- **RF-RF loop:** the additional degradation introduced by the transmitter is in the range 0.3 to 0.6 dB, but different values are to be expected for different levels of non-linear distortion in the high power amplifier (spectrum shoulders). The total system implementation margin is of the order of 2 dB for QPSK 1/2 and 16 QAM 3/4 and of 3 dB for 64 QAM 2/3.

Delayed Echoes

The dTTb-2 demonstrator has been tested in the presence of echoes inside and outside the guard interval. **Figure Annex A3.1** shows the C/N performance loss (compared to the Gaussian channel) of 64 QAM 2/3 versus the echo delay and amplitude (C/I). The guard interval is Δ=1/4, corresponding to 224 μs in the 8K mode, and is suitable for SFN operation. **Figure Annex A3.2** shows similar curves for the 2K mode, with guard interval of 56 μs (Δ=1/4), where the curves relevant to C/I=0 to 6 dB are omitted for simplification.

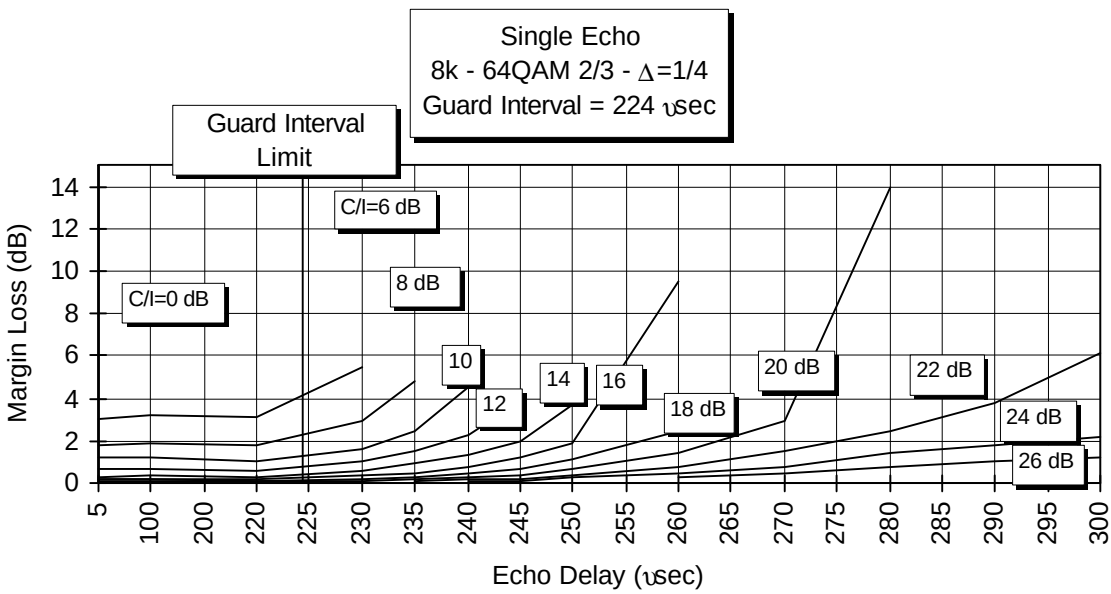

Figure Annex A3.2.1 C/N performance loss versus echo delay

Note that the delay scales after the limit of the guard interval have been expanded, to give more details on the failure characteristics. Note that, for echo amplitudes of less than 10 dB below the "main" signal, the margin loss increases rapidly (system failure) as the echo delay is increased beyond the guard interval.

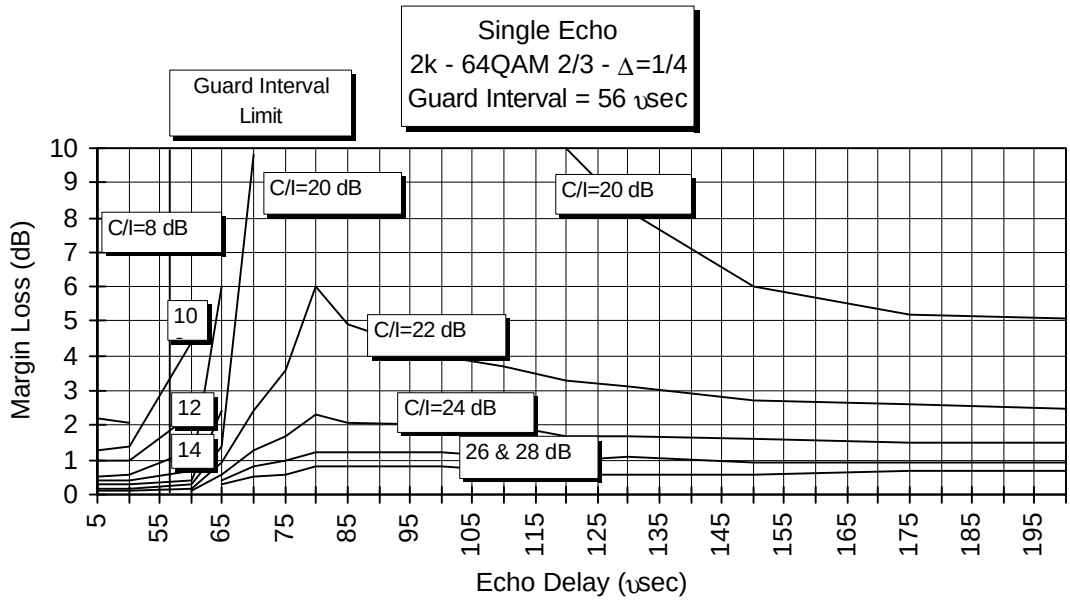

Figure Annex A3.2.2 C/N performance loss versus echo delay

Note that the delay scales after the limit of the guard interval have been expanded, to give more details on the failure characteristics. Furthermore, the performance within the guard interval is not represented with sufficient detail; the measurements have shown that in this area the curves are fairly flat.

Additional tests have been carried out with multiple echoes, simulating fixed, portable, dense SFN and "regional" SFN reception conditions. The first two cases correspond to the six strongest echoes of Annex B of the DVB-T specification. **Table Annex A3.2.2** compares the test results with the simulation results of the specification. The tested mode was 8K, 64 QAM 2/3 with Δ=1/8.

TABLE Annex A3.2.2 - 8K 64 QAM 2/3 -Performance loss (ΔC/N) with multiple echoes at BER=$2 \cdot 10^{-4}$ after Viterbi decoding

Reception condition	Max. echo delay [µs]	**ΔC/N (test)** [dB]	**ΔC/N (simul.)** [dB]
Fixed (Ricean channel)	5.4	0.5	0.6
Portable (Rayleigh channel)	5.4	3.6	2.8
Dense SFN (Rayleigh channel)	23	2.9	N.A.
Regional SFN (Rayleigh channel)	100	2.8	N.A.

N.A.: Not Available

The following conclusions can be drawn:

- the system performance with a single 0 dB echo within the guard interval is good (5.5 to 7 dB degradation compared with the Gaussian channel), without synchronisation or instability problems, and is comparable to or better than that previously reported. In the presence of multiple echoes (Rayleigh channel) the degradations are smaller than with a single 0 dB echo, and the test results are in good agreement with the simulation results;
- as expected from theory, both for 2K and 8K modes and Δ=1/4, the failure characteristic is steep for echoes outside the guard interval. For example in the 8K mode a strong echo with C/I=10 dB can be accepted only for delays shorter than τ =245 µs, corresponding to τ/T_g=1.09; a weak echo at C/I=20 dB can drive the system out of service for τ =275 µs, corresponding to τ/T_g=1.23.

A4. MINIMUM RECEIVER INPUT SIGNAL 2

A4. MINIMUM RECEIVER INPUT SIGNAL

The minimum equivalent receiver input voltage U_s [dBµV] into the receiver input impedance Z_i (75 Ω), can be calculated as a function of the receiver characteristics (noise figure and bandwidth) and of the required RF signal to noise ratio C/N (or EPT) [dB], by means of conventional formulas (Logarithmic units):

$U_s = P_s + 120 + 10 \log (Z_i)$

$P_s = C/N + P_n$

where

P_s is the receiver signal input power [dBW];

P_n is the receiver noise input power [dBW].

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

where

B is the receiver noise bandwidth [Hz] ($B=7.61 * 10^6$);

F is the receiver noise figure [dB];

k is the Boltzmann's Constant ($k= 1.38 * 10^{-23}$ Ws/K);

T_0 is the absolute temperature ($T_0 = 290$ K).

For planning purposes it has been agreed to adopt a DVB-T tuner Noise Figure F= 7 dB.
Tables A4.1 and A4.2 give the minimum input signal levels for 8 MHz and 7 MHz DVB-T variants, respectively.

Frequency Band I, III, IV, V – 8 MHz channels						
Equivalent noise band width	B [Hz]	$7.6*10^6$	$7.6*10^6$	$7.6*10^6$	$7.6*10^6$	$7.6*10^6$
Receiver noise figure	F [dB]	7	7	7	7	7
Receiver noise input power	P_n [dBW]	-128.2	-128.2	-128.2	-128.2	-128.2
RF signal/noise ratio	C/N [dB]	2	8	14	20	26
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBµV]	13	19	25	31	37

Table A4.1: Minimum equivalent input signal level to receiver for 8 MHz version.

Frequency Band I, III, IV, V – 7 MHz channels						
Equivalent noise band width	B [Hz]	$6.7*10^6$	$6.7*10^6$	$6.7*10^6$	$6.7*10^6$	$6.7*10^6$
Receiver noise figure	F [dB]	7	7	7	7	7
Receiver noise input power	P_n [dBW]	-128.7	-128.7	-128.7	-128.7	-128.7
RF signal/noise ratio	C/N [dB]	2	8	14	20	26
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.7	-120.7	-114.7	-108.7	-102.7
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBµV]	12	18	24	30	36

Table A4.2: Minimum equivalent input signal level to receiver for 7 MHz version

Note: This table provides a derivation of minimum required signal levels. §§B1.4.2.1 and B1.4.3.6 provide information on the minimum median values of signal levels required in practical situations.

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A5. PROTECTION RATIOS

Protection ratio (PR) figures have to be established for 8 MHz (VHF and UHF) and for 7 MHz (VHF only) channel rasters. The ITU reference documents are, ITU-R Rec. XYZ and ITU-R Rec. BT. 655. When evaluating the PRs, it is proposed that the rules set out below are observed.

The protection ratios are given in dB and are related to an out-of-channel spectrum attenuation for DVB-T transmitters of 40 dB. This 40 dB figure is only used for protection ratio measurements and is not necessarily recommended for real DVB-T transmitters.

The protection ratios relevant to a given interference should be evaluated without noise or other interference at the relevant quality target.

Quality targets:

- for a wanted DVB-T signal the required protection ratios are preferably measured for a BER of $2.\ 10^{-4}$ after Viterbi decoding, corresponding to a BER of $< 1.\ 10^{-11}$ at the input of the MPEG-2 demultiplexer, and to approximately one uncorrected error per hour. In the case of digital signals as wanted signal, all protection ratio values relate to both tropospheric and continuous interference. For practical reasons, the quality targets are often measured at the service failure threshold (e.g., a few artifacts per minutes);

- for analogue television wanted signals, the quality target is picture Grade 3 (tropospheric interference) and picture Grade 4 (continuous interference).

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 ITU reference document is ITU-R Recommendation: “Planning Criteria for Digital Terrestrial Television Services in the VHF/UHF Television Bands” (at present numbered Rec. ITU-R. XYZ).

All frequencies and frequency differences should preferably be related to the vision carrier (or sound carrier, in the case of analogue sound PRs) and to the center frequency of the digital channel.

Modes M1, M2, M3 of the DVB-T system have been adopted by ITU-R as representative modes of the system. Protection ratio figures and tables are preferably given for these three modes. The protection ratio figures for other modes may be derived from these figures.

A5.1 DVB-T interfered with by DVB-T

Table A5.1 gives co-channel Protection Ratios (rounded to the nearest integer), obtained by measurements or by the extrapolation method given below.

Table A5.1

Co-channel protection ratios (dB) for DVB-T interfered with by DVB-T

ITU-Mode	Modulation	Code rate	PR (*) Gaussian	PR (**) Rice	PR (**) Rayleigh
	QPSK	1/2	5	7	8
M1	16-QAM	1/2		13	14
	16-QAM	3/4	14	16	20
M2	64-QAM	1/2		18	19
M3	64-QAM	2/3	19	20	22

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

Protection ratios for the various modes and for the various channel types (i.e. Gaussian, Ricean, or Raleigh) can be derived by the required C/N given in **Tables A1.1, A1.3 and A1.4** increased by a system implementation loss Δ_1 of 3 dB. For fixed and portable reception, the figures relevant to the Ricean and Rayleigh channels respectively should be adopted.

For **adjacent and image channel interference** a protection ratio of -40 dB is assumed to be an appropriate value due to lack of data.

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

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

PR(CCI) is the co-channel protection ratio;

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

BW is the bandwidth (in MHz) of the wanted signal;

PR = -40 dB should be used when the above formula gives PR < -40 dB.

A5.2 DVB-T interfered with by analogue television

The protection ratios for wanted DVB-T apply to both continuous and tropospheric interference.

In all tables the so-called non-controlled frequency conditions are used. Introducing precisely controlled frequency offsets between the analogue and digital signals, significant lower co-channel protection ratios have been measured. Further studies of using controlled offset for DVB-T are necessary.

A5.2.1 Co-channel protection ratios

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

Table A5.2

Co-channel protection ratios (dB) for DVB-T 7 and 8 MHz interfered with by analogue television and CW (non-controlled frequency condition)

	Protection Ratio														
Constellation	QPSK					16QAM					64 QAM				
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
ITU-Mode						M1					M2	M3			
CW and PAL/SECAM with teletext and sound carriers	-12	-8	-5	2	6	-8	-4	0	9	16	-3	4	10	17	24

The PAL/SECAM figures are valid for all sound carrier modes used in Europe, these are:

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.

The values contained in this table represent the present knowledge of behaviour of the DVB-T systems and are derived from a limited number of measurements mainly with 2k systems. There is a general confidence that the final results will not differ by more than 3 dB.

Reference conditions for coordination are given in §C1.4.

A5.2.2 Lower adjacent channel (n - 1)

Table A5.3

Protection ratios (dB) for DVB-T interfered with by analogue television in the lower adjacent channel (n - 1)

Wanted signal			Interfering signal					
System	BW	Mode	PAL B	PAL G,B1	PAL I	PAL D,K	SECAM L	SECAM D,K
DVB-T	8 MHz	M1			-43			
		M2			-38			
		M3			-34			
DVB-T	7 MHz	M1	-43					
		M2	-40					
		M3	-37					

A5.2.3 Upper adjacent channel (n + 1)

Table A5.4

Protection ratios (dB) for DVB-T interfered with by analogue television in the upper adjacent channel (n + 1)

Wanted signal			**Interfering signal**					
System	BW	Mode	PAL B	PAL B1, G	PAL I	PAL D,K	SECAM L	SECAM D,K
DVB-T	8 MHz	M1			-46			
		M2			-40			
		M3			-38			
DVB-T	7 MHz	M1	-43					
		M2	-38					
		M3	-36					

A5.2.4 Image channel

Table A5.5

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

Wanted signal			Interfering signal					
System	BW	Mode	PAL B	PAL G,B1	PAL I	PAL D,K	SECAM L	SECAM D,K
DVB-T	8 MHz	M1			-58			
		M2			-50			
		M3			-46			

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

A5.2.5 Overlapping channels

Note that protection ratio values for the overlapping channel cases are provisional and will need to be confirmed within the ITU-R.

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

Table A5.6
Protection ratios (dB) for DVB-T 8 MHz interfered with by overlapping PAL B

DVB-T 8 MHz (ITU-M3, 64 QAM 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	-37	-14	-8	-4	-2	1	4	4	4	2	-1	-29	-36

Table A5.7
Protection ratios (dB) for DVB-T 7 MHz interfered with by overlapping PAL B1, D

DVB-T 7 MHz (ITU-M3, 64 QAM rate 2/3)													
Δf (MHz) for B1	-9.25	-8.75	-8.25	-7.75	-6.25	-3.45	-3.25	-2.25	-1.25	-1.75	2.75	4.25	4.75
Δf (MHz) for D	-10.25	-9.75	-9.25	-8.75	-7.25	-3.45	-3.25	-2.25	-1.25	-1.75	2.75	4.25	4.75
PR	-37	-14	-8	-4	-2	1	4	4	4	2	-1	-29	-36

A5.3 Analogue television interfered with by DVB-T

The values of protection ratio quoted apply to interference produced by a single source. In this section the protection ratios for a wanted analogue signal interfered with by an unwanted digital signal apply only to the interference to the vision and colour signals, i.e. excluding sound signals.

The tropospheric interference corresponds to impairment grade 3, that is, acceptable for a small percentage of the time, between 1% and 10%. The continuous interference corresponds to an impairment grade 4, that is, acceptable for 50% of time.

The protection ratio measurements for wanted analogue television signals should be made using the method given in the ANNEX of Rec. ITU-R XYZ. For the co-channel case, the digital interference from a DVB-T signal has a similar effect to Gaussian noise of equal power in the receiver bandwidth.

A5.3.1 Co-channel protection ratios

Table A5.8

Protection ratios (dB) for an analogue vision signal interfered with by DVB-T 8 MHz

Wanted analogue system	Tropospheric interference	Continuous interference
PAL B, B1, G, D, K	34	40
PAL I	37	41
SECAM L	37	42
SECAM D,K	35	41

These figures are taken from Rec. ITU-R XYZ and may be updated as a result of further measurements. **Reference conditions for coordination are given in CH 97 Annex 1.9.**

Table A5.9

Protection ratios (dB) for an analogue vision signal interfered with by DVB-T 7 MHz

Wanted analogue system	Tropospheric interference	Continuous interference
PAL B	35	41

These figures are taken from Rec. ITU-R XYZ and may be updated as a result of further measurements. **Reference conditions for coordination are given in CH 97 Annex 1.9.**

A5.3.2 Lower adjacent channel (n – 1)

Table A5.10

Protection ratios (dB) for an analogue vision signal interfered with by lower adjacent channel DVB-T 8 MHz

Wanted analogue system	Tropospheric interference	Continuous interference
PAL B1, G, D, K	-7	-4
PAL I	-8	-4
SECAM L	-9	-7
SECAM D,K	-5	-1

Table A5.11

Protection ratios (dB) for an analogue vision signal interfered with by lower adjacent channel DVB-T 7 MHz

Wanted analogue system	**Tropospheric interference**	**Continuous interference**
PAL B	-11	-4

A5.3.3 Upper adjacent channel (n + 1)

Table A5.12

Protection ratios (dB) for an analogue vision signal interfered with by upper adjacent channel DVB-T 8 MHz

Wanted analogue system	Tropospheric interference	Continuous interference
PAL B1, G	-9	-7
PAL I	-10	-6
SECAM L	-1	-1
SECAM D, K	-8	-5
PAL D, K		

Table A5.13
Protection ratios (dB) for an analogue vision signal interfered with by upper adjacent channel DVB-T 7 MHz

Wanted analogue system	Tropospheric interference	Continuous interference
PAL B	-5	-3

A5.3.4 Image channel

Table A5.14

Protection ratios (dB) for an analogue vision signal interfered with by image channel DVB-T 8 MHz

Wanted analogue system	Unwanted DVB-T channel	Tropospheric interference	Continuous interference
PAL B1, G	n + 9	-19	-15
PAL I	n + 9		
SECAM L	n - 9	-25	-22
SECAM D, K	n + 8	-16	-11
SECAM D, K	n + 9	-16	-11
PAL D, K	n + 8		
PAL D, K	n + 9		

Table A5.15

Protection ratios (dB) for a PAL B vision signal interfered with by overlapping channel DVB-T 8 MHz

Frequency difference (MHz) between DVB-T and PAL signals Centre frequency of DVB-T signal minus the vision carrier frequency of the analogue television signal	Tropospheric interference	Continuous interference
-7.25	-11	-6
-5.25	-10	-1
-3.75	13	20
-3.25	24	31
-2.75	30	36
-2.25	33	40
-1.25	34	40
-0.25	34	40
2.75 co-channel n	34	40
4.75	34	40
5.75	33	39
7.75	27	35
8.25	24	33
8.75	19	28
9.25	5	12
10.75 channel n-1	-5	-3
12.75	-7	-2

This table is derived from **Table A5.16**, relating to an unwanted DVB-T 7 MHz interferer

A5.3.5 Overlapping channels

Note that protection ratio values for the overlapping channel cases are provisional and will need to be confirmed within the ITU-R.

Table A5.16

Protection ratios (dB) for a PAL B1, D vision signal interfered with by overlapping channel DVB-T 7 MHz

Frequency Difference (MHz) between DVB-T and PAL signals Centre frequency of DVB-T signal minus the vision carrier frequency of the analogue television signal	Tropospheric interference	Continuous interference
-7.75	-13	-8
-4.75 channel n + 1	-10	-4
-4.25	-4	2
-3.75	14	21
-3.25	25	32
-2.75	31	37
-1.75	34	41
-0.75	35	41
2.25 co-channel n	35	41
4.25	35	41
5.25	32	38
7.25	25	34
7.75	20	29
8.25	6	13
8.75	-5	-2
9.25 channel n - 1	-7	-4
12.25	-9	-3

A5.4 Sound signals associated with analogue television, interfered with by DVB-T

In this section, all values quoted refer to the level of the wanted sound carrier.

The reference signal-to-noise ratios (S/N, peak-to-peak weighted) for analogue sound signals are:

- 40 dB for tropospheric interference (approximates to impairment grade 3);
- 48 dB for continuous interference (approximates to impairment grade 4).

The reference bit-error rates for NICAM digital sound signals are:

- $1.\ 10^{-4}$ for tropospheric interference (approximates to impairment grade 3);
- $1.\ 10^{-5}$ for continuous interference (approximates to impairment grade 4).

In the case of a two-sound carrier transmission, each of the two sound signals must be considered separately.

Table A5.17

Protection ratios (dB) for a sound signal associated with analogue television, interfered with by DVB-T

Protection Ratio in dB		Interfering signal	
Wanted sound signal		DVB-T 7 MHz	DVB-T 8 MHz
FM	Tropospheric	6	5
	Continuous	16	15
AM	Tropospheric		
	Continuous		
NICAM System B, B1, G	Tropospheric		
	Continuous		
NICAM System L	Tropospheric		
	Continuous		
NICAM System I	Tropospheric		
	Continuous		

0 kHz frequency separation between the wanted sound carrier and the centre frequency of the DVB-T signal.

Table A5.18

Protection ratios (dB) for an analogue television FM sound signal interfered with by DVB-T 8 MHz

DVB-T 8 MHz (The frequency difference Δf is the centre frequency of DVB-T signal minus the centre frequency of FM sound signal in MHz)									
Frequency difference Δf	-5*	-4.2*	-4	-3.5	0	3.5	4	4.2	4.5
Tropospheric interference	-1	-1	4	5	5	4	2	-18	-33
Continuous interference	8	8	13	15	15	14	11	-12	-28

* the required higher protection at lower frequencies is caused by intercarrier distortions of the vision carrier

Table A5.19

Protection ratios (dB) for an analogue television FM sound signal interfered with by DVB-T 7 MHz

DVB-T 7 MHz (The frequency difference Δf is the centre frequency of DVB-T signal minus the centre frequency of FM sound signal in MHz)									
Frequency difference Δf	-5*	-3.7*	-3.5	-3	0	3	3.5	3.7	> 4
Tropospheric interference	0	0	5	6	6	5	3	-17	< -32
Continuous interference	9	9	14	16	16	15	12	-11	<-27

* the required higher protection at lower frequencies is caused by intercarrier distortions of the vision carrier

A5.5 DVB-T interfered with by T-DAB

Table A5.20

Protection ratios (dB) for a DVB-T 8 MHz interfered with by T-DAB

DVB-T 8 MHz (ITU Mode M3, 64 QAM, 2/3 code rate) **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
PR	-30	-6	-5	28	29	28	-5	-6	-30

Table A5.21

Protection ratios (dB) for a DVB-T 7 MHz interfered with by T-DAB

DVB-T 7 MHz (ITU Mode M3, 64 QAM, 2/3 code rate) **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
PR	-30	-6	-5	28	29	28	-5	-6	-30

A5.6 T-DAB interfered with by DVB-T

Table A5.22

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

DVB-T 8 MHz (ITU Mode M3, 64 QAM, 2/3 code rate) **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
PR	-50	-1	0	1	1	1	0	-1	-50

Table A5.23

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

DVB-T 7 MHz (ITU Mode M3, 64 QAM, 2/3 code rate) **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
PR	-49	0	1	2	2	2	1	0	-49

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B0. INTRODUCTION

This section of the document provides the basic criteria needed for planning and shows how such values are derived. This also permits the derivation of planning criteria for system variants not specifically dealt with here. In addition, considerable information is given on methods of coverage assessment which may be found useful when national coverage and frequency plans are being established.

B1. BASIC CRITERIA

B1.1 Coverage definitions for fixed and portable reception

B1.1.1 Introduction

It is necessary to have definitions for the coverage of a terrestrial television transmitting station or a group of such stations. Such definitions may be based primarily on technical criteria but need to be readily usable for non-technical purposes.

The above is true for analogue television transmissions as well as for digital ones. However, the case of analogue stations is relatively easy to deal with as the line defining any edge of a coverage area is rather “soft” and it is not necessary to be too precise about where the line actually lies in any given area; indeed in many cases it is not really possible to be precise.

Digital television service coverages are characterised by a very rapid transition from near perfect reception to no reception at all and it thus becomes much more critical to be able to define which areas are going to be covered 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, 100 m x 100 m) is set too high. 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.

For this reason, 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.

The definitions do not aim to describe the area where coverage is achieved under worst case conditions. They provide a description of the area where "good" or "acceptable" coverage should be achieved under representative practical conditions.

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;
- by using a (more) directional receiving antenna with a higher gain;
- by using a low-noise antenna amplifier (in the case of fixed antenna reception).

B1.1.2 Fixed antenna reception

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

It is assumed that near-optimal reception conditions (within a relatively small volume on the roof) are found when the antenna is installed.

In calculating the field strength for fixed antenna reception a receiving antenna height of 10 m above ground level is considered to be representative.

B1.1.3 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.

In both categories A and B, above, it is assumed that:

- optimal receiving conditions will be found by moving the antenna up to 0.5 metre in any direction;
- the portable receiver is not moved during reception and large objects near the receiver are also not moved;
- extreme cases, such as reception in completely shielded rooms, are disregarded.

B1.1.4 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: descriptions of the reception conditions are given in §§B1.1.2 and B1.1.3.

  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 100m by 100m).
  In this small area the percentage of covered location 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.

B1.1.5 Examples of practical usage

In the case where simplified definitions of transmitter coverage are required, a phrase such as "area within which good fixed antenna reception is expected" is equivalent to:

- coverage area for a transmitter or a group of transmitters;
- at least 95% of receiving locations within every included small area are covered;
- fixed antenna reception.

In the same way "an area within which acceptable class B portable antenna reception, is expected" is equivalent to;

- coverage area for a transmitter or a group of transmitters;
- at least 70% of (indoor) ground floor receiving locations within every included small area are covered;
- portable antenna reception.

B1.2 Field strength prediction model

As a basis, ITU-R Recommendation P.370 will be used to predict the field strength values, however:

- no correction will be applied for Δh-values other than 50 meters;
- no use will be made of a terrain clearance angle correction due to the absence of a common European topographical database;
- propagation predictions should include a mixed-path calculation with an agreed land/sea boundary being derived from the ITU-R boundary map files or some other suitable source.

On a bilateral basis, if agreed, more detailed propagation prediction methods can be used. Such methods do not need to be specified or identified by the CEPT.

B1.3 Location variation

Within a small area, say 100 m by 100 m, there will be a more-or-less random variation of signal level with location which is due to terrain irregularities. The statistics of this variation are characterised by a log-normal distribution for the signal levels (powers). Recent measurements for digital signals have shown that the standard deviation of the distribution will be about 5.5 dB. There will be some dependency on the environment surrounding the receiving location and this is the reason that only an approximate value is given.

The standard deviation for analogue TV-signals interfering with DVB-T is also taken as 5.5 dB.

These values for digital and analogue TV signals should be verified by further measurements.

It must be stressed that these values of the standard deviation take no account of the inherent inaccuracies of any propagation prediction method.

B1.3.1 Receiving Antennas

B1.3.2 Fixed reception

The antenna diagrams (directivity) to be used for DVB-T planning are given in ITU-R Rec. 419.
The antenna gains (relative to half wave dipole) used in the derivation of the minimum median wanted signal levels in §B1.4.2 are:

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

These values are considered as realistic minimum values.

Within any frequency band, the variation of antenna gain with frequency may be taken into account by the addition of a correction term:

- Corr = 10 log (F_A/F_R)

where:

- F_A is the actual frequency being considered;
- F_R is the relevant reference frequency quoted above.

B1.3.2.1 Feeder losses

The feeder losses used in the derivation of the minimum wanted signal levels in §B1.4.2 are:

65 MHz	250 MHz	500 MHz	800 MHz
1 dB	2 dB	3 dB	5 dB

B1.3.3 Portable reception

Antennas for portable reception can generally not be assumed to have any significant directivity, consequently no antenna gain can be assumed.

The antenna gains (relative to half wave dipole) used in the derivation of the minimum median wanted signal levels in §B1.4.3.3 have been chosen to be equal to 0 dB for UHF and -2.2 dB for VHF.

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

B1.3.3.1 Feeder loss

It is assumed that the feeder loss for portable reception is 0 dB in all bands.

B1.4 Minimum median wanted signal levels

B1.4.1 General

In §A4 the minimum signal levels needed to overcome noise are given as the minimum receiver input power and the corresponding minimum equivalent receiver input voltage. In §A4, no account is taken of any propagation effects. However, it is necessary to take account of these effects when considering television reception in a practical environment.

In §B1.1, it is indicated that, due to the very rapid transition from near perfect to no reception at all, 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. 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 minimum median signal levels are calculated for:

- 3 different receiving conditions:
  - fixed antenna reception;
  - portable outdoor reception;
  - portable indoor reception at ground floor;
- 4 frequencies representing Band I, Band III, Band IV and Band V:
  - 65 MHz;
  - 200 MHz;
  - 500 MHz;
  - 800 MHz;
- 5 representative C/N ratios:
  - 2 dB;
  - 8 dB;
  - 14 dB;
  - 20 dB;
  - 26 dB.

Representative C/N values are used for these examples. Results for any chosen system variant may be obtained by interpolation between relevant representative values.

All minimum median equivalent field strength values presented in this chapter are for coverage by a single transmitter only, not for Single Frequency Networks, where there will be more than one contribution to the wanted signal. Further information on this topic is given in §B5.

To calculate the minimum median power flux density or equivalent field strength needed to ensure that the minimum values of signal level can be achieved at the required percentage of locations, the following formulas are used:

for fixed antenna reception (in **Tables B1.1 to B1.4**)

$\phi_{min} = P_{s\,min} - A_a + L_f$

$\phi_{med} = \phi_{min} + P_{mmn} + C_l$

for portable outdoor (class A) reception (in **Tables B1.5 to B1.8**)

$\phi_{min} = P_{s\,min} - A_a$

$\phi_{med} = \phi_{min} + P_{mmn} + C_l + L_h$

for portable indoor ground floor (class B) reception (in **Tables B1.9 to B1.12**)

$\phi_{min} = P_{s\,min} - A_a$

$\phi_{med} = \phi_{min} + P_{mmn} + C_l + L_h + L_b$

generally

$E_{min} = \phi_{min} + 120 + 10 \log (120\pi) = \phi_{min} + 145.8$

$E_{med} = \phi_{med} + 120 + 10 \log (120\pi) = \phi_{med} + 145.8$

C/N : RF signal to noise ratio required by the system [dB]

ϕ_{min} : Minimum power flux density at receiving place [dBW/m^2]

E_{min} : Equivalent minimum field strength at receiving place [dBμV/m]

L_f : Feeder loss [dB]

L_h : Height loss (10 m. a.g.l. to 1.5 m. a.g.l.) [dB]

L_b : Building penetration loss [dB]

P_{mmn} : Allowance for man made noise [dB]

C_l : Location correction factor [dB]

ϕ_{med} : Minimum median power flux density, planning value [dBW/m^2]

E_{med} : Minimum median equivalent field strength, planning value [dBμV/m]

A_a : Effective antenna aperture [dBm^2]

$P_{s\,min}$: Minimum receiver input power [dBW]

For calculating the location correction factor C_l a log-normal distribution of the received signal is assumed. **It should be noted that this standard deviation only relates to location statistics and the inherent inaccuracies of the propagation prediction method are not taken into account.** The location correction factor may need to be re-assessed as more information becomes available.

The location correction factor can be calculated by the formula:

$$C_l = \mu * \sigma$$

where:

μ is the distribution factor, being 0.52 for 70% and 1.64 for 95%;

σ is the standard deviation taken as 5.5 dB for outdoor reception.

See §B1.4.3.2 for σ values appropriate for indoor reception.

Planning studies for portable reception are based on a receiver able to handle signals of a broadband nature and the carrier to noise ratio requirement of a system will be moderate and may be as low as 2 dB in the case of a particularly rugged system. However, multichannel services may need to be received by receivers having simple antennas. In practice, the possibilities for portable reception of signals with high bit rates and requiring a C/N of 20 to 26 dB will be very restricted due to the high signal level needed to overcome noise.

For these studies it has been assumed that a portable receiver and a receiver for fixed reception have same receiver noise figure, that is 7 dB.

B1.4.2 Fixed antenna reception

Antenna diagrams and gains used for the derivation of the minimum median wanted signal levels for fixed antenna reception are given in §B1.3.2.

B1.4.2.1 Minimum median power flux density and equivalent field strength

The **Tables** below give the minimum median power flux density and the equivalent minimum median field strength for 70% and 95% of location probability in Band I, III, IV and V. These values are related to the minimum power flux density and minimum equivalent field strength at the receiving location. For Bands I and III an allowance for man-made noise has been included.

Receiving condition: Fixed antenna, Band I.

Frequency	f [MHz]	65				
Minimum C/N required by system	**[dB]**	**2**	**8**	**14**	**20**	**26**
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBμV]	13	19	25	31	37
Feeder loss	L_f [dB]	1				
Antenna gain rel. to half wave dipole	G_D [dB]	3				
Effective antenna aperture	A_a [dBm^2]	7.4				
Min power flux density at receiving place	ϕ_{min} [dBW/m^2]	-132.6	-126.6	-120.6	-114.6	-108.6
Min equivalent field strength at receiving place	E_{min} [dBμV/m]	13	19	25	31	37
Allowance for man made noise	P_{mmn} [dB]	6				

Location probability: 70%

Location correction factor	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]	-123.7	-117.7	-111.7	-105.7	-99.7
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	22	28	34	40	46

Location probability: 95%

Location correction factor	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]	-117.6	-111.6	-105.6	-99.6	-93.6
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	28	34	40	46	52

Table B1.1: Minimum median power flux density and equivalent minimum median field strength in Band I for 70% and 95% location probability, fixed antenna reception.

For 7 MHz channels, 0.6 dB is to be subtracted from the input signal power, the power flux density and field strength values given in the Table above.

Receiving condition: Fixed antenna, Band III.

Frequency	f [MHz]	200				
Minimum C/N required by system	**[dB]**	**2**	**8**	**14**	**20**	**26**
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBμV]	13	19	25	31	37
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 power flux density at receiving place	ϕ_{min} [dBW/m^2]	-125.9	-119.9	-113.9	-107.9	-101.9
Min equivalent field strength at receiving place	E_{min} [dBμV/m]	20	26	32	38	44
Allowance for man made noise	P_{mmn} [dB]	1				

Location probability: 70%

Location correction factor	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]	-122	-116	-110	-104	-98
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	24	30	36	42	48

Location probability: 95%

Location correction factor	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]	-115.9	-109.9	-103.9	-97.9	-91.9
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	30	36	42	48	54

Table B1.2: Minimum median power flux density and equivalent minimum median field strength in Band III for 70% and 95% location probability, fixed antenna reception.

For 7 MHz channels, 0.6 dB is to be subtracted from the input signal power, the power flux density and field strength values given in the **Table** above.

Receiving condition: Fixed antenna, Band IV.

Frequency	f [MHz]	500				
Minimum C/N required by system	**[dB]**	**2**	**8**	**14**	**20**	**26**
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBμV]	13	19	25	31	37
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 power flux density at receiving place	ϕ_{min} [dBW/m^2]	-119.9	-113.9	-107.9	-101.9	-95.9
Min equivalent field strength at receiving place	E_{min} [dBμV/m]	26	32	38	44	50
Allowance for man made noise	P_{mmn} [dB]	0				

Location probability: 70%

Location correction factor	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]	-117	-111	-105	-99	-93
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	29	35	41	47	53

Location probability: 95%

Location correction factor	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]	-110.9	-104.9	-98.9	-92.9	-86.9
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	35	41	47	53	59

Table B1.3: Minimum median power flux density and equivalent minimum median field strength in Band IV for 70% and 95% location probability, fixed antenna reception.

Receiving condition: Fixed antenna, Band V.

Frequency	f [MHz]	800				
Minimum C/N required by system	**[dB]**	**2**	**8**	**14**	**20**	**26**
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBμV]	13	19	25	31	37
Feeder loss	L_f [dB]	5				
Antenna gain rel. to half wave dipole	G_D [dB]	12				
Effective antenna aperture	A_a [dBm^2]	-5.4				
Min power flux density at receiving place	ϕ_{min} [dBW/m^2]	-115.8	-109.8	-103.8	-97.8	-91.8
Min equivalent field strength at receiving place	E_{min} [dBμV/m]	30	36	42	48	54
Allowance for man made noise	P_{mmn} [dB]	0				

Location probability: 70%

Location correction factor	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]	-112.9	-106.9	-100.9	-94.9	-88.9
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	33	39	45	51	57

Location probability: 95%

Location correction factor	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]	-106.8	-100.8	-94.8	-88.8	-82.8
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	39	45	51	57	63

Table B1.4: Minimum median power flux density and equivalent minimum median field strength in Band V for 70% and 95% location probability, fixed antenna reception.

B1.4.3 Portable antenna reception

B1.4.3.1 General

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

- absence of receiving antenna gain and directivity;
- reduced 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 noise figure, that is 7 dB.

B1.4.3.2 Elements of portable antenna reception

B1.4.3.2.1 Signal level variations

B1.4.3.2.1.1 General

Field strength variations can be divided into macro-scale and micro-scale variations. The macro-scale variations relate to areas with linear dimensions of 10 m to 100 m or more and are mainly caused by shadowing and multipath reflections from distant objects. The 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 it may be assumed that for portable reception the position of the antenna can be optimised within the order of a wavelength, micro-scale variations will not be too significant for planning purposes. Another way to overcome these variations is the possibility of a receiver using antenna diversity.

Macro-scale variations of the field strength are very important for coverage assessment. In general, a high target percentage for coverage would be required to compensate for the rapid failure rate of digital television signals.

B1.4.3.2.1.2 Micro-scale variations

Measurements carried out in Eindhoven in the Netherlands showed that the standard deviation of the micro-scale field strength distribution is about 3 dB. This value has been confirmed by measurements in the UK. The location variation for micro-scale variations is therefore:

Coverage target	Location variation
>95%	5 dB
>70%	1.5 dB

B1.4.3.2.1.3 Macro-scale variations at outdoor locations

ITU-R Rec. P.370 gives a standard deviation for wide band signals of 5.5 dB. This value is used here for determining the location variation at outdoor locations.

This location variation for macro-scale variations is therefore:

Coverage target	Location variation
>95%	9 dB
>70%	2.9 dB

B1.4.3.2.1.4 Macro-scale variations at indoor locations

The variation factor at indoor locations is the combined result of the outdoor variation and the variation factor due to building attenuation (see §B1.4.3.2.3)

B1.4.3.3 Height loss

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

The propagation prediction method of ITU-R Rec. P.370 uses a receiving height of 10m. To correct the predicted values for a receiving height of 1.5 m above ground level a factor called "height loss" has been introduced. Measurements in the Netherlands at UHF showed a height loss of 12 dB. For VHF, ITU-R Report 1203 gives a value of 10 dB.

B1.4.3.4 Building penetration loss

B1.4.3.4.1 General

Portable television reception will take place at outdoor and indoor locations. The field strength at indoor locations will be attenuated significantly by an amount depending on the materials and the construction of the house. A large spread of building penetration losses is to be expected.

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.

B1.4.3.4.2 Measurements at VHF

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

B1.4.3.4.3 Measurements at UHF

Measurements have been carried out in the Netherlands using a transmitted OFDM signal with a bandwidth of 8 MHz and containing 512 carriers. The measurements were made as samples with a receiver bandwidth of 12 kHz covering the channel in a series of steps.

The signal level was measured as a function of micro-scale variations at indoor and outdoor locations.

It is expected that the value $V_{10\%}$, which represents the received narrow band signal power exceeded at 10% of the locations, is most closely related to the wideband received signal level. Therefore, the values of $V_{10\%}$ for indoor, outdoor and 10m reference measurement sites seem the most well-suited for calculation of loss and gain figures.

It appears that the median value $M(V_{10\%}(\text{outdoor})/V_{10\%}(\text{indoor}))$, which might be a good measure for building penetration loss, is in the order of 6 dB. The standard deviation is estimated to be about 6 dB.

Further measurements carried out in the Netherlands using a transmitted noise signal of 7 MHz and receiver bandwidth of 7 MHz show a median building penetration loss of about 9 dB. However these measurements were done at a limited number of locations. The number of concrete houses was relative high. This might be the reason for the somewhat higher median value.

The influence of people walking around the receiving antenna has also been estimated. The signal level variations (10% and 90% value) ranged from +2.6 dB to -2.6 dB. These variations are relatively small and it does not seem necessary to take them into account for planning purposes.

A number of other measurements have also been carried out in the Netherlands to determine:

- influence of a wet wall;
- time variation of the received signal in a period of 11 days over a short path.

It appeared that neither of these two conditions has a significant influence on the received signal.

Recent measurements carried out in the UK show combined building penetration and height losses for ground floor rooms between 19 dB and 34 dB with an average value of 29 dB. In upstairs rooms, losses between 16 dB and 29 dB with an average value of 22 dB were found.

B1.4.3.4.4 Building penetration loss values for planning purposes

Until more consistent values become available the building penetration loss for planning purposes is taken as:

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

However, the penetration loss does not become negative.

B1.4.3.4.5 Location distribution indoors

The variation factor at indoor locations is the combined result of the outdoor variation and the variation factor due to building 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 individual standard deviations. 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 6.2 dB respectively, the combined value is 8.3 dB.

The location variation for macro-scale variations at indoor locations is therefore at VHF:

Coverage target	Location variation
>95%	10 dB
>70%	3 dB

and at UHF:

Coverage target	Location variation
>95%	14 dB
>70%	4 dB

As indicated in §B1.4.1, the overall field strength prediction process must take account of both the location variation and the difference between predicted and measured values.

B1.4.3.5 Portable receiving antenna properties

B1.4.3.5.1 General

A roof-level antenna as used with fixed reception can be expected to have a gain of about 10 to 12 dB at UHF. For a portable receiver the antenna will most probably be of either the built-in type of very short length and in the extreme case having - 20 dB gain or at best will be a set-top orientable antenna with a few dB gain (at UHF).

For planning purposes it has been assumed that the antenna of a portable receiver is omni-directional and that the gain is 0 dB for a UHF antenna and -2.2 dB for a VHF antenna. A portable receiver can be assumed to have 0 dB feeder loss. For reference, it may be noted that a roof-level antenna will be connected to a receiver by means of a feeder cable. This is likely to have a loss of 3 to 5 dB at UHF. Such values may seem high when the relatively short feeder lengths are considered, but some allowance must be included for feeder ageing effects (for example, corrosion of the copper screening).

B1.4.3.5.2 Measurements of indoor antennas

Measurements have been carried out in the Netherlands to investigate directivity of set-top antennas in practical circumstances. One "rabbit-ear" and two five element yagi antennas of moderate quality have been selected. The results showed that gain and directivity depend very much on frequency and location.

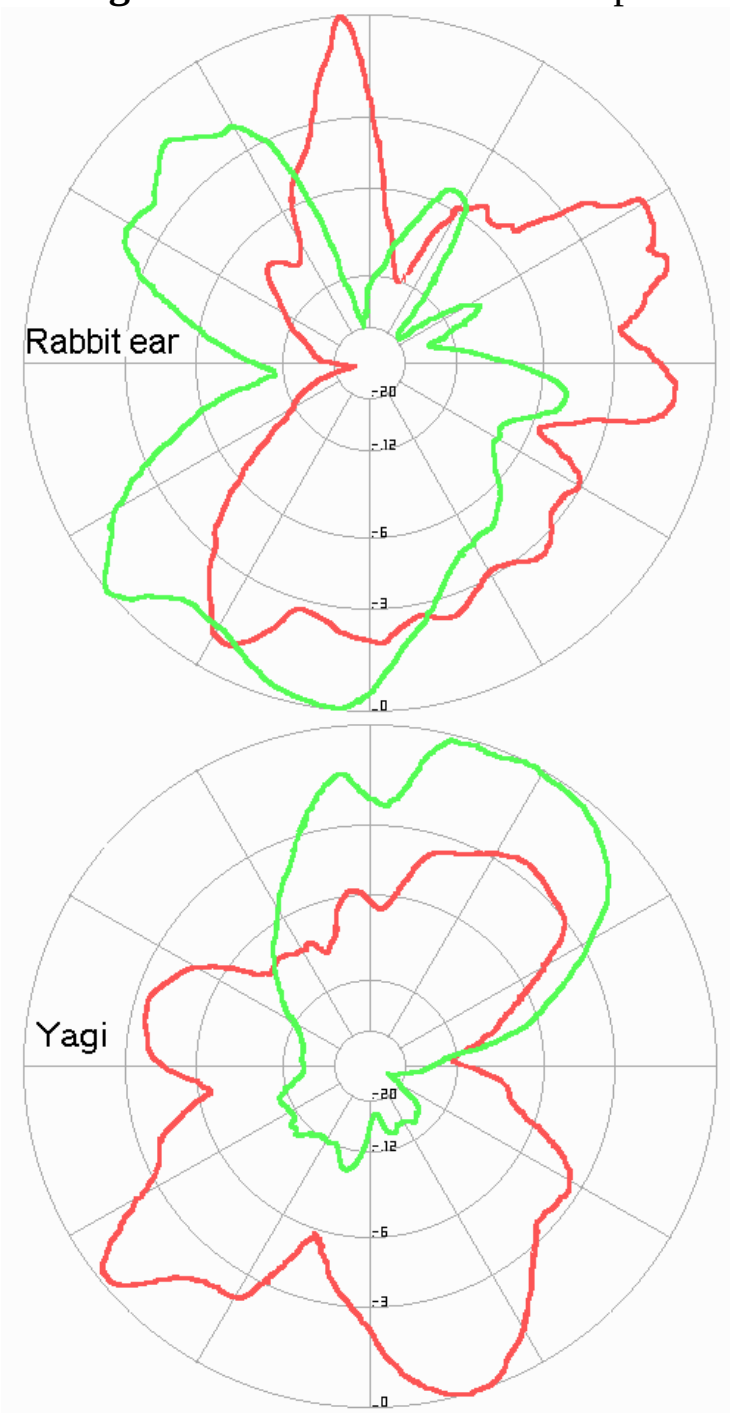
The gain varied from about -15 to +3 dB for the yagi antennas and from about -10 to -4 dB for the "rabbit ear" antenna.

For directivity measurements the antennas were placed in a room close to a wall to represent practical conditions. The radiation patterns changed considerably with the frequency.

In practical conditions the antenna should therefore be directed to obtain the highest signal rather than in the direction of the transmitter (assuming that this is even known).

Examples of antenna patterns for two antenna types at an indoor location close to a wall, measured in the Netherlands, are shown in **Figures B1.1 and B1.2**.

Figures B1.1 and B1.2 - Examples of indoor antenna patterns



Measurements by the BBC of two commercially available indoor antennas showed a better performance. The antennas had a gain of 5 to 6 dB throughout Band IV and V.

B1.4.3.5.3 Measurements of depolarisation

Measurements carried out in the Netherlands, using test transmissions with a vertically polarised digital television signal, showed a depolarisation of the signal at the receiving site and in particular for indoor reception.

The results showed that indoors the depolarisation angle ranges from 20 to 48 degrees at macro-scale.

At micro-scale level the standard deviation of the depolarisation angle ranges from 3 to 16 degrees.

B1.4.3.6 Minimum median power flux density and equivalent field strength

The **Tables** below give the minimum median power flux density and the minimum median equivalent field strength for location probabilities of 70 and 95% in Band I, III, IV and V.

Receiving condition: Portable outdoor (Class A), Band I.

Frequency	f [MHz]	65				
Minimum C/N required by system	**[dB]**	**2**	**8**	**14**	**20**	**26**
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBμV]	13	19	25	31	37
Antenna gain rel. to half wave dipole	G_D [dB]	-2.2				
Effective antenna aperture	A_a [dBm^2]	2.2				
Min power flux density at receiving place	ϕ_{min} dBW/m^2]	-128.4	-122.4	-116.4	-110.4	-104.4
Min equivalent field strength at receiving place	E_{min} dBμV/m]	17	23	29	35	41
Allowance for man made noise	P_{mmn} [dB]	6				
Height loss	L_h [dB]	10				

Location probability: 70%

Location correction factor	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]	-109.5	-103.5	-97.5	-91.5	-85.5
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	36	42	48	54	60

Location probability: 95%

Location correction factor	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]	-103.4	-97.4	-91.4	-85.4	-79.4
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	42	48	54	60	66

Table B1.5: Minimum median power flux density and equivalent minimum median field strength in Band I for 70% and 95% location probability, portable outdoor reception.

For 7 MHz channels, 0.6 dB is to be subtracted from the input signal power, the power flux density and field strength values given in the **Table** above.

Receiving condition: Portable outdoor (Class A), Band III.

Frequency	f [MHz]	200				
Minimum C/N required by system	**[dB]**	**2**	**8**	**14**	**20**	**26**
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBμV]	13	19	25	31	37
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
Min equivalent field strength at receiving place	E_{min} [dBμV/m]	27	33	39	45	51
Allowance for man made noise	P_{mmn} [dB]	1				
Height loss	L_h [dB]	10				

Location probability: 70%

Location correction factor	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
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	41	47	53	59	65

Location probability: 95%

Location correction factor	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
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	47	53	59	65	71

Table B1.6: Minimum median power flux density and equivalent minimum median field strength in Band III for 70% and 95% location probability, portable outdoor reception.

For 7 MHz channels, 0.6 dB is to be subtracted from the input signal power, the power flux density and field strength values given in the **Table** above.

Receiving condition: Portable outdoor (Class A), Band IV.

Frequency	f [MHz]	500				
Minimum C/N required by system	**[dB]**	**2**	**8**	**14**	**20**	**26**
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBμV]	13	19	25	31	37
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
Min equivalent field strength at receiving place	E_{min} [dBμV/m]	33	39	45	51	57
Allowance for man made noise	P_{mmn} [dB]	0				
Height loss	L_h [dB]	12				

Location probability: 70%

Location correction factor	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
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	48	54	60	66	72

Location probability: 95%

Location correction factor	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
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	54	60	66	72	78

Table B1.7: Minimum median power flux density and equivalent minimum median field strength in Band IV for 70% and 95% location probability, portable outdoor reception.

Receiving condition: Portable outdoor (Class A), Band V.

Frequency	f [MHz]	800				
Minimum C/N required by system	**[dB]**	**2**	**8**	**14**	**20**	**26**
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBμV]	13	19	25	31	37
Antenna gain rel. to half wave dipole	G_D [dB]	0				
Effective antenna aperture	A_a [dBm^2]	-17.4				
Min power flux density at receiving place	ϕ_{min} [dBW/m^2]	-108.8	-102.8	-96.8	-90.8	-84.8
Min equivalent field strength at receiving place	E_{min} [dBμV/m]	37	43	49	55	61
Allowance for man made noise	P_{mmn} [dB]	0				
Height loss	L_h [dB]	12				

Location probability: 70%

Location correction factor	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]	-93.9	-87.9	-81.9	-75.9	-69.9
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	52	58	64	70	76

Location probability: 95%

Location correction factor	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]	-87.8	-81.8	-75.8	-69.8	-63.8
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	58	64	70	76	82

Table B1.8: Minimum median power flux density and equivalent minimum median field strength in Band V for 70% and 95% location probability, portable outdoor reception.

Receiving condition: Portable indoor ground floor (Class B), Band I.

Frequency	f [MHz]	65				
Minimum C/N required by system	**[dB]**	**2**	**8**	**14**	**20**	**26**
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBμV]	13	19	25	31	37
Antenna gain rel. to half wave dipole	G_D [dB]	-2.2				
Effective antenna aperture	A_a [dBm^2]	2.2				
Min power flux density at receiving place	ϕ_{min} dBW/m^2]	-128.4	-122.4	-116.4	-110.4	-104.4
Min equivalent field strength at receiving place	E_{min} dBμV/m]	17	23	29	35	41
Allowance for man made noise	P_{mmn} [dB]	6				
Height loss	L_h [dB]	10				
Building penetration loss	L_b [dB]	8				

Location probability: 70%

Location correction factor	C_l [dB]	3				
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} [dBW/m^2]	-101.4	-95.4	-89.4	-83.4	-77.4
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	44	50	56	62	68

Location probability: 95%

Location correction factor	C_l [dB]	10				
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} [dBW/m^2]	-94.4	-88.4	-82.4	-76.4	-70.4
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	51	57	63	69	75

Table B1.9: Minimum median power flux density and equivalent minimum median field strength in Band I for 70% and 95% location probability, portable indoor reception at ground floor.

Note: Minimum median equivalent field strength values at 10 m a.g.l. for 50% of time and 50% of locations are expected to be:

5 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.

For 7 MHz channels, 0.6 dB is to be subtracted from the input signal power, the power flux density and field strength values given in the Table above.

Receiving condition: Portable indoor ground floor (Class B), Band III.

Frequency	f [MHz]	200				
Minimum C/N required by system	**[dB]**	**2**	**8**	**14**	**20**	**26**
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBμV]	13	19	25	31	37
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
Min equivalent field strength at receiving place	E_{min} [dBμV/m]	27	33	39	45	51
Allowance for man made noise	P_{mmn} [dB]	1				
Height loss	L_h [dB]	10				
Building penetration loss	L_b [dB]	8				

Location probability: 70%

Location correction factor	C_l [dB]	3				
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} [dBW/m^2]	-96.7	-90.7	-84.7	-78.7	-72.7
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	49	55	61	67	73

Location probability: 95%

Location correction factor	C_l [dB]	10				
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} [dBW/m^2]	-89.7	-83.7	-77.7	-71.7	-65.7
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	56	62	68	74	80

Table B1.10: Minimum median power flux density and equivalent minimum median field strength in Band III for 70% and 95% location probability, portable indoor reception at ground floor.

Note: Minimum median equivalent field strength values at 10 m a.g.l. for 50% of time and 50% of locations are expected to be:

- 5 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.

For 7 MHz channels, 0.6 dB is to be subtracted from the input signal power, the power flux density and field strength values given in the Table above.

Receiving condition: Portable indoor ground floor (Class B), Band IV.

Frequency	f [MHz]	500				
Minimum C/N required by system	**[dB]**	**2**	**8**	**14**	**20**	**26**
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBμV]	13	19	25	31	37
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
Min equivalent field strength at receiving place	E_{min} [dBμV/m]	33	39	45	51	57
Allowance for man made noise	P_{mmn} [dB]	0				
Height loss	L_h [dB]	12				
Building penetration loss	L_b [dB]	7				

Location probability: 70%

Location correction factor	C_l [dB]	4				
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} [dBW/m^2]	-89.9	-83.9	-77.9	-71.9	-65.9
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	56	62	68	74	80

Location probability: 95%

Location correction factor	C_l [dB]	14				
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} [dBW/m^2]	-79.9	-73.9	-67.9	-61.9	-55.9
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	66	72	78	84	90

Table B1.11: Minimum median power flux density and equivalent minimum median field strength in Band IV for 70% and 95% location probability, portable indoor reception at ground floor.

Note: Minimum median equivalent field strength values at 10 m a.g.l. for 50% of time and 50% of locations are expected 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.

Receiving condition: Portable indoor ground floor (Class B), Band V.

Frequency	f [MHz]	800				
Minimum C/N required by system	**[dB]**	**2**	**8**	**14**	**20**	**26**
Min. receiver signal input power	$P_{s\,min}$ [dBW]	-126.2	-120.2	-114.2	-108.2	-102.2
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ [dBμV]	13	19	25	31	37
Antenna gain rel. to half wave dipole	G_D [dB]	0				
Effective antenna aperture	A_a [dBm^2]	-17.4				
Min power flux density at receiving place	ϕ_{min} [dBW/m^2]	-108.8	-102.8	-96.8	-90.8	-84.8
Min equivalent field strength at receiving place	E_{min} [dBμV/m]	37	43	49	55	61
Allowance for man made noise	P_{mmn} [dB]	0				
Height loss	L_h [dB]	12				
Building penetration loss	L_b [dB]	7				

Location probability: 70%

Location correction factor	C_l [dB]	4				
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} [dBW/m^2]	-85.8	-79.8	-73.8	-67.8	-61.8
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	60	66	72	78	84

Location probability: 95%

Location correction factor	C_l [dB]	14				
Minimum median power flux density at 10m a.g.l. 50% of time and 50% of locations	ϕ_{med} [dBW/m^2]	-75.8	-69.8	-63.8	-57.8	-51.8
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} [dBμV/m]	70	76	82	88	94

Table B1.12: Minimum median power flux density and equivalent minimum median field strength in Band V for 70% and 95% location probability, portable indoor reception at ground floor.

Note: Minimum median equivalent field strength values at 10 m a.g.l. for 50% of time and 50% of locations are expected 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.

B1.5 Assessment of Coverage

B1.5.1 Introduction

For the implementation of new digital terrestrial television networks it necessary to evaluate the area covered and the population covered. These evaluations are made by the estimation of the level of the useful signal(s) and the level of the interfering signals. Because of the rapid failure of digital reception when the level of the useful signal decreases below its "minimum" value, the target for the percentage of locations nominally covered at any edge - where edge

means any transition between a covered area and a non-covered area - of the coverage area has to be much higher for digital systems than the 50% of locations used for analogue television systems. Values of 70 and 95% are proposed for digital transmissions. These higher coverage probability targets necessitate a more elaborate statistical treatment of signal levels. This is in particular true if more than one wanted or unwanted signal is encountered and hence sum fields have to be considered.

As far as this statistical treatment is concerned, it would be desirable to perform coverage calculations by means of Monte Carlo simulations, since this approach gives the highest accuracy, but in most cases it needs a prohibitively large amount of computational effort. It is thus necessary to use methods which give a reasonably close approximation to the results of using a Monte Carlo simulation. Several methods are known in this respect; of these, one of the variations of the Log Normal Method may be chosen for signal summation.

B1.5.2 Approximation Method for the Combination of Signal Levels (Log-normal method)

The Log-Normal Method is an analytical approximation method for the statistical computation of the sum distribution of log-normally distributed variables. The method is based on the assumption that the resulting sum distributions of the wanted and unwanted fields is also log-normal. It delivers mean value and standard deviation of the resulting sum field distribution, both parameters forming the basis of the calculation of coverage probabilities.

Several implementations of the method exist with differing accuracy and complexity: standard LNM, k-LNM, t-LNM and the Schwartz & Yeh method. At the moment, these approaches are under evaluation with respect to their feasibility for DVB-T planning. After the evaluation process a detailed description of the chosen approach will be given.

B1.5.3 Effective protection target

When the coverage probability of a location within the coverage area of a digital service is to be evaluated, different kinds of interfering fields will be encountered: noise, signals from interfering digital and analogue services both co-channel and adjacent channel, etc. Each of these unwanted fields has its own Protection Ratio (PR) with respect to the wanted digital field.

The condition that a location is covered by a digital service is formulated as follows (all power levels being arithmetic values):

$$\sum_i C_i \geq (C/N)_{req(uired)} * N + \sum_i PR_i * I_i \qquad \text{(B1-1)}$$

where:

C_i denotes the power of the ith wanted signal. In the case of an MFN there is only one useful signal, in the case of an SFN there may be more than one useful signal;

N denotes the noise power;
$(C/N)_{req}$ denotes the required protection ratio against noise;
I_i denotes the power of the ith interfering signal;
PR_i denotes the protection ratio of the ith interfering signal.

The protection ratios are not fixed constants but depend, in principle, on the transmission channel. Usually, in the laboratory, protection ratios are measured in a Gaussian channel. In order to apply them to planning calculations these values have to be increased by a channel dependent component which reflects deleterious effects of the multipath reception. In particular in OFDM systems operated in SFN mode, where active echoes play an important part, the protection ratios show a strong dependence on the signal configuration in the channel. This fact is taken account of in the concept of the effective protection target (EPT) which is described in detail in §A2.

The present chapter shows a suitable way how the EPT concept may be incorporated into the procedure of assessing coverage for the general case of interference.

In §A2 the case of noise and OFDM co-channel interference, i.e. noise-like interference, is dealt with. For that case equation. B1.1 reads:

$$\sum_i C_i \;\geq\; EPT * \left(N + \sum_i I_i \right) \qquad \text{(B1.2)}$$

EPT denotes the effective protection target which replaces $(C/N)_{req}$ and PR_i in equation.(B1.1). EPT depends on the DVB-T system variant and on the configuration of the delayed wanted signals which arrive within the guard interval. In equation B1.2 only noise-like co-channel interference is regarded. Therefore EPT is the same for all interfering components.

In the general case of interference each interferer has its own individual EPT:

$$\sum_i C_i \;\geq\; EPT_N * N + \sum_i EPT_i * I_i \qquad \text{(B1.3)}$$

In order to make equation B1.3 accessible to the measured protection ratios, EPT is split up into a part reflecting the Gaussian channel signal reception and a second part describing the particular channel properties:

$$EPT = EPT^{g(auss)} * EPT^{ch(annel)} \qquad \text{(B1.4)}$$

Equation B1.3 then becomes

$$\sum_i C_i \;\geq\; EPT_N^g * EPT_N^{ch} * N + \sum_i EPT_i^g * EPT_i^{ch} * I_i \qquad \text{(B1.5)}$$

With the assumption that the part of EPT describing the channel is equal or at least similar for all kind of interference, EPT^{ch} can be taken out of the sum in equation B1.5:

$$\sum_i C_i \;\geq\; EPT^{ch} * \left(EPT_N^g * N + \sum_i EPT_i^g * I_i \right) \qquad \text{(B1.6)}$$

In this formulation EPT^{ch} still depends on the DVB-T system variant but is now independent of the particular interfering signal. EPT_N^g and EPT_i^g are known from laboratory measurements, and EPT^{ch} is also known from the EPT formula 2.2 in §A2 for the case of noise-like interferers:

$$EPT^{ch} = EPT / EPT_N^g \qquad \text{(B1.7)}$$

Therefore equation B1.6 can be used for the evaluation of coverage in any case of interference.

B1.5.4 Evaluation of coverage probability

The standard approach for frequency and network planning in the broadcasting field uses propagation margins for protection ratios and minimum median field strengths to incorporate statistical field effects. In a reception situation, however, where signal combination effects become important, these quantities are no longer suitable planning parameters. They have to be replaced by the more fundamental system values for minimum field strengths and protection ratios and the appropriate coverage probability targets, and a statistical approach for the evaluation of the signal configuration has to be used.

In assessing coverage and compatibility, basically the following procedure is applied. At the location under consideration, wanted and unwanted signal levels are evaluated and the wanted signal level is compared to the unwanted signal level and the noise level. If the wanted signal level exceeds the combined noise and interference level the location is regarded as covered. The ways to end up at this result are slightly different for the statistical and the standard approach.

The statistical approach performs the evaluation (prediction and statistical summation) of the wanted and unwanted signals at the location of the receiving antenna taking account of individual signal variation effects separately, whereas the standard approach shifts all statistical effects into propagation margins for minimum field strengths and protection ratios.

The statistical approach for the evaluation of coverage probabilities is described in the following paragraphs.

With an appropriate prediction method the parameters (mean value and standard deviation) of the wanted and unwanted individual fields at the receiving location are evaluated. For an ITU-R Rec. P.370 prediction this means that height loss and building penetration loss, including statistical spread, have to be incorporated at this stage. (This is different from the standard approach where these quantities are incorporated into the minimum field strength.) In practice, the correlations between wanted and unwanted signals with regard to height loss and building penetration loss are neglected because of a lack of knowledge of their magnitudes.

The appropriate protection ratios are added to the individual unwanted fields to get the respective nuisance fields. The protection ratios are the system values for the Gaussian channel, measured in the laboratory.

Noise is treated as an additional interfering field. This is done by taking the system value of the minimum field strength as mean value of the interfering field and attributing to it a standard deviation of 0 dB. The system value of the minimum field strength is given by the "minimum equivalent field strength at a receiving location" of the **Tables B1.1 to B1.12** increased by the "allowance for man made noise". $(C/N)_{req}$ is that for the Gaussian channel, increased by the appropriate implementation margin.

The distribution parameters of wanted and unwanted sum fields are evaluated by means of one of the statistical summation methods described in §B1.5. In the general case and when the highest accuracy is to be achieved the Monte Carlo method should be used. In many cases and when the computational effort is to be restricted one of the LNM approaches may be used. The choice between the LNM variants depends on the required accuracy.

Formulas for the steps so far, apart from the introduction of nuisance fields, can be found in the chapters on the effective protection target (§§A2 and §B.1.5.3). The final equation of

$$\sum_i C_i \;\geq\; EPT^{ch} * \left(EPT_N^g * N + \sum_i EPT_i^g * I_i \right) \qquad \text{(B1.8)}$$

If the EPT concept is not used $EPT^{ch} * EPT_N^g$ and $EPT^{ch} * EPT_i^g$ are to be replaced by $(C/N)_{req}$ and PR_i, respectively.

Nuisance fields B are introduced in the following way.

$$B_N^g = EPT_N^g * N, \qquad B_i^g = EPT_i^g * I_i \qquad \text{(B1.9)}$$

The nuisance field is a weighted interfering field which takes into account the interference potential of the unwanted field with respect to the wanted field:

With the further definitions

$$C = \sum_i C_i\,, \qquad B^g = B_N^g + \sum_i B_i^g\,. \qquad \text{(B1.10)}$$

equation B1.8 then becomes

$$C \;\geq\; EPT^{ch} * B^g \qquad \text{(B1.11)}$$

So far only C and B^g have been treated statistically. But also EPT^{ch} is a statistical quantity, since it depends on the signal configuration in the channel. Within a Monte Carlo simulation the statistical properties of EPT^{ch} are incorporated automatically. For the LNM approaches

the mean value of EPT^{ch} can be chosen as an approximation to treat equation (B1.11). In both cases B^g and EPT^{ch} can be combined to the final nuisance field B:

$$B = EPT^{ch} * B^g \qquad \text{(B1.12)}$$

and the condition for the coverage of a location is put into the form

$$C - B \geq 0 \qquad \text{(B1.13)}$$

Mean values and standard deviations of the respective sum fields C and B are denoted by $\overline{C}$, s_C and $\overline{B}$, s_B. The coverage probability CP at the considered location is then given by

$$CP = P(C - B \geq 0) \qquad \text{(B1.14)}$$

where the right hand side expression describes the probability P that the wanted field exceeds the unwanted field.

P can be evaluated in the following way:

$$P(C - B \geq 0) = I\left(\overline{C} - \overline{B}, \sqrt{(s_C)^2 + (s_B)^2}\right) \qquad \text{(B1.15)}$$

and the function I is given by

$$I(F, s) = \frac{1}{2}\left[1 + erf\left(\frac{-F}{\sqrt{2}s}\right)\right] \qquad \text{(B1.16)}$$

The error function erf is evaluated with the help of tables or parametrisations. These can be found in ITU-R Report 945 or mathematical handbooks.

B2. PRACTICAL ASPECTS **1**

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B2. PRACTICAL ASPECTS

B2.1 Suppression of unwanted emissions

In the starting phase of terrestrial digital television, channels will have to be found in the UHF bands, and in some countries probably also in Band III, between those already in use for analogue television. In some cases it will be necessary to use channels adjacent to existing analogue television channels. To avoid mutual interference between the two services it is considered important to limit the out-of-channel emissions from both television transmitters as much as possible. This leads to a need for defined spectrum masks for both digital and analogue television transmitters.

The modulation scheme to be used for digital television will be quite complex, for example OFDM 64 QAM. Such a modulation scheme will demand a very high degree of linearity in the transmitter power amplifier in order to avoid intermodulation products.

The ñatural"sidebands of the OFDM spectrum can (and must) be cut off in a suitable filter at IF in the modulator. The sidebands will, however, re-appear at RF due to intermodulation products between the individual carriers occurring in the amplifier chain of the transmitter. In order to achieve a reasonable (although still rather low) efficiency of the transmitter, extensive linearity pre-correction must be applied. Very non-linear amplifying components like klystrons are not expected to be readily usable for digital television.

The prevailing types of intermodulation products falling in or near the digital television channel are the third and the fifth order products. The third order products will fall in the range:

- Channel centre frequency +/- 1.5 (OFDM signal bandwidth);

and the fifth order intermodulation products will fall in the range:

- Channel centre frequency +/- 2.5 (OFDM signal bandwidth).

Intermodulation products falling inside the channel will act as interference from a co-channel (non SFN) digital television transmitter and cause an increased bit error rate. The maximum acceptable level of intermodulation inside the channel can thus be estimated to be approximately equal to the minimum required C/N for the digital system in question. If this maximum level is reached, no margin for noise or interference is left.

Intermodulation products falling outside of the channel could cause a noise-like co-channel interference to existing analogue television services operating on one or more channels adjacent or near to the digital television channel. The protection ratio needed for the analogue television service will be near to 40 dB, depending on the analogue system used. If the analogue television signal is radiated from the same station (or antenna) sufficient attenuation of the intermodulation products from the digital television transmitter is fairly easily specified. If the analogue television signal is not radiated from the same site as the digital television signal

but still covering the same area or a part of it, the necessary attenuation of digital television intermodulation products can be quite difficult to achieve. In both cases a suitable spectrum mask filter is needed.

Analogue television transmitters use AM / VSB modulation for the vision signal. The vestigial (lower) sideband is attenuated from 0.75 MHz or 1.25 MHz below the vision carrier. The vestigial sideband tends to re-appear mainly due to non-linearity in the power amplifiers. In order to make compatibility calculations possible, spectrum masks for analogue television transmitters have to be established.

B2.1.1 Spectrum masks for co-sited transmitters

It is generally expected that, to a large extent, digital television transmitters will be co-sited with existing analogue television transmitters and, in many cases, will use the same polarisation.

On this basis, spectrum masks for digital television transmitters, covering interference into various analogue television systems, can be derived on the basis of known protection ratios for the individual parts of the analogue signal.

Spectrum masks for analogue television transmitters can be established on the basis of existing standards for the individual systems in use. In cases where the e.r.p. from the analogue and the digital television transmitters are too different, special filtering may have to be introduced on the transmitter having the higher output power.

B2.1.1.1 Spectrum masks for DVB-T

In most cases only protection of analogue television in adjacent channels needs to be considered, exceptions being channels such as 21, 60 or 69, where other services demanding high protection operate at frequencies just outside of the television channel. However, even in such cases only one side of the spectrum mask needs to have the shape of the mask for sensitive cases while the other side can have an out-of-band attenuation satisfactory for protection of analogue television.

The examples presented have all been based on the following assumptions:

- the digital and the analogue transmitters are co-sited;
- there is no polarisation discrimination;
- no offset is used on either of the transmitters except for System L sound transmitters, where a positive offset of 50 kHz has been taken into account.
- the e.r.p. of the analogue transmitter (peak-sync) and the digital transmitter (total power) are the same.

If the radiated powers are not equal, proportional corrections must be made, i.e. if the e.r.p. of the DVB-T transmitter is 10 dB lower than the e.r.p. of the analogue transmitter, then in **Figure B2.1** the breakpoints outside of the range ±3.8 MHz can be moved upwards by 10 dB.

The protection ratios used for analogue television are based on protection ratios taken from **Annex 2** to the Final Acts of Wiesbaden 95 but recalculated to impairment grade 4.5. From these protection ratios, the maximum permissible relative power in a 4 kHz bandwidth has been calculated for a set of representative frequencies in the analogue channel.

The relative level in a 4 kHz bandwidth at ±12 MHz from the centre of the television channel has been chosen to be -100 dB.

For details about the derivation of the values see **Annex B2.1**.

The spectrum masks shown in **Figure B2.1** are based directly on the protection ratios derived in **Annex B2.1** for the lower adjacent channel. In the upper adjacent channel the sound carriers demand less protection than the vision carriers. This would lead to spectrum masks having less attenuation further away from the DVB-T channel than just outside of it. For this reason, the protection ratios for the vision carrier are repeated at frequencies corresponding to the upper end of the video sideband in the upper adjacent channel. This will, however, lead to an over-protection of about 5 dB at these frequencies.

These masks are considered to cover the minimum protection needed for co-sited analogue and digital television transmitters having equal radiated powers.

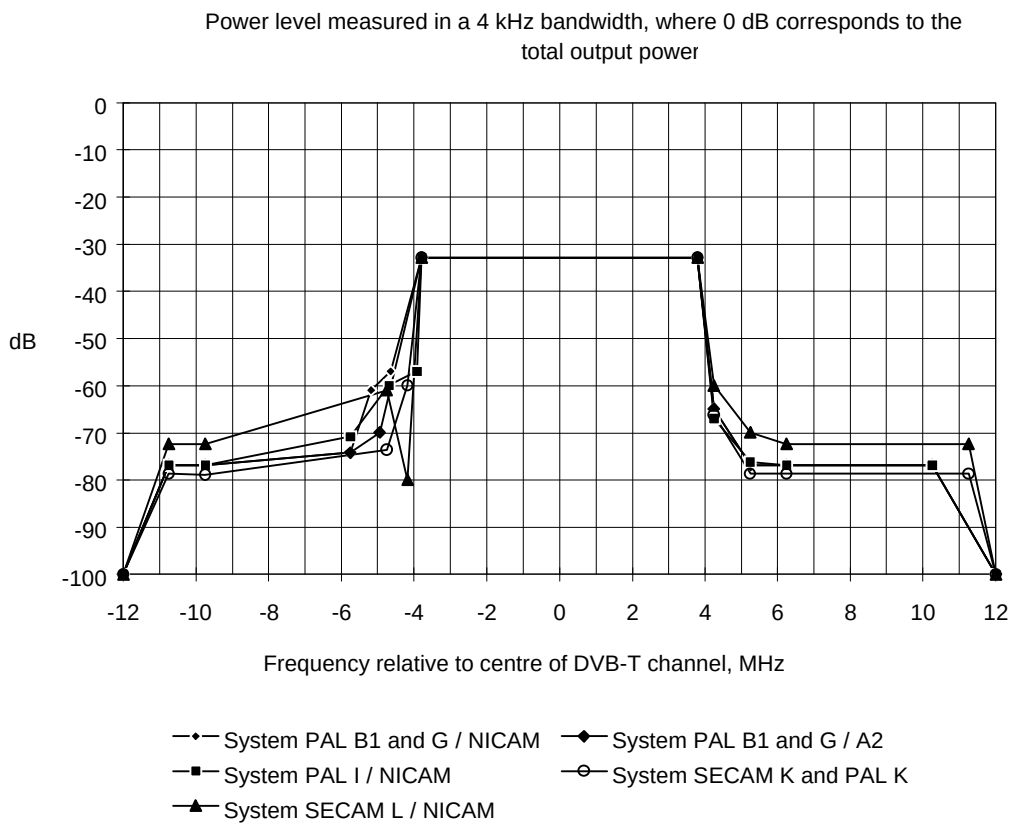

Figure B2.1

Spectrum masks for a digital terrestrial television transmitter operating on a channel adjacent to a co-sited analogue television transmitter (8 MHz channels)

Table B.2.1

Breakpoints for spectrum masks in Figure B2.1

Breakpoints										
	G / PAL / NICAM		G / PAL / A2		I / PAL / NICAM		K / SECAM K / PAL		L / SECAM / NICAM	
See Note below	rel. freq. MHz	rel. level dB	rel. freq. MHz	rel. level dB	rel. freq. MHz	rel. level dB	rel. freq. MHz	rel. level dB	rel. freq. MHz	rel. level dB
1	-12	-100	-12	-100	-12	-100	-12	-100	-12	-100
2	-10.75	-76.9	-10.75	-76.9	-10.75	-76.9	-10.75	-78.7	-10.75	-72.4
3	-9.75	-76.9	-9.75	-76.9	-9.75	-76.9	-9.75	-78.7	-9.75	-72.4
4	-5.75	-74.2	-5.75	-74.2	-5.75	-70.9	-4.75	-73.6	-4.75	-60.9
5	-5.185	-60.9	-5.185	n.a.	-4.685	-59.9	-4.185	-59.9	-4.185	-79.9
6	n.a.	n.a.	-4.94	-69.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
7	-4.65	-56.9	n.a.	n.a.	-3.925	-56.9	n.a.	n.a.	n.a.	n.a.
8	-3.8	-32.8	-3.8	-32.8	-3.8	-32.8	-3.8	-32.8	-3.8	-32.8
9	+3.8	-32.8	+3.8	-32.8	+3.8	-32.8	+3.8	-32.8	+3.8	-32.8
10	+4.25	-64.9	+4.25	-64.9	+4.25	-66.9	+4.25	-66.1	+4.25	-59.9
11	+5.25	-76.9	+5.25	-76.9	+5.25	-76.2	+5.25	-78.7	+5.25	-69.9
12	+6.25	-76.9	+6.25	-76.9	+6.25	-76.9	+6.25	-78.7	+6.25	-72.4
13	+10.25	-76.9	+10.25	-76.9	+10.25	-76.9	+11.25	-78.7	+11.25	-72.4
14	+12	-100	+12	-100	+12	-100	+12	-100	+12	-100

Notes to the **Table B2.1**:

For details about the determination of breakpoints and attenuations, see **Annex B2.1**.

1. Lower end of lower adjacent channel
2. Vision carrier in lower adjacent channel
3. Vision carrier + 1 MHz in lower adjacent channel
4. Upper end of video sideband in lower adjacent channel
5. Upper end of the RF bandwidth of the first sound carrier in lower adjacent channel
6. Upper end of the RF bandwidth of the A2 second sound carrier in lower adjacent channel
7. Upper end of the RF bandwidth of the NICAM signal in the lower adjacent channel
8. Lower end of the RF bandwidth of the DVB-T signal
9. Upper end of the RF bandwidth of the DVB-T signal
10. Lower video sideband (vision carrier - 1 MHz) in upper adjacent channel
11. Vision carrier in upper adjacent channel
12. Vision carrier + 1 MHz in upper adjacent channel
13. Upper end of video sideband in upper adjacent channel
14. Upper end of upper adjacent channel

Table B2.1 some cells are marked with ñn.a.." This means that this part of the analogue television signal does not exist or has no influence on the shape of the spectrum mask.

B2.1.1.2 Symmetrical spectrum mask for 7 MHz and 8 MHz channels

For digital television transmitters using the channels adjacent to other services (low power or receive only) this spectrum mask may not give enough attenuation on the side of the digital television channel falling in the frequency band where the other service operates.

In such cases, special spectrum masks have to be defined, based on the characteristics of the other service and the distance between the digital television transmitter and the service area (or receiving installation) of the other service. It must, however, be borne in mind that spectrum mask filters showing a higher attenuation close to the digital television channel will be very expensive and imply a higher insertion loss.

Two symmetrical spectrum masks are shown in **Figure B2.2**. The mask having a shoulder attenuation of 40 dB is intended for non-critical cases and 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.

The shape of the masks have been based on:

- the natural spectrum of a 7.6 MHz OFDM signal (for 8 MHz channels) and a 6.7 MHz OFDM signal (for 7 MHz channels);
- the amplitude response of an IF SAW-filter;
- the power amplifier of the transmitter produces intermodulation outside of the channel at a level limited by the amount of intermodulation acceptable inside the channel;
- the mask for sensitive cases also include the amplitude response of a six-cavity bandpass filter at the output of the transmitter.

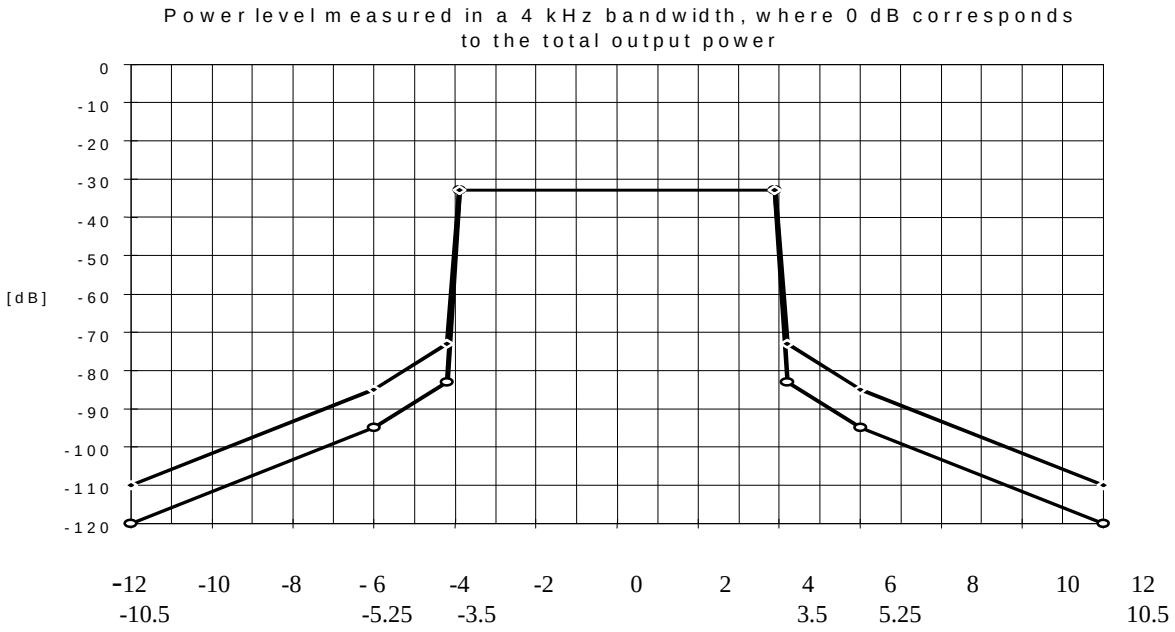

Figure B2.2

Frequency relative to centre of DVB-T channel [MHz],
upper scale: 8 MHz channel, lower scale: 7 MHz channel
upper curve: non-critical cases, lower curve: sensitive cases

Breakpoints					
8 MHz channels			7 MHz channels		
	Non-critical cases	Sensitive cases		Non-critical cases	Sensitive cases
Relative Frequency [MHz]	Relative Level [dB]	Relative Level [dB]	Relative Frequency [MHz]	Relative Level [dB]	Relative Level [dB]
-12	-110	-120	-10.5	-110	-120
-6	-85	-95	-5.25	-85	-95
-4.2	-73	-83	-3.7	-73	-83
-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	-83	+3.7	-73	-83
+6	-85	-95	+5.25	-85	-95
+12	-110	-120	+10.5	-110	-120

Table B2.2

Symmetrical spectrum masks for non-critical and for sensitive cases

B2.2 Analogue television

Based on information from the Radio Regulations (Article 3 and Appendix S3) and ITU-R Report 624-4 spectrum masks have been established for a number of analogue television systems in use. The results are given in **Figures B2.3 to B2.8** and the derivation of the breakpoints used is given in **Table B2.3**.

For transmitters operating in the frequency range 30 MHz to 235 MHz the unwanted power measured at the output terminal of the transmitter shall be attenuated at least 60 dB relative to the mean output power and shall not exceed 1 milliwatt. The maximum limit is thus proportional for transmitters with output powers up to 1 kW and fixed for higher output powers.

For transmitters operating in the frequency range 235 MHz to 960 MHz the unwanted power measured at the output terminal of the transmitter shall be attenuated at least 60 dB relative to the mean output power and shall not exceed 20 milliwatt. The maximum limit is thus proportional for transmitters with output powers up to 20 kW and fixed for higher output powers.

The mean power of a television transmitter depends considerably on the picture content. For transmitters using negative modulation the highest mean power is achieved at "Black with sync" and no pedestal where the mean power of the vision signal is 2.5 dB lower than the peak sync power. This leads to an out-of-band attenuation of 62.5 dB relative to peak sync power for transmitters within the "proportional" power range.

For transmitters using positive modulation the highest mean power occurs with an all white picture where the mean power of the vision signal is 1.2 dB lower than the nominal transmitter output power.

If intermodulation products between the vision carrier and the sound carrier(s) are considered it is assumed that the sum of the vision power and the sound power(s) shall be used as reference.

When typical antenna gains and feeder losses for VHF transmitters are taken into consideration then transmitter output powers up to 1 kW corresponds to radiated powers of up to 10 kW and the fixed limit of 1 milliwatt corresponds to an e.r.p. of 10 milliwatt. For UHF the values become 400 kW and 400 milliwatt respectively. It is assumed that most antenna systems will show the same or nearly the same gain in the adjacent channels as in the channel used. It is also assumed that diplexers inserted into the feeder line do not contribute to the attenuation of unwanted emissions in the adjacent channels.

At this stage only analogue UHF transmitters are considered. In the **original** ST61 Plan 4479 UHF stations are listed. These stations can be subdivided into the following categories:

2041 stations	e.r.p. ≤ 400 kW
818 stations	400 kW < e.r.p. ≤ 500 kW

1589 stations	500 kW < e.r.p. ≤ 1 MW
31 stations	e.r.p. > 1 MW (maximum = 2 MW)

The 400 kW limit thus only applies to less than the half of the stations. For stations with an e.r.p. > 400 kW the out-of-band attenuation shall be increased accordingly (for 2 MW by additional 7 dB).

Reference bandwidth

Generally it is considered desirable to use a low reference bandwidth in order to show the real spectrum of the signal in question, on the other hand it is necessary to use a bandwidth wide enough to make it possible to measure the RF spectrum realistically.

For DVB (and DAB) spectrum masks are based on the power measured in a 4 kHz bandwidth.

In analogue television three different types of modulation are used (ignoring the colour subcarrier): AM, FM and QPSK. The signal components have different bandwidths and use different "quiescent" modulation, e.g. the vision carrier is always modulated with at least a sync-signal and the NICAM subcarrier is always occupying a constant bandwidth whereas FM- or AM- sound carriers are not modulated when no sound signal is present.

Tests have shown that power spectrum of the vision carrier and its sideband(s) can be measured correctly with a spectrum analyser using "max. hold" and resolution bandwidths down to 50 kHz. At 10 kHz resolution bandwidth the level is shown about .2 dB too low and at 3 kHz resolution bandwidth the level error is about 1 dB. In all cases the video bandwidth of the spectrum analyser was 100 kHz. A resolution bandwidth of 300 kHz and a video bandwidth also of 300 kHz were used as reference. When measuring the contour of the video sideband(s) with narrow resolution bandwidths a very slow sweep rate is mandatory, 10 seconds is recommended for video frequencies swept from 100 kHz to 6 MHz.

The power spectrum of FM sound carriers can only be measured correctly (at full deviation) if the resolution bandwidth of the spectrum analyser is at least equal to the highest modulation frequency, i.e. 15 kHz, otherwise the result will depend on the modulation frequency and the deviation. The video bandwidth of the spectrum analyser should be somewhat higher, e.g. 30 kHz.

AM sound carriers can be measured correctly with even very low resolution bandwidths as long as the modulation frequency is kept constant or swept very slowly.

For QPSK carriers like NICAM the measured level depends only on the resolution bandwidth of the spectrum analyser and scaling can be done from or to any relevant bandwidth.

As a result of the above described differences between the individual components of an analogue television signal a reference bandwidth of 50 kHz is used for spectrum masks for analogue television.

Description of breakpoint	Frequency relative to vision carrier in analogue channel [MHz]	Frequency relative to centre of channel [MHz]	Analogue tv-system G / PAL (mono), V / S ratio = 10 dB	Analogue tv-system G / PAL / NICAM V / S / N ratio = 13 / 20 dB	Analogue tv-system G / PAL / A2 V / S / s ratio = 13 / 20 dB	Analogue tv-system I / PAL / NICAM V / S / N ratio = 10 / 20 dB	Analogue tv-system K / SECAM V / S ratio = 10 dB	Analogue tv-system L / SECAM V / S ratio = 10 dB
Lower end of lower adjacent 8 MHz channel	-9,25	-12	-62,5	-62,5	-62,5	-62,5	-62,5	-61,2
Image of colour sub-carrier syst. G and I, Lower limit of colour subc. image syst. K	-4,43	-7,18	-46	-46	-46	-46,7	-46	n.a.
Image of colour subcarrier syst. L	-4,3	-7,05	n.a.	n.a.	n.a.	n.a.	n.a.	-13 -30= -43
Upper limit of colour subcarrier image, syst. K	-4,23	-6,98	n.a.	n.a.	n.a.	n.a.	-46	n.a.
Attenuation of lower video sideband, syst. G and I	-3	-5,75	-36	-36	-36	-36,7	n.a.	n.a.
Attenuation of lower sideband syst. L	-2,7	-5,45	n.a.	n.a.	n.a.	n.a.	n.a.	-13 -15= -28
Lower end of channel	-1,25	-4	-36	-36	-36	-16,7	-36	-13
Lower corner of vestigial sideband, syst. G and K	-0,75	-3,5	-16	-16	-16	n.a.	-16	n.a.
Lower end of sync. signal spectrum	-0,13	-2,88	-16	-16	-16	-16,7	-16	-13
Vision carrier (for syst. L at an all 100% white picture)	0	-2,75	0	0	0	0	0	0
Upper end of sync. signal spectrum	0,13	-2,62	-16	-16	-16	-16,7	-16	-13
Upper end of video sideband, syst. G	5	2,25	-16	-16	-16	n.a.	n.a.	n.a.
Gap between video sideband and 1st sound carrier, syst. G	5,25	2,5	-20	-20	-20	n.a.	n.a.	n.a.
Lower corner of 1st sound carrier, syst. G	5,435	2,685	-10	-13	-13	n.a.	n.a.	n.a.
Upper end of video sideband, syst. I	5,5	2,75	n.a.	n.a.	n.a.	-16,7	n.a.	n.a.
Upper corner of 1st sound carrier, syst. G	5,565	2,815	-10	-13	-13	n.a.	n.a.	n.a.
Lower corner of NICAM signal, syst. G / NICAM	5,6	2,85	n.a.	-20	n.a.	n.a.	n.a.	n.a.
Lower corner of 2nd sound carrier, syst. G / A2	5,675	2,925	n.a.	n.a.	-20	n.a.	n.a.	n.a.
Gap between video sideband and 1st sound carrier, syst. I	5,75	3	n.a.	n.a.	n.a.	-20	n.a.	n.a.
Upper end of spectrum used by syst. G / mono	5,8	3,05	-62,5	n.a.	n.a.	n.a.	n.a.	n.a.
Upper corner of 2nd sound carrier, syst. G / A2	5,805	3,055	n.a.	n.a.	-20	n.a.	n.a.	n.a.
Lower corner of 1st sound carrier, syst. I	5,9346	3,1846	n.a.	n.a.	n.a.	-10	n.a.	n.a.
Upper end of spectrum used by syst. G / A2	5,97	3,22	n.a.	n.a.	-62,5	n.a.	n.a.	n.a.
Upper end of video sideband, syst. K and L	6	3,25	n.a.	n.a.	n.a.	n.a.	-16	-13
Upper corner of 1st sound carrier, syst. I	6,0646	3,3146	n.a.	n.a.	n.a.	-10	n.a.	n.a.
Upper corner of NICAM signal, syst. G / NICAM	6,1	3,35	n.a.	-20	n.a.	n.a.	n.a.	n.a.
Gap between video sideband and 1st sound carrier, syst. K and L	6,25	3,5	n.a.	n.a.	n.a.	n.a.	-20	-20
Upper end of spectrum used by syst. G / NICAM	6,28	3,53	n.a.	-62,5	n.a.	n.a.	n.a.	n.a.
Lower corner of NICAM signal, syst. I / NICAM	6,302	3,552	n.a.	n.a.	n.a.	-25	n.a.	n.a.
Lower corner of 1st sound carrier syst. K and L	6,435	3,685	n.a.	n.a.	n.a.	n.a.	-10	-10
Centre of NICAM signal, syst. I / NICAM	6,552	3,802	n.a.	n.a.	n.a.	-20	n.a.	n.a.
Upper corner of 1st sound carrier syst. K and L	6,565	3,815	n.a.	n.a.	n.a.	n.a.	-10	-10
Upper end of 8 MHz channel	6,75	4	n.a.	n.a.	n.a.	n.a.	-54	-54
Upper end of spectrum used by syst. K and L [1)]	6,8	4,05	n.a.	n.a.	n.a.	n.a.	-62,5	-61.2
Upper corner of NICAM signal, syst. I / NICAM	6,802	4,052	n.a.	n.a.	n.a.	-25	n.a.	n.a.
Upper end of spectrum used by syst. I / NICAM	6,94	4,19	n.a.	n.a.	n.a.	-62,5	n.a.	n.a.
Upper end of upper adjacent 8 MHz channel	14,75	12	-62,5	-62,5	-62,5	-62,5	-62,5	-61,2

Note: [1)] Because of 50 kHz reference bandwidth used
[2)] Values given from System G also apply to System B1.

Table B2.3: Breakpoints for spectrum masks for analogue television systems, based on 50 kHz bandwidth

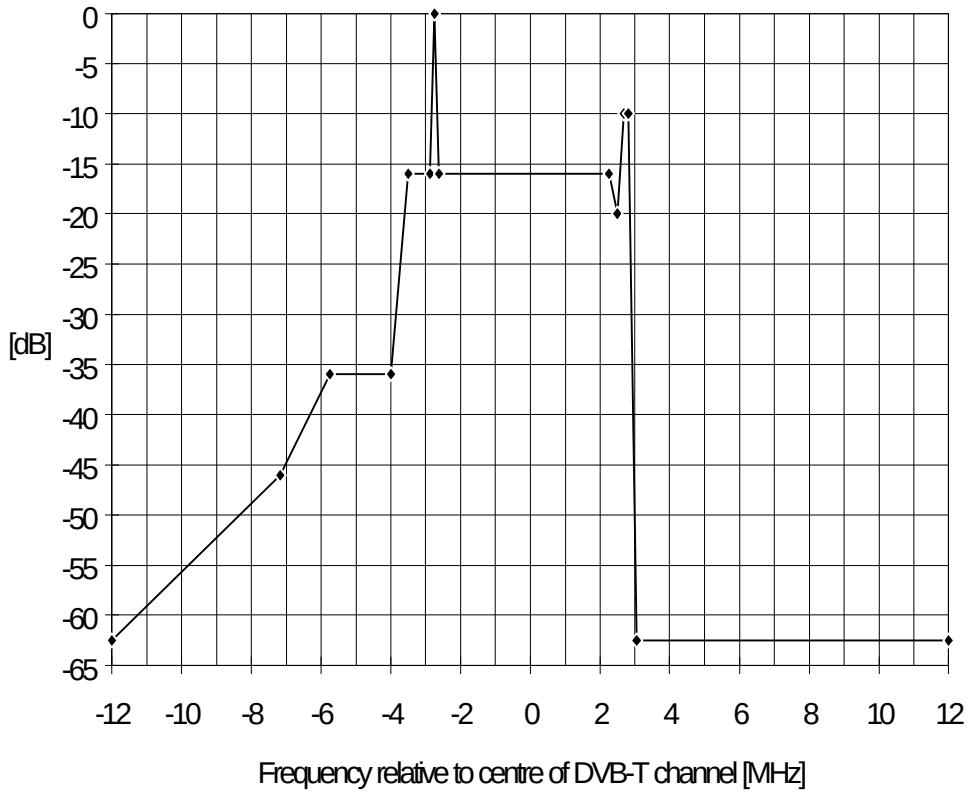

Figure B2.3
Analogue system G / PAL / mono, V / S ratio = 10 dB

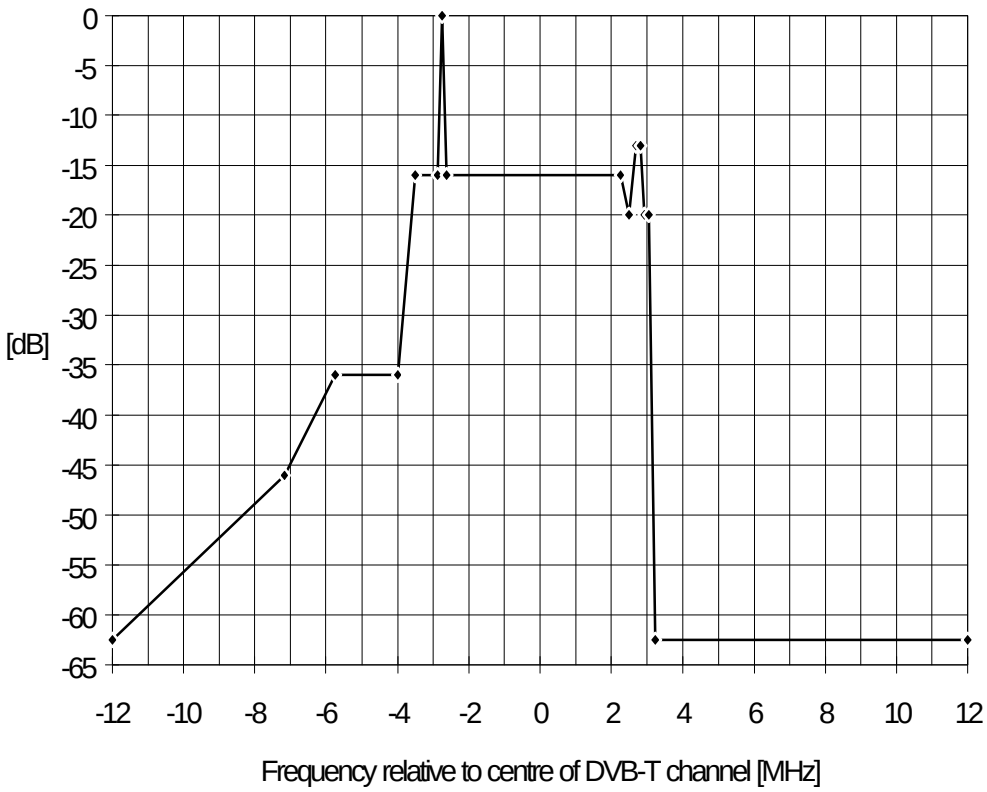

Figure B2.4
Analogue system G / PAL / A2, V / S / s ratio = 13 dB / 20 dB

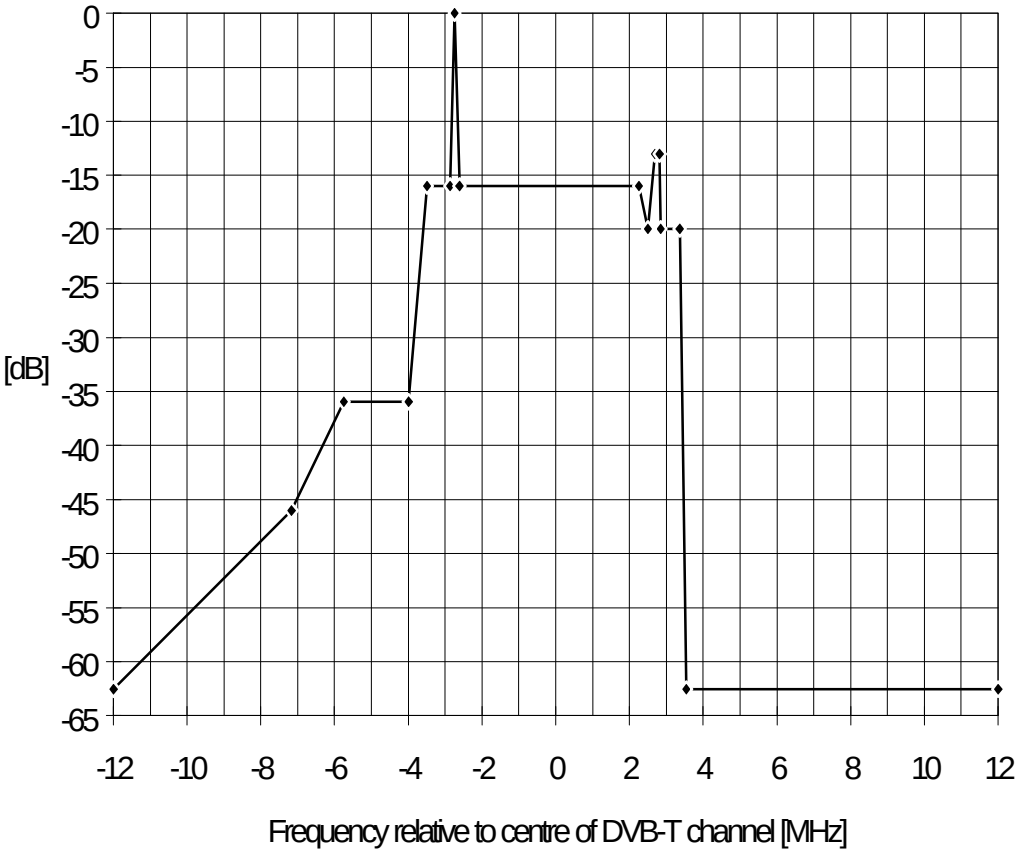

Figure B2.5
Analogue system G / PAL / NICAM, V / S / N ratio = 13 dB / 20 dB

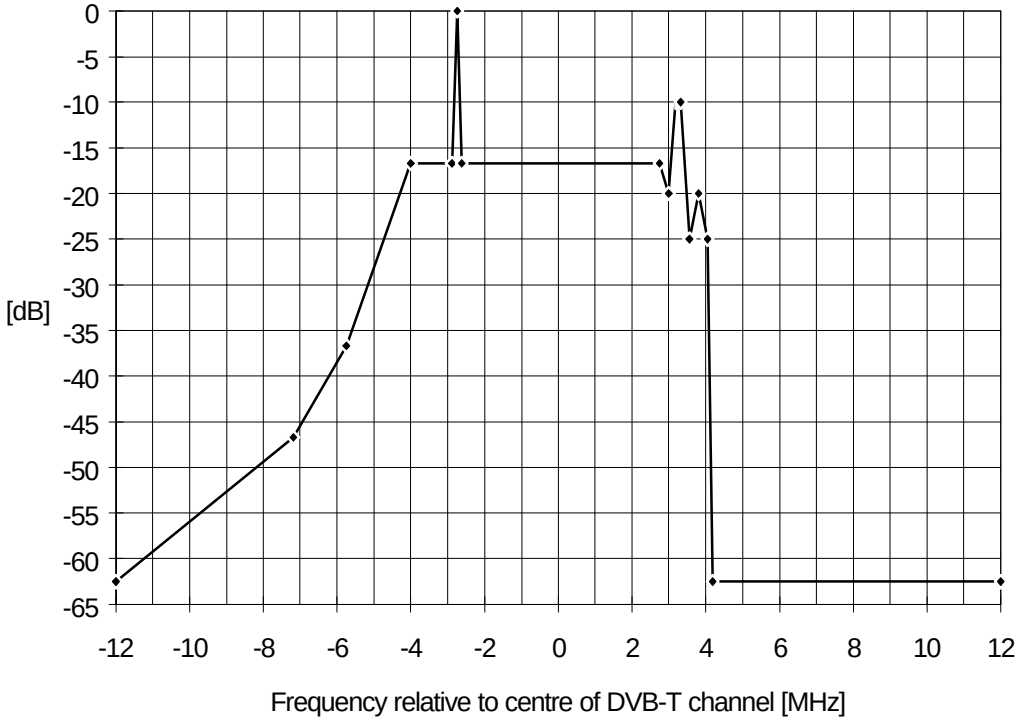

Figure B2.6
Analogue system I / NICAM, V / S / N = 10 dB / 20 dB

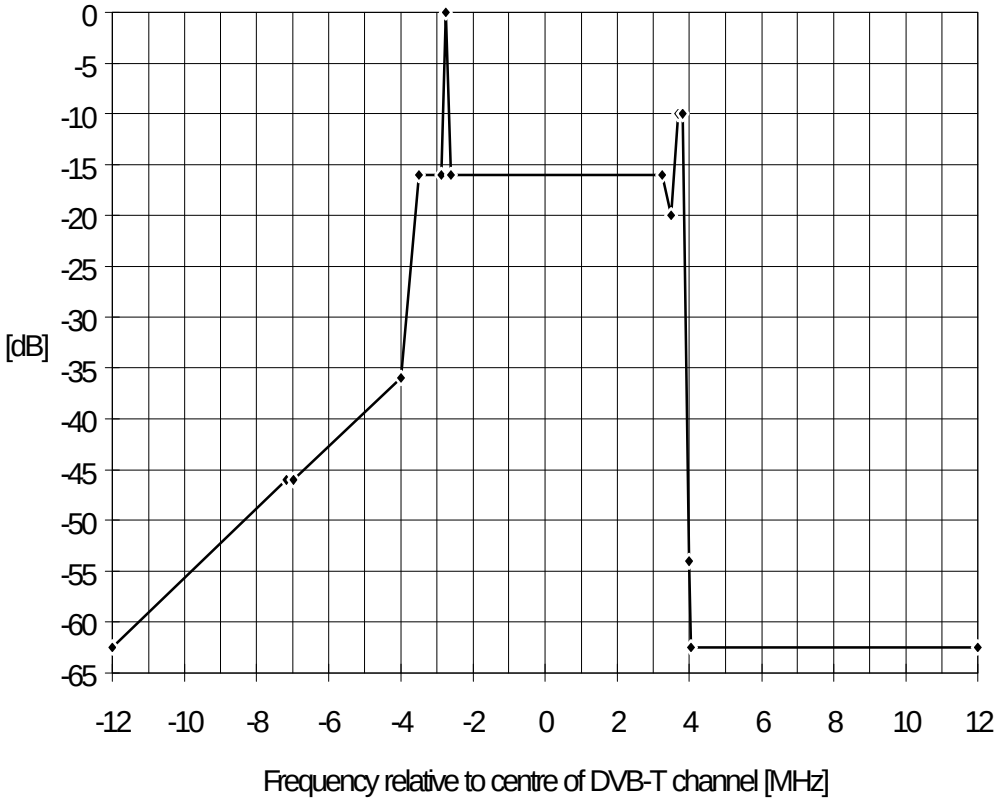

Figure B2.7
Analogue system K / SECAM, V / S ratio = 10 dB

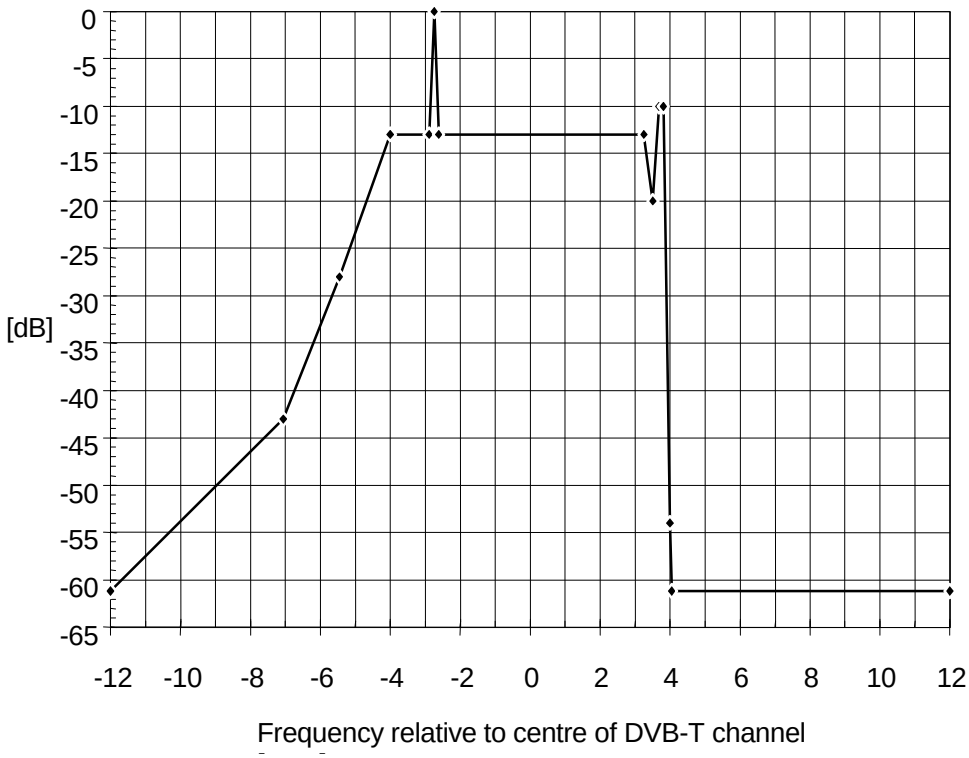

Figure B2.8
Analogue system L / SECAM, V / S ratio = 10 dB

Annex B2.1: Derivation of protection ratio values used in the asymmetrical DVB-T spectrum masks.

G*/ PAL / NICAM interfered with by DVB-T

Vision carrier in lower adjacent channel

Frequency: 1.25 MHz,
corresponding to -10.75 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Vision carrier + 1 MHz in lower adjacent channel:

Frequency: 2.25 MHz
corresponding to -9.75 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Upper end of video sideband in lower adjacent channel:

Bandwidth: 5 MHz
Upper sideband frequency: (1.25 + 5) MHz = 6.25 MHz,
corresponding to -5.75 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 48.3 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(48.3 +25.9) dB = -74.2 dB

Analogue mono FM-sound carrier in lower adjacent channel:

Bandwidth: $(2 * (\Delta f + f_{mod.\ max.})) = 130$ kHz
Centre frequency of sub-carrier: 5.5 MHz above the vision carrier
Upper end of band: (1.25 + 5.5 + (0.130 / 2))MHz = 6.815 MHz,
corresponding to -5.185 MHz relative to centre of the DVB-T channel.

* Note that where values are given for System G, they also apply to System B1.

Protection ratio for Grade 4.5: 35 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(35 +25.9) dB = -60.9 dB

NICAM sub-carrier in lower adjacent channel:

Bandwidth: 500 kHz
Centre frequency of sub-carrier: 5.85 MHz above the vision carrier
Upper end of NICAM signal: (1.25 + 5.85 + (0.5 / 2))MHz = 7.35 MHz,
corresponding to -4.65 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 31 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(31 +25.9) dB = -56.9 dB

Lower video sideband in upper adjacent channel:

Frequency: (1.25 - 1) MHz = 0.25 MHz
corresponding to +4.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 39 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(39 +25.9) dB = -64.9 dB

Vision carrier in upper adjacent channel:

Frequency: 1.25 MHz,
corresponding to +5.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Vision carrier + 1 MHz in upper adjacent channel:

Frequency: 2.25 MHz
corresponding to +6.25 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Upper end of video sideband in upper adjacent channel:

Upper sideband frequency: (1.25 + 5) MHz = 6.25 MHz,
corresponding to +10.25 MHz relative to centre of the DVB-T channel.

Taken equal to the value for the vision carrier: -76.9 dB

G / PAL / A2 interfered with by DVB-T

Vision carrier in lower adjacent channel

Frequency: 1.25 MHz,
corresponding to -10.75 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Vision carrier + 1 MHz in lower adjacent channel:

Frequency: 2.25 MHz
corresponding to -9.75 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Upper end of video sideband in lower adjacent channel:

Bandwidth: 5 MHz
Upper sideband frequency: (1.25 + 5) MHz = 6.25 MHz,
corresponding to -5.75 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 48.3 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(48.3 +25.9) dB = -74.2 dB

Analogue mono FM-sound carrier in lower adjacent channel:

Bandwidth: $(2 * (\Delta f + f_{mod.\ max.})) = 130$ kHz
Centre frequency of sub-carrier: 5.5 MHz above the vision carrier
Upper end of band: (1.25 + 5.5 + (0.130 / 2))MHz = 6.815 MHz,
corresponding to -5.185 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 35 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(35 +25.9) dB = -60.9 dB

As the necessary protection ratio is lower than that for the second sound carrier and the centre frequency is further away from the DVB-T channel, this value is ignored.

Second analogue FM-sound carrier in lower adjacent channel:

Bandwidth: $(2 * (\Delta f + f_{mod.\ max.})) = 130$ kHz
Centre frequency of sub-carrier: 5.742 MHz above the vision carrier
Upper end of NICAM signal: (1.25 + 5.742 + (0.13 / 2))MHz = 7.06 MHz,
corresponding to -4.94 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 44 dB

Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(44 +25.9) dB = -69.9 dB

Lower video sideband in upper adjacent channel:
Frequency: (1.25 - 1) MHz = 0.25 MHz
corresponding to +4.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 39 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(39 +25.9) dB = -64.9 dB

Vision carrier in upper adjacent channel:
Frequency: 1.25 MHz,
corresponding to +5.25 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Vision carrier + 1 MHz in upper adjacent channel:
Frequency: 2.25 MHz
corresponding to +6.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Upper end of video sideband in upper adjacent channel:
Upper sideband frequency: (1.25 + 5) MHz = 6.25 MHz,
corresponding to +10.25 MHz relative to centre of the DVB-T channel.

Taken equal to the value for the vision carrier: -76.9 dB

G / PAL (Vision/sound ratio = 10 dB) interfered with by DVB-T
for information only, not included in the curves in Figure B2.1

Vision carrier in lower adjacent channel
Frequency: 1.25 MHz,
corresponding to -10.75 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Vision carrier + 1 MHz in lower adjacent channel:
Frequency: 2.25 MHz
corresponding to -9.75 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Upper end of video sideband in lower adjacent channel:
Bandwidth: 5 MHz
Upper sideband frequency: (1.25 + 5) MHz = 6.25 MHz,
corresponding to -5.75 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 48.3 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(48.3 +25.9) dB = -74.2 dB

Lower adjacent mono FM-sound carrier:
Bandwidth: $(2 * (\Delta f + f_{mod.\ max.})) = 130$ kHz
Centre frequency of sub-carrier: 5.5 MHz above the vision carrier
Upper end of band: (1.25 + 5.5 + (0.130 / 2))MHz = 6.815 MHz,
corresponding to -5.185 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 34 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(34 +25.9) dB = -59.9 dB

Lower video sideband in upper adjacent channel:
Frequency: (1.25 - 1) MHz = 0.25 MHz
corresponding to +4.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 39 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(39 +25.9) dB = -64.9 dB

Vision carrier in upper adjacent channel:

Frequency: 1.25 MHz,
corresponding to +5.25 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Vision carrier + 1 MHz in upper adjacent channel:

Frequency: 2.25 MHz
corresponding to +6.25 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Upper end of video sideband in upper adjacent channel:

Upper sideband frequency: (1.25 + 5) MHz = 6.25 MHz,
corresponding to +10.25 MHz relative to centre of the DVB-T channel.

Taken equal to the value for the vision carrier: -76.9 dB

I / PAL / NICAM interfered with by DVB-T

Vision carrier in lower adjacent channel:

Frequency: 1.25 MHz,
corresponding to +5.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 50.3 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(50.3 +25.9) dB = -76.2 dB

As the necessary protection ratio is lower than that for the vision carrier and the centre frequency is further away from the DVB-T channel, the value for the maximum relative level is replaced by that for the vision carrier + 1 MHz: -76.9 dB

Vision carrier + 1 MHz in lower adjacent channel:

Frequency: 2.25 MHz
corresponding to -9.75 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Upper end of video sideband in lower adjacent channel:

Bandwidth: 5 MHz
Upper sideband frequency: (1.25 + 5) MHz = 6.25 MHz,
corresponding to -5.75 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 45 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(45 +25.9) dB = -70.9 dB

Analogue mono FM-sound carrier in lower adjacent channel: (-10 dB)

Bandwidth: $(2 * (\Delta f + f_{mod.\ max.})) = 130$ kHz
Centre frequency of sub-carrier: 6.0 MHz above the vision carrier
Upper end of band: (1.25 + 6.0 + (0.130 / 2))MHz = 7.315 MHz,
corresponding to -4.685 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 34 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(34 +25.9) dB = -59.9 dB

NICAM sub-carrier in lower adjacent channel: (-20 dB)

Bandwidth: 550 kHz (-10 dB), used to determine the upper limit and
364 kHz (-3 dB), used determine the 4 kHz correction factor
Centre frequency of sub-carrier: 6.55 MHz above the vision carrier
Upper end of NICAM signal: (1.25 + 6.55 + (0.55 / 2))MHz = 8.075 MHz,
corresponding to -3.925 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 31 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(31 +25.9) dB = -56.9 dB

Lower video sideband in upper adjacent channel:

Frequency: (1.25 - 1) MHz = 0.25 MHz
corresponding to +4.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 41 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(41 +25.9) dB = -66.9 dB

Vision carrier in upper adjacent channel:

Frequency: 1.25 MHz,
corresponding to +5.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 50.3 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(50.3 +25.9) dB = -76.2 dB

Vision carrier + 1 MHz in upper adjacent channel:

Frequency: 2.25 MHz
corresponding to +6.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 51 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(51 +25.9) dB = -76.9 dB

Upper end of video sideband in upper adjacent channel:

Upper sideband frequency: (1.25 + 5) MHz = 6.25 MHz,
corresponding to +10.25 MHz relative to centre of the DVB-T channel.

Taken equal to the value for the vision carrier + 1 MHz: -76.9 dB

K / SECAM, K / PAL, D / SECAM and D / PAL
(Vision/sound ratio = 10 dB) interfered with by DVB-T

Vision carrier in lower adjacent channel
Frequency: 1.25 MHz,
corresponding to -10.75 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 52.8 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(52.8 +25.9) dB = -78.7 dB

Vision carrier + 1 MHz in lower adjacent channel:
Frequency: 2.25 MHz
corresponding to -9.75 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 52.8 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(52.8 +25.9) dB = -78.7 dB

Upper end of video sideband in lower adjacent channel:
Bandwidth: 6 MHz, used to determine the 4 kHz correction factor
5 MHz is the significant point on the protection ratio curve
Upper sideband frequency: (1.25 + 6) MHz = 7.25 MHz,
corresponding to -4.75 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 47.7 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(47.7 +25.9) dB = -73.6 dB

Analogue mono FM-sound carrier in lower adjacent channel:
Bandwidth: $(2 * (\Delta f + f_{mod.\ max.})) = 130$ kHz
Centre frequency of sub-carrier: 6.5 MHz above the vision carrier
Upper end of band: (1.25 + 6.5 + (0.130 / 2))MHz = 7.815 MHz,
corresponding to -4.185 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 34 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(34 +25.9) dB = -59.9 dB

Lower video sideband in upper adjacent channel:
Frequency: (1.25 - 1) MHz = 0.25 MHz
corresponding to +4.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 40.2 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(40.2 +25.9) dB = -66.1 dB

Vision carrier in upper adjacent channel:

Bandwidth: 6 MHz
Frequency: 1.25 MHz,
corresponding to +5.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 52.8 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(52.8 +25.9) dB = -78.7 dB

Vision carrier + 1 MHz in upper adjacent channel:

Frequency: 2.25 MHz
corresponding to +6.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 52.8 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(52.8 +25.9) dB = -78.7 dB

Upper end of video sideband in upper adjacent channel:

Upper sideband frequency: (1.25 + 6) MHz = 7.25 MHz,
corresponding to +11.25 MHz relative to centre of the DVB-T channel.

Taken equal to the value for the vision carrier: -78.7 dB

L / SECAM / NICAM interfered with by DVB-T

Vision carrier in lower adjacent channel

Frequency: 1.25 MHz,
corresponding to -10.75 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 44 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(44 +25.9) dB = -69.9 dB

As the necessary protection ratio is lower than that for the vision carrier and the centre frequency is further away from the DVB-T channel, the value for the maximum relative level is replaced by that for the vision carrier + 1 MHz: -72.4 dB

Vision carrier + 1 MHz in lower adjacent channel:

Frequency: 2.25 MHz,
corresponding to -9.75 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 46.5 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(46.5 +25.9) dB = -72.4 dB

Upper end of video sideband in lower adjacent channel:

Bandwidth: 6 MHz
Upper sideband frequency: (1.25 + 6) MHz = 7.25 MHz,
corresponding to -4.75 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 35 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(35 +25.9) dB = -60.9 dB

Analogue mono AM-sound carrier in lower adjacent channel:

Bandwidth: 30 kHz
Centre frequency of sub-carrier: 6.5 MHz above the vision carrier
Allowance for positive sound carrier offset: 50 kHz
Upper end of band: (1.25 + 6.5 + 0.05 + (0.030 / 2))MHz = 7.815 MHz,
corresponding to -4.185 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 54 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(54 +25.9) dB = -79.9 dB

Lower video sideband in upper adjacent channel:

Frequency: (1.25 - 1) MHz = 0.25 MHz
corresponding to +4.25 MHz relative to centre of the DVB-T channel

Protection ratio for Grade 4.5: 34 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(34 +25.9) dB = -59.9 dB

Vision carrier in upper adjacent channel:

Frequency: 1.25 MHz,
corresponding to +5.25 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 44 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(44 +25.9) dB = -69.9 dB

Vision carrier + 1 MHz in upper adjacent channel:

Frequency: 2.25 MHz,
corresponding to +6.25 MHz relative to centre of the DVB-T channel.

Protection ratio for Grade 4.5: 46.5 dB
Correction for 4 kHz bandwidth: 10 * log(1540 / 4) = 25.9 dB
Maximum relative level in 4 kHz: -(46.5 +25.9) dB = -72.4 dB

Upper end of video sideband in upper adjacent channel:

Upper sideband frequency: (1.25 + 6) MHz = 7.25 MHz,
corresponding to +11.25 MHz relative to centre of the DVB-T channel.

Taken equal to the value for the vision carrier + 1 MHz: -72.4 dB

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B3. PLANNING METHODS

B3.1 Introduction

Terrestrial digital television services can be planned using assignments and/or allotments. The methods for both these approaches are given in this section and they can be used in preparation for and during, an international planning conference. Within Europe it has been decided to use only assignment planning. The planning of an individual station (or group of stations), intended to provide coverage to a specified area, is also covered.

B3.1.1 Assignment Planning for Terrestrial Digital Television

In the past, terrestrial television planning in Europe has been by way of assignment conferences. In assignment planning, a significant amount of individual station planning is needed to prepare for a planning conference. Stockholm ’52 and Stockholm ’61 were two such conferences related to terrestrial television and European broadcasters have gained much experience in assignment planning, particularly since the planning methods and criteria of the ’61 conference are still applied to analogue television planning.

Assignment planning for terrestrial digital television is appropriate where:

- a broadcaster wishes to use an existing transmission infrastructure for environmental and economic reasons;
- there is a need to share spectrum with existing analogue television transmissions in the same country;
- where digital assignments are envisaged.

At the completion of the assignment plan, the locations and characteristics of the transmitters in the planning area are known, and the transmitters can be brought into service without further co-ordination.

B3.1.2 Allotment Planning for Terrestrial Digital Television

The alternative possibility of obtaining **allotments** at a conference has received considerable attention in recent years, particularly because of the opportunities offered by SFNs. Allotment planning for SFNs is probably best carried out where spectrum is available or can be made available in large region or throughout a country. Allotments may also be applicable for MFN planning where a country has no plans to use specific transmitter sites and wishes to retain some flexibility for late future.

In allotment planning, a channel is “given” to an administration to provide coverage over all or part of its territory, but as there are no agreed definitions of words such as “national” or “regional”, care is needed in their application. At the allotment planning stage, in general nothing is known of the actual location of the transmitter sites, nor of the specific transmission

characteristics to be used. The only parameters available are a definition of the area to be covered and the channel to be used. Thus in order to carry out the planning exercises it is necessary to define some reasonably realistic reference transmission conditions so that any necessary compatibility calculations can be made.

To implement networks within an allotment it is necessary to convert the allotments into individual transmitter assignments.

B3.1.3 Planning constraints for co-ordination

The constraints on co-ordination are the same for allotment and assignment planning. These are:

- compatibility with existing analogue television services;
- compatibility with other services (§B4);
- mutual protection of digital television allotments or assignments.

B3.1.4 Digital television planning in Europe

It is likely that terrestrial digital television planning in Europe in the reasonably near future will have to be based on a mixture of assignment and allotment planning.

B3.2 Elements of planning

B3.2.1 Planning criteria

The planning criteria consist of the following elements:

- Protection ratios (§A5);
- Percentage of time for which protection is required (§B1.1);
- Percentages of locations for which protection is required (§B1.1);
- Signal levels and C/N values (§B1.4).

The range of C/N values under discussion for different digital systems and their variants is very large and the differences between some of the C/N values are smaller than the inherent accuracy of the propagation prediction methods available (including the assumptions necessary in the case of portable reception). For planning the introduction of DVB-T in Europe it will be necessary to restrict the interim planning studies to a representative sub-set of C/N values.

B3.2.2 Propagation prediction methods

The signal level prediction method is ITU-R Rec. P.370 for individual transmitters and the statistical approach given in §B1.5 for SFNs.

B3.2.3 Combination of multiple signals

The methods to combine the wanted and unwanted signals are given in §B1.5.

B3.2.4 Databases for planning

Terrestrial digital television broadcasting will be primarily accommodated in the same bands as analogue television. Extensive compatibility calculations will be needed in planning studies and subsequent co-ordination to facilitate this accommodation. These calculations require databases containing:

- analogue transmitter stations;
- digital transmitter station assignments;
- allotment plans containing, for example, areas to be covered;
- details of other services.

Details of the transmitter database formats are given in **Tables B3.1 and B3.2**. Further consideration is needed with regard to suitable contents and formats for databases for allotments and for other services. The latter, in particular, will require additional study to determine suitable compatibility criteria and calculation methods.

B3.3 Procedures for the protection of analogue television services

It is necessary to ensure that the existing and planned analogue television services continue to be protected. This applies to both assignment and allotment planning for digital television. In either case, before a channel is chosen for a digital television service, it is necessary to establish the size of the coverage area for each co-ordinated analogue station. This may be done by the calculation process given in §B3.5 or by specifying boundary test points in special cases. Examples of the latter would be where a calculated coverage area would cross a national boundary or in mountainous terrain where propagation predictions based on Rec. 370 cannot be expected to give accurate results.

B3.4 Definitions of test points

Two categories of test points are needed. One category represents the coverage area for a given station, or SFN, while the other represents country boundaries.

All test points are defined by their geographical coordinates.

B3.4.1 Test points representing coverage areas

The transmitter site will normally be inside the contour described by the test points, however, in special cases the transmitter can be located outside of this area.

For small stations, i.e. stations with a coverage area whose width is less than 5 km, only one test point, located at the transmitter site, may be sufficient. However, up to 36 test points can be defined if necessary. If only one test point is given, no receiving antenna directivity is assumed.

For stations with a coverage area whose width is 5 km or more up to 36 test points are used. These test points may be located on radials at 10 degree intervals.

If the contour of the coverage area crosses a country boundary, the test points in this area are located at the crossing points between a radial and the boundary unless otherwise agreed by the concerned administrations.

B3.4.2 Test points at the country boundary

A maximum of 499 test points can be used to represent the boundary of a country.

The location of test points at a boundary should be agreed between the countries sharing this boundary and be used as boundary test points by all countries.

The set of test points representing the boundary of a country shall be a complete individual set, as shall a set representing a coverage area.

B3.4.3 Availability of test point locations

The location of test points, i.e. their geographical coordinates, shall be commonly available to all CEPT members in order to facilitate calculations of interference into other countries or coverage areas of stations in other countries.

B3.5 Calculation of the location for test points representing coverage areas

To calculate the coverage area of a television station on a given channel, two elements are necessary:

- the parameters particular to an individual transmitting station (coordinates, height of the antenna, radiated power, etc.) which are used to calculate the wanted signal;
- the system parameters such as the protection ratios, which are used to calculate the individual nuisance field strengths and the usable field strength, and the minimum median field strength.

These calculations should take into account:

- interference from analogue television assignments;
- interference from digital television assignments.

The individual nuisance field strength En is the field strength of an unwanted signal to which has been added the relevant protection ratio, propagation correction factor and receiving antenna discrimination. It is calculated as follows:

$$En = E + PR + C + A$$

where

E is the field strength of the unwanted signal. The appropriate time percentage according to the wanted signal is to be chosen (see note 1);
PR is the appropriate protection ratio (see note 1);
C is the propagation correction factor (see note 2);
A is the receiving antenna discrimination (taking into account polarisation discrimination), ($A \leq 0$);

and all quantities are expressed in dB or dB(μV/m).

note 1:
In the case of a wanted digital service the 1% time 50% location field strength of the unwanted service is to be chosen. In the case of a wanted analogue service the larger of the 1% time 50% location field strength of the unwanted signal together with the protection ratio for tropospheric interference and the 50% time 50% location field strength of the unwanted signal together with the protection ratio for continuous interference is to be chosen.

note 2:
The propagation correction factor C = (location correction factor in the case of a wanted and an unwanted signal) equals 0 dB in the case of a wanted analogue television service. In the case of a wanted digital television service it equals $\sqrt{2} \times \mu \times \sigma$, where the distribution factor μ and the standard deviation σ (in dB) are given in §B1.4.1.

The usable field strength is the minimum value of the field strength necessary to permit a desired reception quality, under specified receiving conditions, in the presence of natural and man-made noise and interference. The usable field strength is calculated by combining the individual nuisance fields and the minimum median field strength. The combination is done by means of the power sum method:

$$E_u = 10 \times \log_{10}\left(10^{\frac{E_{\min}}{10}} + \sum_{i=1}^{n} 10^{\frac{En_i}{10}}\right),$$

where

E_u is the usable field strength (in dB(µV/m));
E_{min} is the minimum median field strength (in dB(µV/m));
En_i is the nuisance field strength of the i-th unwanted signal (in dB(µV/m));
n is the number of interferers,

and

for analogue television reception, the value of E_{min} is given in Rec. ITU-R BT.417;
for digital television reception, the value of E_{min} is given in §C1.4.

The test points representing a coverage area can thus be determined in three stages:

Stage 1 Calculation of noise limited coverage area

Using Rec. ITU-R P.370, the locations of the noise-limited test points are found, which represent the area that could be served if there were no interference. This area may be approximated on the basis of up to 36 radials, using the e.r.p. and the effective antenna height. For each radial, that location is determined where the field strength of the wanted transmitter equals the minimum median field strength.

Stage 2 Identification of interferers

The impact of co-channel, adjacent channel and image channel interference from other transmitters is calculated for each wanted station and each noise-limited test point from Stage 1. First, the sub-set of possible interferers is established. This consists of the stations which can produce a nuisance field which is no more than 15 dB below the minimum median field strength at any of the noise-limited test points from Stage 1.

Stage 3 Calculation of the test points for the interference limited coverage.

The individual nuisance field strength En caused by each of the interfering stations in this sub-set of interferers is calculated at each of the noise limited test points from Stage 1 (see **Figure B3.1**). The usable field strength is calculated for each of these test points.

In the case of no interferers the usable field strength at a test point is equal to the minimum median field strength, no further calculation is required, and the coverage radius is that of Stage 1 above (see also **Figure B3.1**).

If the usable field strength at a test point is greater than the minimum median field strength, it is then necessary to find the new coverage radius on this bearing at which the field strength from the wanted station equals the usable field strength.

Because, in general, the coverage radius thus calculated will not equal the radius previously calculated for the same bearing and thus the nuisance field strengths will

change, the process of the previous paragraph is repeated to obtain a close approximation to the required coverage radius on each of the bearings.

It must be noted that a given station will normally have different coverage areas on different channels and that this can be important when considering the relative coverage of digital and analogue services.

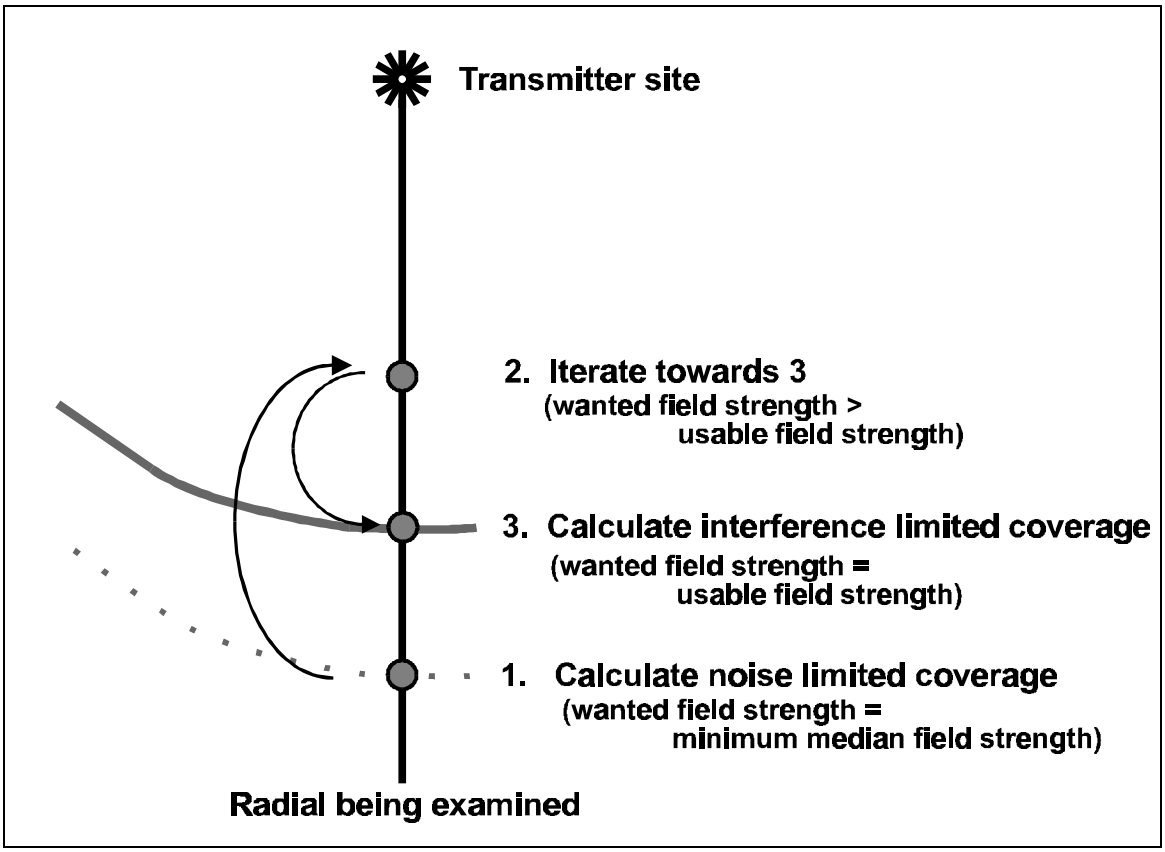

Figure B3.1
Illustration of the calculation of location of test points for the interference limited coverage

B3.6 Method for combination of signals (power sum method)

The power sum method is a procedure in which individual field strengths are combined such that the power of the resultant field strength equals the sum of the powers of the individual field strengths. If the (logarithmic) field strength of a single signal is denoted by E_i and is expressed in dB(µV/m), the combined field strength E_Σ is given by:

$$E_\Sigma = 10 \times \log_{10}\left(\sum_{i=1}^{n} 10^{\frac{E_i}{10}}\right)$$

where n is the number of individual field strengths.

B3.7 Planning methods for digital television assignments

This section describes a method for finding **potentially** available channels for individual new digital television transmitters in the case of MFN planning. The basic idea is to determine the amount of power which may be radiated in each channel without causing excessive interference (that is beyond a pre-determined increase of say, 0.3 dB) to existing analogue services or an equivalent increase for digital services. The results obtained by using the process described in §§B3.7.1 and B3.7.2 may be used to identify which channels could provide useful digital coverage from any given transmitter site.

The actual channel or channels to be used at that site, rather than at any other, nearby, site would need to be selected during a co-ordination process, which would also need to take account of the potential mutual interference between digital television transmitters which could use the same channel.

An alternative, but related, approach would be to identify the channels and the station characteristics for a group of digital assignments arranged in a mini SFN. The basic concept remains the same as that described above but the actual processing is significantly more complex.

Of course, the station characteristics determined as in §B3.7.1 and agreed in a co-ordination process could be used as the basis for the **implementation** of a mini SFN, provided that the latter did not have a larger interference potential (at any of the test points for other stations agreed during the co-ordination process).

B3.7.1 Establishment of the characteristics of a digital television station

For a given transmitting site, the following characteristics have to be established for a digital television station:

- channel(s);
- polarisation;
- transmitting antenna effective height above mean terrain;
- maximum e.r.p.;
- horizontal radiation pattern.

Information on the effective antenna effective height and radiation pattern is required at 10 degree intervals, starting at true north.

Many iterations may be required in the choice of the characteristics which will give maximum coverage of the digital service, while at the same time not causing unacceptable levels of interference to existing analogue television stations and other services.

For a particular choice (or trial choice) of channel and polarisation, the maximum permissible radiated power of the digital service must be determined.

For each analogue television station which may suffer interference from the DVB-T station with the proposed characteristics, the following steps should be carried out:

1. at each point representing the coverage area of the analogue station, calculate the power sum of the nuisance field strengths of other existing analogue stations. These values have already been established in the course of the procedures described in §B3.5

2. at the same points, calculate the combined nuisance field of the proposed DVB-T station together with the existing analogue television stations;

3. compare the combined nuisance field strengths calculated as above. If there is an increase of no more than an agreed value, say 0.3 dB, then the e.r.p. of the digital station is regarded as acceptable (for the purpose of establishing a list of potentially available channels). Otherwise, the e.r.p. is adjusted so that an acceptable value of interference is achieved.

In this way the maximum permissible radiated power of the digital television station in all directions can be determined.

B3.7.2 Establishment of the size of digital television coverage areas

When the characteristics of the digital station have been established, its coverage can be calculated for a specified system variant requiring a certain C/N. This calculation should take into account:

- interference from analogue television stations to the potential digital station coverage area;
- interference from other digital television services;
- interference from other services.

In order to do this, the signal summation methods described in §B1.5 should be used. As a result of this process, for each small area, the percentage of locations served is obtained. The predicted digital service area can also be calculated using the method given in §B3.5.

B3.7.3 Establishment of the characteristics of a group of digital television stations in a mini SFN

The basic concept employed is similar to that of §B3.7.1 and the details given there are not repeated. It is necessary that the set of transmitter sites to be regarded as a mini SFN be identified to the computerised process. The additional complexity, compared with the process given in §B3.7.1, is that multiple combinations of power levels radiated from each of the transmitters in the mini SFN would need to be considered. It would be necessary for a choice to be made among the many possibilities, on each possible channel, by considering the coverage which could be achieved by the given combination under study. This would involve an interactive process in which intermediate results produced by a computer process were studied to determine which combination of digital power levels is regarded as optimum for each channel.

B3.8 Protection of digital television services

Because of the rapid failure of digital reception when the level of the useful signal decreases below its "minimum" value, the target for the percentage of locations nominally covered at any edge - where edge means any transition between a covered area and a non-covered area - of the coverage area has to be much higher for digital systems than the value used for analogue television systems. For coordination, the reference conditions, including the percentage of location value, for digital coverage are given in §C1.4.

Since the reception conditions of the **actual** implementation of a digital television service may differ from the **reference** reception conditions given in §C1.4, the test points representing a digital assignment do not necessarily lie on the boundary of the actual coverage area of that digital assignment. The test points may lie inside or outside the actual coverage area of the digital assignment.

Table B3.1

CEPT analogue television transmitter database record

Field	Item	Start Column	Width	Type
1	File identifier, must be TVA1	1	4	A4
2	ITU code for administration responsible	5	3	A3
3	Identification code used by organisation	8	9	A9
4	Update code used by organisation	17	1	A1
5	Space reserved for serial number (e.g. ITU No.)	18	9	A9
6	Status code (**O**perating/**N**ot operating)	27	1	A1
7	Date of entry into operation (DDMMYYYY)	28	8	2I2, I4
8	ITU code for country in which transmitter is sited	36	3	A3
9	Station name	39	20	A20
10	Latitude (in degrees, N/S, min., sec.)	59	7	I2, A1, 2I2
11	Longitude (in degrees, E/W, min., sec.)	66	8	I3, A1, 2I2
12	Height of site (m asl; as sign followed by a number)	74	5	I5
13	Television system (**B**/**D**, ... etc.)	79	2	A2
14	Colour system (**P**al, **S**ecam, or **N**TSC)	81	1	A1
15	Channel	82	3	A3
16	Vision offset value (in 1/12 line units; as sign followed by a number)	85	4	I4
17	Nominal vision carrier frequency in MHz (including decimal point)	89	9	F9.3
18	Vision offset value in Hz (as sign followed by a number)	98	8	I8
19	Offset type (**U**nspecified /**N**ormal/**P**recision/**S**ynchronised)	106	1	A1
20	Maximum vision e.r.p. of horizontally polarised component (in dBW; as sign followed by a number including a decimal point)	107	5	F5.1
21	Maximum vision e.r.p. of vertically polarised component (in dBW; as sign followed by a number including a decimal point)	112	5	F5.1
22	Nominal primary sound carrier frequency minus nominal vision carrier frequency in MHz (as a number including a decimal point; if value is negative, e.g. System L at VHF, include sign in first column of field)	117	4	F4.1
23	Primary Sound carrier offset (zero, unless a special sound offset is in use) value in Hz (for system L only)	121	7	I7
24	Vision to primary sound carrier power ratio (in dB)	128	2	I2
25	Nominal secondary sound carrier frequency minus nominal vision carrier frequency in MHz (as a number including a decimal point; if value is negative, e.g. System L at VHF, include sign in first column of field)	130	6	F6.2
26	Unused columns	136	6	
27	Secondary sound system (**F**M/**N**icam; leave blank if no secondary sound system)	142	1	A1
28	Vision to secondary sound carrier power ratio (in dB)	143	2	I2

Field	Item	Start Column	Width	Type
29	Polarisation (**H**/**V**/**M**)	145	1	A1
30	Height of antenna (m a.g.l.)	146	3	I3
31	Directional? (**D**irectional/**N**on-directional)	149	1	A1
32	36 values of e.r.p. reduction (in dB) of the horizontally polarised component in the horizontal plane relative to the maximum e.r.p. of the horizontally polarised component as given in field 20 (at 10 degrees intervals, starting at North)	150	72	36I2
33	36 values of e.r.p. reduction (in dB) of the vertically polarised component in the horizontal plane relative to the maximum e.r.p. of the vertically polarised component as given in field 21 (at 10 degrees intervals, starting at North)	222	72	36I2
34	Elevation angle of the horizontally polarised component (in degrees, negative if above the horizontal)	294	4	F4.1
35	Unused columns	298	2	
36	Elevation angle of the vertically polarised component (in degrees, negative if above the horizontal)	300	4	F4.1
37	Unused columns	304	2	
38	Unused column	306	1	
39	Maximum effective antenna height (m)	307	5	I5
40	36 values of effective antenna height (in m, at 10 degrees intervals, starting at North)	312	180	36I5
41	Organisation name or code	492	5	A5
42	Programme identifier	497	5	A5
43	Date of last change to data on file (DDMMYYYY)	502	8	2I2, I4
44	Designation of emission for the vision signal	510	9	A9
45	Designation of emission for the primary sound signal	519	9	A9
46	Designation of emission for the secondary sound signal	528	9	A9
47	Unused columns. May be used for comments	537	231	
99	Reserved for database housekeeping purposes	768	32	A32

Table B3.2

CEPT digital television transmitter database record

Field	Item	Start Column	Width	Type
1	File identifier, must be TVD1	1	4	A4
2	ITU code for administration responsible	5	3	A3
3	Identification code used by organisation	8	9	A9
4	Update code used by organisation	17	1	A1
5	Space reserved for serial number (e.g. ITU No.)	18	9	A9
6	Status code (**O**perating/**N**ot operating)	27	1	A1
7	Date of entry into operation (DDMMYYYY)	28	8	2I2, I4
8	ITU code for country in which transmitter is sited	36	3	A3
9	Station name	39	20	A20
10	Latitude (in degrees, N/S, min., sec.)	59	7	I2, A1, 2I2
11	Longitude (in degrees, E/W, min., sec.)	66	8	I3, A1, 2I2
12	Height of site (m asl; as sign followed by a number)	74	5	I5
13	Digital Television system, from Table A1.1	79	2	A2
14	Carrier and guard interval, from Table A1.2	81	1	A1
15	Channel	82	3	A3
16	Unused	85	4	A4
17	Block centre frequency in MHz (including decimal point)	89	9	F9.3
18	Offset value in Hz (as sign followed by a number)	98	8	I8
19	Offset type (**U**nspecified/**N**ormal/**P**recision)	106	1	A1
20	Maximum e.r.p. of horizontally polarised component (in dBW; as sign followed by a number including a decimal point)	107	5	F5.1
21	Maximum e.r.p. of vertically polarised component (in dBW; as sign followed by a number including a decimal point)	112	5	F5.1
22	Identifier for SFN	117	5	A5
23	Relative timing of transmitter within an SFN (μsec)	122	6	I6
24	Unused	128	17	A17
29	Polarisation (**H**/**V**/**M**)	145	1	A1
30	Height of antenna (m a.g.l.)	146	3	I3
31	Directional? (**D**irectional/**N**on-directional)	149	1	A1
32	36 values of e.r.p. reduction (in dB) of the horizontally polarised component in the horizontal plane relative to the maximum e.r.p. of the horizontally polarised component as given in field 20 (at 10 degrees intervals, starting at North)	150	72	36I2
33	36 values of e.r.p. reduction (in dB) of the vertically polarised component in the horizontal plane relative to the maximum e.r.p. of the vertically polarised component as given in field 21 (at 10 degree intervals, starting at North)	222	72	36I2
34	Elevation angle of the horizontally polarised component (in degrees, negative if above the horizontal)	294	4	F4.1

Field	Item	Start Column	Width	Type
35	Unused columns	298	2	
36	Elevation angle of the vertically polarised component (in degrees, negative if above the horizontal)	300	4	F4.1
37	Unused columns	304	2	
38	Unused column	306	1	
39	Maximum effective antenna height (m)	307	5	I5
40	36 values of effective antenna height (in m, at 10 degrees intervals, starting at North)	312	180	36I5
41	Transmission provider	492	5	A5
42	Service provider	497	5	A5
43	Date of last change to data on file (DDMMYYYY)	502	8	2I2, I4
44	Designation of emission	510	9	A9
45	Unused columns. May be used for comments	519	249	249
99	Reserved for database housekeeping purposes	768	32	A32

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B4. INTERACTION WITH OTHER SERVICES

B4.1 General

Broadcasting does not have exclusive access to the frequency bands allocated to the broadcasting service. A number of sharing situations exist and these vary from one country to another, both in terms of the "other service" involved and its status in Radio Regulatory terms. Neither the status nor the right to protection are of direct concern here, however, it is clear that methods for calculating any potential interference either from or to the broadcasting service are required. This calculation process is complicated by the fact that it may be necessary to consider either assignments or allotments as the basis for digital television planning. (This is also a difficulty which must be dealt with in the planning of television services with no consideration of interference to or from other services.)

The sharing situations include:

- radiodetermination in the UK in channel 36;
- radioastronomy in channel 38;
- various military (ground and airborne) services in Band V up to channel 69;
- services ancillary to broadcasting and programme making (SAB/SAP);
- any other service sharing with television in Bands III, IV and V up to channel 69.

B4.2 Other service stations

Regardless of whether planning is done on the basis of digital television assignments or allotments, it is essential to have a clear definition of the other service requirements, in terms of their susceptibility to interference and their protection needs and also in terms of their potential to cause interference. In the case of a receive-only service, such as Radio Astronomy, the potential for causing interference may be regarded as zero.

B4.2.1 Protection needs of other services

In addition to obvious elements:

- centre frequency;
- signal level to be protected;
- protection ratio as a function of frequency separation between other service and digital television centre frequencies;
- percentage time for which protection is required;
- other service receiving antenna orientation and discrimination (if relevant).

it is also necessary to determine the area or the locations for which the protection is required. The latter may conveniently be done by specifying a set of test point locations (as longitude, latitude and height above ground level) which represent either:

- the boundary of the area within which protection is required; or,
- the actual locations at which a receiving installation is, or may be, installed.

In order to avoid some ambiguities which have created difficulties in the past, special care needs to be taken when obtaining information about other service receiving antenna characteristics:

- in the case of mobile reception, it is assumed that there is neither directivity nor polarisation discrimination; and,

- in the case of fixed reception, it is necessary to specify the orientation of the receiving antenna, as well as its co- and cross- polar discrimination as a function of relative bearing.

B4.3 Technical elements of other services needed for compatibility calculations

The parameters which are needed for compatibility calculations are for transmitting and/or receiving terminals:

- modulation;
- frequency;
- bandwidth;
- maximum radiated power;
- azimuthal radiation pattern;
- polarisation;
- polarisation discrimination;
- site co-ordinates and height information (longitude, latitude and height above ground level, or sea level, as appropriate);
- protection ratio as a function of frequency separation;
- minimum signal level to be protected for a given installation;
- time percentage to be protected;
- coverage area defined by calculation test points (up to 36).

B4.4 Calculation of the protection of other services

A calculation should be made for each of the test points used in the definition of the other service. This calculation should take into account:

- the protection ratio for the frequency difference between the other service and the digital television service;

- the signal level from the interfering assignment;
- other service receiving antenna discrimination (polarisation and directivity), where relevant.

From the above information, the nuisance field strength (at each of the test-points) may be calculated for the other service.

The nuisance field strength, En, is defined as:

$$En = E_i + PR + A$$

where, expressed in dB:

E_i = field strength value of DVB-T assignment
PR = relevant protection ratio
A = relevant receiving antenna discrimination ($A \leq 0$)

During any necessary co-ordination discussions, the nuisance field strength (at each of the test points) may be compared with the minimum signal level to be protected for the other service.

The calculation of the interfering signal level is dependent upon the other service being considered. Rec. ITU-R P.370 (for individual transmitters) or a statistical method (for SFNs) may be used for terrestrial other services, taking into account the relevant percentage of time. However, free-space calculations will be needed for aeronautical (or satellite) services if a line-of-sight condition between other service receiver and interfering transmitter exists.

B4.5 Calculation of the protection of digital television

A calculation should be made for each of the test points used in the definition of a digital television coverage area. This calculation should take into account:

- the protection ratio for the frequency difference between the other service and the digital television service;
- the signal level from the other service transmitter;
- the digital television service receiving antenna discrimination (in the case of fixed antenna reception).

From the above information, the nuisance field strength (at each of the boundary test-points) may be calculated for the digital television service.

The nuisance field strength, En, is defined as:

$$En = E_i + PR + C + A$$

where, expressed in dB:

E_i	=	field strength value of the other service assignment
PR	=	relevant protection ratio
C	=	location correction factor (to achieve a location probability of 95% instead of 50%). See also §B1.4.
A	=	relevant receiving antenna discrimination ($A \leq 0$)

During any necessary co-ordination discussions, the nuisance field strength (at each of the boundary test points) may be compared with the minimum signal level of the digital television service.

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B5. NETWORK PLANNING

B5.1 Introduction

Throughout Europe analogue television is highly developed, and most countries achieve more than 99% population coverage on at least two or three national networks. In parallel, a large number of local networks with lower coverages are operated. The need to achieve a large percentage of coverage leads to the use of very many television transmitters. The radiated power of these covers a wide range: from about 1 MW effective radiated power (e.r.p.) for major stations serving large areas, to less than 1 W e.r.p. for small stations intended to serve perhaps a few hundred people.

Analogue TV systems (PAL, SECAM) are very sensitive to interference from other analogue TV signals, and require high co-channel protection ratios (of the order of 30 dB to 45 dB, depending on the value of frequency off-set). Furthermore, adjacent channels cannot generally be used from the same transmitting location.

In addition, analogue TV systems cannot operate in a single frequency network (SFN) configuration, where neighbouring transmitters cover overlapping service areas with the same programme, on the same RF channel. Therefore the existing analogue services are planned in multi-frequency network (MFN) configurations, covering adjacent service areas with different RF channels. The same RF channel is re-used only in regions separated by a large distance, to avoid harmful co-channel interference.

European television coverage is therefore characterised by an intensive exploitation of VHF/UHF channels, with large areas where a given channel cannot be re-used because of the high protection ratios required by analogue systems. The total available RF channels (at maximum 10 channels at VHF and 48 at UHF) allow for only up to about 2 VHF programmes and 3 to 5 UHF programmes per coverage area, if high protection from interference is required. Higher spectrum exploitation could be obtained by using precision offset techniques.

It should be noted that in some countries a more intensive use of the spectrum is achieved, but in this case it is commonly found that many programmes show a very poor technical quality, due to interference or noise, especially in the less densely populated areas.

Analogue MFNs are usually based on relatively few high power transmitters, located where possible on hills or mountains. They are fed by cable or by radio links or sometimes by satellite or optical fibres. In addition to these, to follow precisely the terrain orography in the presence of hills or mountains or other obstacles, or to improve reception in highly populated regions, a very large number of lower power transmitters has been put in operation. They are usually fed by the signals broadcast by the higher power transmitters or, sometimes, by radio links.

In conclusion, the current analogue TV networks make use of a large percentage of the available VHF/UHF spectrum, and operate in MFN configurations with medium to high transmitter density. In each service area, a large number of RF channels cannot be re-used for high power analogue services, because of potential interference. Since digital systems can be

significantly less sensitive to noise and interference, this spectrum could be used to introduce digital TV services, capable of operating at reduced e.r.p. levels. (However, care must still be taken to ensure that these digital services do not **cause** interference to existing analogue services).

The digital TV systems may offer improved RF performance over the analogue systems, in terms of spectrum efficiency and power requirements. First of all, digital systems allow multi-programming: in a single 8 MHz channel, 2 to 4 standard definition programmes (SDTV), at about 6 Mbit/s each, can be transmitted in time division multiplex. The total capacity (from 12 to 24 Mbit/s) can also be allocated to higher quality TV standards, such as enhanced definition TV (EDTV, requiring about 10 to12 Mbit/s per programme) or HDTV (requiring about 24 Mbit/s per programme). Of course, the higher capacity systems also have higher minimum C/N ratio requirements.

Digital systems can be significantly less sensitive to noise and interference, especially when the system spectrum efficiency is not too high and sophisticated modulation and error correction techniques are adopted. This can offer the possibility to operate at low e.r.p. levels (depending on the modulation) thereby reducing interference to existing analogue services.

Nevertheless, it should be taken into account that the best modulation and error correction systems show a very steep failure characteristic; a digital system can operate under severe reception condition without decoding errors, but an increase of 1 to 2 dB of the noise or interference level can suddenly interrupt the service. Therefore wide margins must be kept in the planning procedures to allow for service availability at a high percentage of locations and a high percentage of time.

Digital modulation and channel coding systems can achieve different trade-offs between spectrum efficiency and ruggedness against noise and distortion. For example, for fixed reception, a suitable spectrum efficiency can be of the order of 4 bits/s/Hz, (i.e., a useful bit-rate of about 24 Mbit/s in an 8 MHz channel), while for static portable reception a more suitable value may be 1 to 2 bits/s/Hz.

The introduction of digital terrestrial television in the immediate future has a main constraint which is the need to protect the existing analogue services. In addition, good digital service coverage is needed to provide an attractive development basis.

In many countries, due to the intensive spectrum exploitation, there is no possibility of access to unused television networks or individual station assignments (co-ordinated and included in the updated Stockholm Plan) at least at relatively high power. In these countries, the use of new channel assignments (for example, in the range 61 to 69) is almost essential in order to introduce any new digital services.

B5.2 Multi-frequency networks

The advantage of the multi-frequency planning approach is that a large part of the existing analogue network infrastructure may be re-used. This has obvious cost-saving implications for the broadcaster but should also provide benefits for the viewer. The latter will arise in any case where it is found possible to use channels for the digital transmissions from a particular site

which are close to the channels used for the analogue transmissions from the same site, especially if the same polarisation can be used. This should permit viewers to re-use their existing receiving antenna and feeder system. Some form of signal splitter or switch may be needed to permit separate feeds to the analogue and digital receivers although this could be avoided if the digital receiver provides loop-through facilities.

During the transition period of co-existence of analogue and digital services, and especially at the first introduction of digital services, it may be important not to place unnecessary difficulties in front of potential viewers and thus avoiding the necessity of a new receiving antenna system can be regarded as desirable.

Another aspect of multi-frequency planning is that it makes an inherent assumption that the existing analogue services, which currently serve more than 98% of the population in most European countries, will remain in use for many years and that relatively few changes to the analogue stations will occur in that time. In particular, there are likely to be no generally-applied channel or site changes within the analogue networks.

However, it may be found desirable to introduce a limited number of channel changes, or even site changes, at some of the lower power analogue stations where this can be shown to have a significant impact on the implementation opportunities for digital stations and services.

In most countries there are few (or even no) opportunities for the introduction of new analogue stations with a significant population coverage. Opportunities exist for the introduction of new digital stations because of their greater immunity to interference and the ability of digital receivers to make use of lower input signal levels, given a suitable digital television system. Even so, these opportunities are limited by the need to protect existing analogue viewers from additional interference.

B5.2.1 Conventional planning of MFNs

The term "conventional planning" is used to describe the situation where the network for a digital service has a similar configuration to that for an analogue service, at least for the higher power stations. This means that digital stations would use much the same transmitter sites as analogue stations and would have comparable transmitting antenna heights, although the e.r.ps. would be lower.

The primary reasons for the lower e.r.p. values are:

- the lower minimum field strength requirement;
- the need to protect existing analogue viewers.

It seems likely that in many cases the digital services would use channels close to those of the analogue services, for example the adjacent channels. Generalisations with regard to choice of polarisation are not possible, but the use of the same polarisation for the digital and analogue services would at least mean that existing domestic receiving antennas could be used for the digital services without change. Because the services come from the same site and because the digital service e.r.p. would be lower than that of the analogue service (for the reasons given

earlier), there would be little risk of causing adjacent channel interference to the existing analogue service viewers. If this type of interference were to exist, it would be present for 100% of the time and therefore must be avoided. It must be noted that many of the technical aspects related to the use of adjacent channel transmissions from the same site still need to be investigated.

The coverage areas for the digital services are likely to be reduced in size compared with those for the analogue services, the amount of reduction being dependent on the C/N value required. Nonetheless, it is to be expected that significant population coverages can be obtained, provided that some degradation of the analogue service due to co-channel interference can be accepted.

It seems unlikely that channels could be found which would permit the duplication of existing analogue services by digital services at all higher power analogue transmitter sites in all countries.

B5.3 Single frequency networks

B5.3.1 General

In a single frequency network (SFN) all transmitters of a network use the same channel. They possess a common coverage area and cannot be operated independently. MFN and SFN concepts are based, in principle, on the same network topology, i.e. main transmitters with auxiliary gap fillers, if necessary.

OFDM, the modulation technique which enables the reception (and constructive summation) of more than one useful RF signal, is described in §A0.

B5.3.2 Spectrum efficiency

Spectrum efficiency is regarded as a major advantage of the SFN concept as compared to the MFN approach. Spectrum efficiency is an important feature in a situation where spectrum is scarce, for example, in the introductory phase of digital television, when most of the TV spectrum is still occupied by analogue services, as well as in the long term, when a large number of programmes has to be provided to make terrestrial digital television attractive for the consumer.

Current analogue services are operated as MFNs. Within the UHF band, with 40 channels, 2 to 4 well-protected full-coverage analogue programmes can be achieved (depending upon the geographic situation of an individual country). Digital systems will be more efficient than this. Using MFNs, it can be expected that 3 to 6 full coverage networks could be implemented; with 4 programmes per channel, this would amount to 12 to 24 programmes. Using SFNs, it can be expected that the number of full-coverage networks (and the number of programmes delivered) is two to three times higher. If the target for coverage were changed to be the more densely populated areas only, the number of channels available could theoretically be around 40. All of these figures are based on theoretical considerations and the effect of practical considerations

has to be checked case by case, for example, taking account of services in neighbouring countries.

B5.3.3 Echo delay in SFNs

Terrestrial television broadcasting in VHF/UHF bands is characterised by attenuation and multipath propagation, due to the presence of obstacles and reflections in the propagation environment. Therefore the signal at the receiver is characterised by the presence of a main signal component, and of many echoes, with variable amplitude and delay (Ricean channel). In the case of portable reception, the principal signal can be absent (Rayleigh channel). The delay of these "natural echoes" is usually limited to 20 to 30 µs, corresponding to difference of propagation path of about 6 to 9 km.

The presence of SFN transmitters and gap-fillers produces a significantly more critical multipath propagation environment, introducing "artificial echoes" of high amplitude and long delay. These artificial echoes are superposed on the natural echoes. The range of delay times of the artificial echoes is proportional to the transmitter distance, and it is determined by the transmitter network geometry. For example, assuming that in a large SFN with transmitter distance D=100 km the range of delay times is 330 µs, for a dense SFN with D=10 km it would be only 33 µs.

B5.3.4 Network gain

In an SFN many receiving locations can be covered by more than one transmitter, thus introducing a certain level of redundancy in the signal sources and improving the service availability, especially when portable reception is required. Particularly in portable reception, the field strength from a single transmitter shows statistical variations due to the presence of obstacles on the propagation path. This field strength variation can be reduced by the presence of several transmitters, located in different directions, since when one source is shadowed, others may be easily receivable. This is known as "network gain" (see also **Annex B5.1)**. Numerical examples are given in §B5.4.2.

As a result of network gain, SFNs can be operated at lower power for the main transmitters and the field strength distribution is more homogeneous as compared to MFNs. The impact of these features for fixed reception may not be very prominent but portable reception with its non-favourable receiving sites and non-elaborate receiving antennas will benefit from these features to a large amount. The SFN approach seems to be the most reasonable way to provide satisfactory coverage for larger areas when portable reception is envisaged.

B5.3.5 Planning of SFNs

Since the MFN and SFN approaches are based on the same network transmitter topology, SFNs can use, in principle, the network structure of the existing MFN analogue networks. In general, it can be expected that fewer gap fillers are needed with SFNs because of their more uniform field strength distribution.

The introduction of SFN-based DVB-T services is faced with the major problem that most (or all, in some countries) of the TV spectrum is occupied by analogue services which use a MFN structure. Even if some unused Stockholm 61 assignments exist (in a given country) which could be used for digital television, this is only of limited use for the introduction of an SFN-based large area service since a network can only operate in the SFN mode under the condition that its channel is cleared for the entire service area. If there are still analogue services using this channel - and this is probable as long as there is any national or regional analogue service in operation - the affected analogue transmitters would have to be shifted in frequency. Among these transmitters there will be main stations with a considerable amount of population coverage. It is questionable whether it makes sense, from the accompanying large cost efforts for broadcasters and consumers, to re-arrange an analogue service which will later be phased out. However, there may be suitable channel configurations that make this transformation practicable. In particular, for smaller area networks comprising only two or three high power transmitters the SFN approach may be applicable and attractive.

In some countries the possibility exists that in the UHF band one or more channels will be released for the implementation of digital services on a nation-wide scale. These channels are either not yet allocated to TV broadcasting, or they are already allocated but not used by TV services. These countries are offered a good chance to implement an SFN-based digital service on a national or regional scale, which potentially represents the introduction of an attractive long term scenario from the very beginning. In general, the use of these channels may not be possible on an entire nation-wide basis because of neighbouring countries which probably use these channels for analogue TV or other services.

B5.3.6 Types of SFNs

SFNs can be implemented in different ways. **Annex B5.2** gives definitions of the various types of SFN being considered.

B5.3.6.1 Large area SFNs

Large area SFNs are built from at least two up to several dozens of high power transmitters together with associated medium and low power transmitters. They form the best way of exploiting the high spectrum efficiency inherent in the SFN approach.

In the case that a group of new frequencies is allocated to the new digital services, a straightforward approach is the introduction of some national SFNs, and smaller SFNs to cover the regional programming requirements. This scenario could equally apply to the long term situation for digital television, when the analogue services will have been phased-out.

On the other hand, in a country with fully developed analogue networks and few unused but accessible assignments it is unlikely that large-scale SFNs could be implemented. One possibility which might be explored would be to implement general channel changes at existing analogue stations. However, it seems unlikely that this could be undertaken in practice

because of the widespread disruption of existing reception for the country concerned and for its neighbours.

B5.3.6.2 Mini SFNs

In a mini SFN an existing main station and many (perhaps all) of its auxiliary low power stations would share the same channel. This is an attractive concept in terms of channel economy and homogeneity of the field strength distribution but there are still a number of technical matters to be examined.

Among these, is the fact that there are likely to be viewers of the existing analogue transmissions from the main station who are situated close to the relay station sites. Such viewers are likely to experience interference from the digital transmissions from the relay station if these use channels adjacent to those of the analogue services. In addition, in the case of fixed reception, the receiving antennas used by the viewers of the analogue services from the relay stations may not be suitable for reception of the new digital services because of channel differences. On the other hand, for portable reception the concept of mini SFNs provides an attractive means for increasing the coverage of digital television.

B5.4 Multiple signal effects

In general, the reception of digital services is faced with a multi-signal environment, multiple interference as well as multiple wanted signals in the case of SFNs. To assess the wanted and unwanted resultant field strengths the individual signals have to be combined. Since signal strengths are described by statistical quantities they have to be combined statistically.

Basically, this is true for both location and time statistics. However, it is usual to treat them in different ways. Time statistics are taken account of by using tabulated field strength propagation curves for the appropriate time percentages. Location statistics are dealt with by using field strength distributions.

General aspects of time and location statistics and mathematical methods to perform statistical summation are described in §B1.5. The impact of signal summation effects on planning methods and parameters is discussed in the present section.

B5.4.1 Single signals and propagation margins

Location statistics of an individual (logarithmic) field strength originating from one transmitter is described by means of a normal distribution which is characterised by two parameters, mean value and standard deviation. Accordingly, the power of the signal is then distributed log-normally.

Coverage probability targets play a key role as planning parameters for a digital system is discussed (see §B1.5). These target figures are related to the field strength distribution

parameters. 50% coverage probability is determined by the mean value of the distribution, for the calculation of higher (and also lower) coverage probabilities both mean value and standard deviation of the signal distribution are needed.

In the case of a single signal, where the distribution parameters are known a priori, propagation margins to cater for higher coverage probabilities, as described in §B1.4.1, are easily calculated, e.g., the propagation margin for a 95% coverage probability is given by $1.64 \times \sigma$, where σ denotes the standard deviation. This is how the minimum median field strengths for planning are determined in §B1.4. The same applies to propagation margins for protection ratios when one wanted and one unwanted field are involved.

B5.4.2 Multiple signals and network gain

When a multi-signal situation is encountered, the parameters of the resulting sum signal distribution are no longer known a priori. Mean value and, especially, standard deviation strongly depend on the particular signal configuration having to be determined by means of statistical procedures. As a consequence, minimum field strengths and propagation margins to be used in coverage calculations no longer have fixed values, they rather become variables depending on the number, strength and spread of the individual single fields. However, two general trends can be identified. Firstly, the mean value of the combined sum signal is larger than the arithmetic sum of the mean values of the individual signals and, secondly, the standard deviation of the combined sum signal is smaller than that of the individual signals, both facts creating the effect of network gain (in the case of wanted signals).

The following examples may illustrate the significance of field strength summation effects. A coverage probability target of 95% is assumed in the examples and the standard deviation of the single fields is chosen to be 5.5 dB. The examples are calculated for receiving systems with a non-directional antenna pattern thus taking maximum benefit from the space diversity introduced by the active echoes in an SFN. For receiving systems with directional antennas, e.g., fixed roof top reception, the effect of network gain is reduced, since active echoes are attenuated by the space selectivity of the antenna.

Maximum statistical network gain is achieved if the contributing fields are of equal strength. In the case of, e.g., 3 single signals it amounts to 5.1 dB. This means, it would allow for an overall power reduction in an SFN by a factor of 3 as compared to a single transmitter coverage.

Not all locations covered by an SFN benefit to such an amount from network gain. As a second example, an edge location of a typical, closed 7-transmitter hexagon SFN is chosen. Though situated on the fringe of the coverage area it still experiences a network gain of about 4 dB, reducing the minimum field strength for planning by that amount.

Similarly, propagation margins for protection ratios are reduced by signal summation effects. Again, as an example, an edge location in a 7-transmitter hexagon SFN is chosen, now interfered with by a second, identical SFN situated at the re-use distance, i.e. fairly close. Here field summation effects for both wanted and unwanted signals lead to a reduction of the necessary propagation margin of about 4.5 dB, indicating the ability of the wanted SFN to

cope with a roughly three times higher interference without losing the coverage probability target.

The examples show that signal summation effects in SFNs may impact the coverage of a digital service to a significant amount.

It has already been stated that signal summation effects increase the mean value and lower the standard deviation of the resulting sum signal distribution as compared to the outcome of the standard treatment. This is an important finding, since it gives the possibility to fix the results of the standard treatment as an upper bound for initial planning estimates. Allowing for some additional implementation margin, they form an appropriate basis for planning when detailed information about the transmitter characteristics of a network is not available, e.g., when setting up an allotment plan. These figures are given in §B1.4.

On the other hand, detailed planning, e.g., installing an assignment plan or implementing a real transmitter network, has to take account of signal summation effects. Propagation margins for minimum field strengths and protection ratios then no longer form suitable planning parameters. They have to be replaced by the more basic coverage probability targets. Their relation to the sum distribution parameters of the wanted and unwanted sum fields is described in §B1.5.

B5.4.3 Multiple interference and self interference

Time statistics for interfering fields are taken account of by basing calculations on 1% time propagation curves, whereas wanted field calculations are based on 50% (or 99%) time propagation curves. Statistical signal summation effects for interfering fields with respect to location statistics are effective, in principle, in the same manner as described for wanted fields in the previous section. However, their impact on coverage calculations is not that important because of the asymmetrical characteristics of the sum field distribution. Therefore, it is often justified to treat multiple interference with simpler statistical procedures.

In considering SFNs it should be recognised that not all the transmitters in a network will contribute to the wanted signal. Depending on the system and network parameters, such as guard interval and distances between transmitters, some signals may become interferers. This effect is called the self interference of the SFN. It is of larger importance for the DVB-T system with its higher protection demand than for T-DAB, and has to be met by careful network design.

With respect to signal summation, self interference fields are treated as ‘normal’ unwanted signals. 1% time propagation curves are used, and they are added to the other source of possible interference from outside the SFN.

However, a problem arises with the treatment of the interfering and the contributing signal parts. Usually, unwanted field strengths are calculated on the basis of 1% time propagation curves and wanted fields on the basis of 50% time propagation curves. If both parts emerge from the same field the question is whether to adopt the 1% time or the 50% time propagation curves as the basis of the calculation. A possible treatment could be to base it on 50% time

propagation curves as long as the major part of the signal shows a contributing behaviour, otherwise to base it on 1% time propagation curves.

In addition, a similar problem is encountered with location statistics. Usually, wanted and unwanted signals are treated as statistically independent. In the case of an interfering and a contributing signal part emerging from the same field this is obviously not true. The impact of this 'self correlation' effect on coverage calculations has not yet been evaluated and needs further investigation.

B5.4.4 Correlations

Spatial correlations between RF signals have been reported to be of non-vanishing significance for the evaluation of the coverage of broadcasting services. Nevertheless, no generally agreed assessment of correlations has yet been established.

Basically, correlation is not a signal summation effect, it may also occur in the presence of only one wanted and one unwanted field. In this case, correlation increases coverage for a given configuration of wanted and unwanted field strengths.

In a multi-signal situation, the opposite effect can be observed. Correlations between wanted signals reduce the network gain of a transmitter network and correlations between unwanted signals increase their interference potential, both effects lowering coverage for a given configuration of wanted and unwanted signal strengths.

In view of the uncertain general assessment of correlations and the different effects they produce with respect to coverage, it seems to be justified to neglect them in planning calculations, at least at the present time.

ANNEX B5.1: Characterisation of theoretical SFNs

Studies have been undertaken to characterise the impact of the digital TV system performance (guard interval, protection ratios) on the service availability in the service area, versus the dimension of a SFN (large or dense). The analysis methodology has been defined and a number of results have been obtained for DVB-T networks.

In a single frequency network, all transmitters broadcast exactly on the same RF channel. The service areas of these transmitters are overlapping, and the transmitted signals are fully synchronised.

Compared with a conventional multiple frequency network (MFN), an SFN allows significant improvements in spectrum utilisation, but it imposes heavy constraints in the design of the transmission system. In fact the useful signal is interfered with by the artificial echoes produced by the other transmitters, characterised by large amplitudes and long delays. The echo delays depend on the difference of the propagation path lengths, and can be of the order of some tens to some hundreds of microseconds, depending on the transmitter distance (e.g., a path difference of 10 km corresponds to a delay of about 33 µs).

These SFN echoes are superposed on the echoes generated by the obstacles (mountains, hills, buildings) often present in the propagation environment (multipath echoes). In general the delays associated with the multipath echoes are shorter than 20-30 µs. This **Annex** refers only to the artificial SFN echoes, while the natural multipath echoes are neglected.

The performance of a digital television system in an SFN heavily depends on the echo delay and amplitude characteristics. Only OFDM systems are considered here, with powerful channel coding schemes suitable to operate under very severe multipath propagation conditions, such as those produced in SFNs. These systems can process the echoes (natural or artificial) in such a way that, up to a certain amount of delay spread, all the fields contribute constructively to the wanted signal. This offers the possibility of establishing SFNs.

A uniform semi-infinite lattice network is used to study the theoretical performance of a SFN, usually based on hexagonal coverage areas.

The propagation model described in Rec ITU-R P.370 is usually used to evaluate the field strength produced by each transmitter in the network in a given receiving point. Mean values for the field-strength location distributions are taken for the land 50% location / 50% time-curves for the useful components of the SFN signal. For interfering signals, it is more usual to use the 50% location / 1% time-curves, which correspond to greater impairment. Calculations are carried out with a location variation standard deviation of 5.5 dB for individual signals.

For DVB-T services, both fixed reception (with roof-top directive antennas) and portable reception are of interest. Rec ITU-R P.370 propagation curves give field strengths which are valid for reception with an antenna situated 10 metres above ground level (a.g.l.). This model

is suitable for DVB-T fixed reception with roof-top antennas. For portable DVB-T reception, it is necessary to subtract some 10-20 dB from the field strength value predicted for 10 m agl.

A location coverage of 95% is generally demanded for DVB-T services, at least for fixed reception and roof-top antennas. It is well known that in this high-probability domain, the statistical network gain of a SFN provides a significant part of the overall coverage. Particularly for portable reception in shadowed areas, the space diversity of the signal sources provides a reduction in the field-strength variations and improvement in the coverage. It is therefore necessary to treat the statistical aspects as thoroughly as possible. Non-statistical approaches lead to severe under-estimation of the coverage and give an incorrect impression of the validity of SFN concept.

The statistical summation of the field-strengths is performed by means of a "Monte Carlo" technique. For every location, the signal components from the various transmitters are randomly generated with the suitable statistical distributions, and according to the delay and the system guard interval, an equivalent aggregate carrier to noise C/N and interference ratio C/I is obtained. For a first investigation of the SFN performance, a simplifying assumption of "interference limited network" (i.e. no noise) can be done. In the case of roof-top directive antenna, it is assumed that it is pointed in the direction of the strongest transmitter (although this may not always be appropriate).

The combination of C/N and C/I is compared with the system threshold (relevant to a severe multipath environment, such as a Rayleigh channel), to determine whether this particular receiving point is served or not served. To achieve statistically significant results, this procedure is repeated thousands of times for each "small area" or “pixel”, and then repeated on a regular grid over the complete service area.

This method can provide the coverage probability for the service area and overall aggregate values of percentage of served locations. An important indicator of the network performance is the percentage of locations served in the worst pixel. Alternatively, the performance can be quantified by means of the percentage of pixels for which a given coverage target is achieved.

This analysis can allow the optimisation of the system parameters (guard interval, threshold C/N and C/I) given a theoretical network configuration (transmitter distance, antenna height), or alternatively, permits a choice of network parameters given a digital modulation/coding system.

ANNEX B5.2: Definitions related to transmitting stations and single frequency networks for digital television services

Transmitting stations for digital services

High power station:

A station with an e.r.p. greater than 10 kW and an effective antenna height usually greater than 150 metres.

Medium power station:

A station with an e.r.p. in the range 100 W to 10 kW (inclusive) and an effective antenna height usually in the range 75 to 150 metres.

Low power station:

A station with an e.r.p. less than 100 W and an effective antenna height usually less than 75 metres.

Single Frequency Networks

Large area SFN:

An SFN which contains more than one high power station together with any associated medium and low power stations, usually with a composite coverage greater than about 10,000 sq. km.

Mini SFN:

One high power station together with at least one (and probably several) associated medium or low power stations.

National SFN:

An SFN covering a whole country.

Regional or Local SFN:

An SFN covering part of a country.

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C0. INTRODUCTION

Because of the close link between the results of the Chester 97 meeting, §C of this document is closely linked to the text of the Chester 97 Agreement.

C1. PRINCIPLES AND PROCEDURES

In considering the development of principles and procedures for the introduction of DVB-T, it has been concluded that the ST61 Article 4 procedure does not prevent co-ordination of DVB-T stations, but some additional provisions are necessary. These have been prepared for Article 4 of the ST61 and are given in Articles 4 and 5 of the Chester 97 Agreement (abbreviated elsewhere as CH97)

C1.1 General principles

For DVB-T the following general principles should be taken into account:

a) **Frequency Bands**
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.

b) **Equitable access**
All countries shall as far as practicable have equitable access to the frequency bands to be used for DVB-T. Therefore if co-ordination requests may have major implications on the development of DVB-T plans of other administrations, the requesting administration should inform the countries affected prior to sending out co-ordination requests.

c) **Unified system values**
International co-ordination should be based on unified system values and planning parameters throughout the planning area (this does not exclude the use of different values, on a national basis). (See §C1.4).

d) **Fixed and portable reception**
For the establishment of technical parameters for co-ordination, both fixed and portable reception should be considered.

For co-ordination purposes a compromise set of receiving conditions have been agreed. (See §C1.4).

e) **Single Frequency Networks**
Administrations are encouraged to use SFNs as far as practicable because of their frequency efficiency.

f) **Assignments or allotments**
The question of assignment or allotment planning has been considered in PT FM 24 and the following points have been identified: (see also §3)

- where transmitter sites are known co-ordination by means of assignments is appropriate;
- in the case of MFN (or small SFN) planning, assignments are more practical;
- where transmitter sites are not known co-ordination by allotments is appropriate;
- if channels are available for planning of DVB-T in large areas, allotments are particularly useful;
- in the case of allotment planning a reference network and conversion rules have to be specified.

For several countries portable reception is seen to be the prime requirement. In the case of portable reception it is foreseen that SFN networks may be necessary in order to achieve good coverage. The use of SFNs allows for diversity of reception, that is the provision of a higher and more uniform field strength within the desired coverage area. In this situation the transmitter sites are not necessarily known at the time of co-ordination.

Due to the intensive use of the spectrum the use of allotment planning for large areas is not feasible and therefore provisions are only made for assignments. However, assignments on the same channel for several sites can be used to form an SFN.

C1.2 Co-ordination Principles

The co-ordination procedures needed in addition to the provisions contained in Article 4 of the Stockholm Agreement are based on the following principles:

a) **Coverage definitions**
Definition of coverage areas according to definitions given in CH97, Annex 1, §.

b) **Co-ordination distances**
The co-ordination distances as given in the ST61 Plan can also be used for the co-ordination of digital television assignments up to 862 MHz, until further studies indicate that it is more appropriate to use other distances. See also CH97, Annex 4.

c) **Test-points**

If co-ordination is required the acceptability of an individual digital assignment or SFN will be assessed by means of calculations of the increase of interference at test points representing the coverage area of any affected individual assignment or SFN. The locations of these test points will either be defined by means of the agreed method outlined in CH97, Annex 1, §, or may be specified by the administration.

d) **Margin**

In general, a moderate increase in interference levels for analogue and new digital stations, at agreed test points, should normally be accepted. Generally calculations will be made using Rec. ITU-R P.370 and summation by the power sum method. For certain areas these calculations will not give realistic results and other propagation models should be considered. In such cases the values given below should be used with caution.

The margin should be applied as a trigger threshold for further investigation. This means that if the increase in the usable field strength is less than the margin the new or modified station(s) should normally be accepted. An increase of more than the margin is open to negotiations, in which more detailed calculation methods may be used.

The increase in interference level is related to a reference value which is the calculated usable field strength at an agreed point in time, that is 25 July 1997, or at a later time when a new digital or analogue assignment is entered in the Plan. The usable field strength is calculated as the power sum of all the nuisance field strengths from assignments in the updated ST61 Plan and the minimum field strength for the television system and the frequency band under consideration.

The increase in usable field strength which should normally be accepted is 0.3 dB per request in relation to the reference value. An increase of more than 0.3 dB is open to negotiations, in which more detailed calculation methods may be used.

However, in some areas and on some channels, the usable field strength for digital stations may be low, near the minimum field strength value. In these cases, a larger value of the margin might be acceptable.

In the case of a request for an SFN, the nuisance field is calculated as the power sum of the contributions from all transmitters of this SFN.

For the protection of low-power television assignments (analogue or digital) special treatment may be needed.

e) **Location of transmitters**

The nominal location of the stations is given by their geographical co-ordinates (longitude and latitude) expressed in degrees, minutes and seconds. A change of location should always be notified unless the site remains within 2 km of the nominal location, provided that the change in topographical conditions does not substantially increase the probability of interference to the stations of other countries.

C1.3 Co-ordination Procedures

C1.3.1 Introduction

If co-ordination of a DVB-T assignment is requested the administrations consulted should determine if it is acceptable with regard to the protection of their own analogue TV assignments, their own DVB-T assignments, their own T-DAB allotment boundaries and their other services that require protection. **Table C1.1** gives the various possibilities.

The positions indicated as ST61 are covered by the Stockholm agreement; the Wiesbaden Arrangement as WI95; the position indicated as RR is covered by the Radio Regulations; the positions indicated as CH97 are related to digital television; co-ordination procedures for these cases have been developed by CEPT.

Service to be protected	Service to be coordinated			
	Analogue TV	DVB-T[1]	T-DAB[2]	Any other services
Analogue TV	ST61	CH97	WI95	ST61
DVB-T[3]	CH97	CH97	CH97	CH97
T-DAB[4]	WI95	CH97	WI95	WI95
Any other services	ST61	CH97	WI95	RR

Table C1.1: Matrix of co-ordination possibilities

C1.3.2 Flowcharts for co-ordination procedures

To assist in the application of the CH97 Article 4 procedures flow charts (reproduced from CH97 as **Figures C1.1 to C1.3**) have been developed for the co-ordination of:

Service to be coordinated	**Co-ordination procedure**	**Flow chart**
Analogue television	CH97 Art. 4 §A	Fig. C1.1
DVB-T	CH97 Art. 4 §B	Fig. C1.2
T-DAB	WI95	none
Other Services	CH97 Art. 4 §C	Fig. C1.3

The flow chart for the conversion procedure of CH97 Annex 6 is given in **Figure C1.4**.

[1] Individual assignments or SFNs.
[2] As defined in the Wiesbaden Special Arrangement 1995

Part of the co-ordination procedure is a compatibility analysis in which the service to be coordinated is tested against all four services to be protected. The compatibility analyses, as far as appropriate, are shown in separate flow charts, Fig. C1.5 to C1.8.

Service interfered with/by	Co-ordination procedure	Flow Chart
DVB-T/analogue television		
DVB-T/DVB-T	CH97 Annex 4 § A & C	Fig. C1.5
Analogue television/DVB-T	CH97 Annex 4 § B	Fig. C1.6
Other services/DVB-T	CH97 Annex 4 § D	Fig. C1.7
DVB-T/Other services	CH97 Annex 4 § E	Fig. C1.8

The flowchart in **Figure C1.9** indicates which database is to be used in each compatibility analysis.

The shadings in the flow charts of co-ordination procedure A, B, and C have the following meaning:

Action by the administration requesting the new assignment or allotment.

Action by the administration consulted.

Common action of requesting and consulted administration.

The flow charts are for information only and are not formally part of the Chester Agreement.

C1.3.3 Co-ordination procedures covering DVB-T

The co-ordination procedures for DVB-T are based on Article 4 of ST61. The procedures are given in CH97 Articles 4 & 5. These procedures deal with the co-ordination of analogue television stations, DVB-T stations (including SFNs and stations of other services than broadcasting having primary status. The consulted administrations should calculate the compatibility of the request by using the “Compatibility analyses” described in CH97 Annexes 4 & 5.

C1.3.4 Conversion of analogue into digital assignments

Analogue television will continue for a long time. Therefore, conversion rules have been defined for protection of existing analogue services and also to provide the possibility of conversion from analogue to digital assignments. These procedures have been developed to maintain equitable rights irrespective of the time of conversion.

It is assumed that all analogue assignments may be converted into digital in future.
The conversion procedures are based on two principles:

a) the future digital coverage area should not significantly be restricted by new analogue or digital television stations or stations of other services.
   In order to assure protection of the current analogue coverage and also of the future digital coverage two sets of calculations are required.

   The first set of calculations is for the actual situation where the interfering stations are analogue or already co-ordinated digital stations.

   The second set of calculations is for the future digital situation. In this hypothetical case all analogue stations are assumed to be digital, the erp values are taken as the original analogue erp values minus 7 dB.

b) the nuisance field of a digital station or the power sum of the nuisance fields of an SFN resulting from a conversion of an analogue assignment may have the same value as the nuisance field of the original analogue assignment provided that a conversion of the affected station and possibilities for new digital stations are not restricted.

In order to assure the future developments in affected countries two sets of calculations are required. The first set of calculation is to assess that the field strength of the converted station is 7 dB below the field strength of the original analogue assignment at test points at the edge of the coverage area and at border test points.

The second set of calculations determines the bottom line radiation characteristic that could always be used because the nuisance field remains below the minimum usable field strength.

C1.4 Reference reception conditions

For co-ordination a set of reference reception conditions have been agreed. It should be pointed out that these reference conditions represent in a number of cases compromise values.

C1.4.1 Reference reception conditions for digital television

Due to the inherent flexibility of DVB-T which can be selected to meet a given country's requirements, it is likely that various planning criteria will be used throughout the CEPT planning area.

In order to place international co-ordination on an equitable basis it is necessary to use a representative set of reference conditions.

The values given in **Table C1.2** for the reference reception conditions represent a compromise between requirements for fixed reception and portable outdoor reception.

These values can form a basis for the initial implementation of DVB-T. As there is a significant interest in portable reception, including indoor portable reception, the values shall be reviewed at a relevant point in time.

Changes to the values in **Table C1.2** should be done on a multilateral basis.

The reference conditions for analogue television are given implicitly by the systems.

Table C1.2
Reference reception conditions for digital television

Conditions	Value			Notes
	Band III	Band IV	Band V	
Nominal receiving antenna height	10 m agl	10 m agl	10 m agl	1
Receiving antenna directivity discrimination	None	None	None	
Receiving antenna polarisation discrimination	None	None	None	
Required C/N value	20 dB	20 dB	20 dB	2
Co-channel protection ratio for DVB-T interfered with by analogue television.	8 dB	8 dB	8 dB	3
Minimum equivalent field strength at the receiving place	46 dBμV/m	56 dBμV/m at 500 MHz	60 dBμV/m at 800 MHz	4
Location correction factor	9 dB	9 dB	9 dB	5
Minimum median equivalent field strength	55 dBμV/m	65 dBμV/m at 500 MHz	69 dBμV/m at 800 MHz	6

Notes
1. This value does not imply that a receiving antenna must be at 10 m agl, it only sets a (commonly used) reference.
2. Including the implementation margin. This value is also to be used as the co-channel protection ratio value for the case of DVB-T interfering with DVB-T.
3. This value is to be used for co-ordination and includes the implementation margin.
4. To account for the variation of minimum equivalent field strength with frequency in Bands IV and V, the value to be used is given by 56 + 20 log (f / 500) dB μV/m where f is the frequency of the digital assignment in MHz.
5. Corresponding to a target reception location probability of 95%. For the purpose of interference assessment, a propagation correction factor of 13 dB is required (see CH 97 Annex 1 §.2).
6. To account for the variation of minimum median equivalent field strength with frequency in Bands IV and V, the value to be used is given by 65 + 20 log (f / 500) dB μV/m where f is the frequency of the digital assignment in MHz.

C1.4.2 Reference reception conditions for analogue television to be used in digital television

Table C1.3
Reference reception conditions for analogue television

Conditions	Value			Notes
	Band III	Band IV	Band V	
Nominal receiving antenna height	10 m agl	10 m agl	10 m agl	1
Receiving antenna directivity and polarisation discrimination	Rec. ITU-R BT.419	Rec. ITU-R BT.419	Rec. ITU-R BT.419	
Protection ratio values for the case of analogue television interfered with by analogue television	Rec. ITU-R BT.655	Rec. ITU-R BT.655	Rec. ITU-R BT.655	
Protection ratio values for the case of analogue television interfered with by DVB-T.	see note 2	See note 2	see note 2	2
Minimum median field strength to be protected in accordance with Rec. ITU-R BT.417	55 dBµV/m	65 dBµV/m	70 dBµV/m	

Notes
1. This value does not imply that a receiving antenna must be at 10 m agl, it only sets a (commonly used) reference.
2. For co-ordination purposes, the following values should be used for co-channel protection ratios for analogue television interfered with by DVB-T and for tropospheric interference :

PAL B, B1, D	35 dB	(DVB-T 7 MHz)
PAL B, B1, G, D, K	34 dB	(DVB-T 8 MHz)
PAL I	35 dB	(DVB-T 8 MHz)
SECAM L	35 dB	(DVB-T 8 MHz)
SECAM D, K	35 dB	(DVB-T 8 MHz)

The protection ratio values in all other cases can be found in CH 97 Annex 1 §3. All of these values should be used in conjunction with an interference increase margin of 0.3 dB (see CH 97 Annex 2 §8d). The values for PAL I and SECAM L are interim values which need to be confirmed within the ITU-R. A uniform reference method should be used for measurements of co-channel protection ratios for analogue television interfered with by DVB-T.

C2. FREQUENCY BANDS FOR DVB-T 2

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C2. FREQUENCY BANDS FOR DVB-T

C2.1 Selection of Frequency bands for DVB-T

C2.1.1 General

The DVB-T system can in principle be applied in all television bands. The system was primarily designed for DVB-T services to operate within the existing UHF spectrum allocation for analogue television - that is 8 MHz channel spacing - but can be adapted for 7 MHz channels.

There are technical and spectrum management issues to be considered in the choice of frequency bands to be used for DVB-T.

C2.1.2 Technical Considerations

Band III propagation is particularly suitable for portable reception, because of the homogeneous field strength distribution that can be achieved in that band, together with power budget considerations regarding large area coverage. For the same reason Band IV may be preferred to Band V for portable reception.

In Band III, the overlapping channels situation and the mixed use of 7 MHz and 8 MHz channels will present disadvantages with respect to planning and coordination.

The useful data capacity of 7 and 8 MHz channels can be aligned by the use of slightly different code rates. The loss of ruggedness that accompanies the higher code rate can be compensated by a higher e.r.p.

C2.1.3 Long term spectrum considerations

The Detailed Spectrum Investigation phase 2 (DSI-2) gives recommendations on the future use of the frequency spectrum in the range 29.7 to 960 MHz. No final conclusions have been reached yet in CEPT.

Nevertheless, long term considerations lead to the conclusion that:

- Band I (47 - 68 MHz) should not be used for digital television.

- Band III could be used with the exception of the range 216 - 230 MHz which is seen as the core band for T-DAB. It should be noted that no agreement has yet been reached on a European wide use of the band 230 - 240 MHz for T-DAB, therefore there may be pressure to use (parts of) the range 174 - 216 MHz for T-DAB in future.

- Band IV/V (470 - 862 MHz) is a good candidate for implementation of DVB-T. In particular channels that may become available in short or medium term (channels 61 - 69 in a number of countries) will give good opportunities to introduce DVB-T.

C2.1.4 Planning considerations

Some broadcasters have expressed the wish to use Band III for DVB-T in the existing 7 MHz channel scheme, whereas other broadcasters may wish to use DVB-T in an 8 MHz channel scheme in this band.

Band III is not only used for television (with different standards and different rasters, leading to overlapping channels), but also for T-DAB and a range of other services. In the Wiesbaden Special Arrangement for T-DAB some 80 other services (including the various analogue television systems) have been identified. It is necessary to establish sharing criteria between DVB-T (in a 7 MHz and 8 MHz bandwidth) and all these other services.

Sharing criteria between DVB-T (in a 7 MHz and 8 MHz bandwidth) and all other services have been established as far as possible. Provisions have been made to supplement and update the protection ratios later when more measurement results are available (see CH97 Resolution 3)

C2.2 Broadcasting use of channels above 60

The situation regarding channels above 60 with respect to television broadcasting differs from country to country. Generally, these can be split into three categories:

a) countries with assignments for channels in the range 61 to 69 in the ST61 Plan that currently have most of them or even all in use for television broadcasting;

b) countries with assignments for channels in the range 61 to 69 in the ST61 Plan that have only some, or even none, in use for television because these channels were not needed up to now, or because this frequency range is allocated to other services;

c) countries having no assignments for channels in the range 61 to 69 in the ST61 Plan and where these frequencies are allocated to other services.

In countries belonging to categories b) and c), channels above 60 may give a good opportunity for the introduction of DVB-T using SFNs. Indeed, in some countries these channels provide the only practical possibility for introduction of DVB-T using either SFNs or MFNs. It is therefore very important that some, if not all of the channels, soon become available for the broadcasting service in order to facilitate planning for DVB-T.

Irrespective of the difficult sharing situation, this frequency range is important for planning DVB-T in MFNs and SFNs and the possibility to allocate it to the broadcasting service only within CEPT countries should be pursued.

C3. SHARING 2

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C3. SHARING

C3.1 Sharing situations

Only services having a primary status should be considered.

The main sharing situations concerning:

- analogue television broadcasting;
- radiodetermination in the UK in Ch. 36;
- radioastronomy in Ch. 38;
- various military (terrestrial and airborne) services in Band V up to channel 69;
- services ancillary to broadcasting (SAB);
- T-DAB in band III;
- any other service sharing with TV in Bands III, IV and V up to channel 69.

When considering sharing, the status of services has to be taken into account. In this context, Radio Astronomy is a special case; although allocated on a secondary basis the Radio Regulations urge that other radio services take measures to protect Radio Astronomy observations.

C3.2 Sharing in the range 790 to 862 MHz

The situation according to the Radio Regulations for the frequency range 790-862 MHz for Europe is given according to the results of WRC-95.

It should be noted that:

- In the Table of Frequency Allocations the band 790-862 MHz is allocated on a co-primary basis to:

  FIXED
  BROADCASTING

- Several footnotes specify additional primary allocations in certain European countries. These are quoted below (not necessarily literally)

S5.312
In BLR, BUL, HNG, LAT, LTU, MDA, POL, SVK, CZE, ROU, RUS and UKR the band (645) - 862 MHz is also allocated to the aeronautical radionavigation service on a primary basis.

S5.316
In D, BIH, HRV, DNK, FIN, MKD, LIE, MCO, NOR, HOL, POR, S, SUI, YUG the band 790-862 MHz and in these same countries and in E, F, MLT the band 830-

862 MHz are also allocated to the mobile, except aeronautical mobile, service on a primary basis.

However, assignments of the mobile service in the countries mentioned in connection with each band referred to in this footnote shall not cause harmful interference to, or claim protection from, assignments of services operating in accordance with the Table in countries other than those mentioned in connection with the band.

S5.319
In BLR, RUS and UKR the bands 806-840 MHz (Earth-to-space) and 856-(890) MHz (space-to-Earth) are also allocated to the mobile-satellite, except aeronautical mobile-satellite (R), service.

The use of these bands by this service shall not cause harmful interference to, or claim protection from, services in other countries operating in accordance with the Table of Frequency Allocations and is subject to special agreements between the administrations concerned.

S5.313
In E and F, the band 790-830 MHz is allocated to the broadcasting services (only) on a primary basis.

S5.315
In GRC and I the band 790-838 MHz is allocated to the broadcasting service (only) on a primary basis.

S5.321
In I, the band 838-854 MHz is allocated to the broadcasting service (only) on a primary basis.

C3.3 Military services in Band V

In some Western European countries, mainly belonging to NATO, tactical links are operated within the band 790-862 MHz; while originally being considered as belonging to the fixed services, CEPT has recently decided that tactical links belong to the mobile services.

In some Eastern European countries, a variety of military services are operated in the band 645-862 MHz, both terrestrial, as well as in connection with aircraft. In individual countries parts of some UHF television channels have been set aside for these services, and several of the countries concerned intend to cease the military operation in this band when the existing equipment will be replaced. These military services were established on the basis of a permitted status and had never been coordinated.

C3.4 SAB

SAB can be operated on a secondary basis in Band IV and V, in Band I and III however SAB as an application of the mobile service has co-primary status. It is well understood that there is a problem regarding SAB, however due to the secondary status in Band IV and V, SAB should not restrict the planning of digital television as BC has primary status.

Although a re-allocation of SAB services can be done on a national basis, in the long term harmonised European solutions may have to be found within or outside the frequency bands allocated to the broadcasting service.

C3.5 T-DAB

The Wiesbaden Arrangement (WI95) including the revision agreed in Bonn (8 November 1996) contains procedures for coordination of T-DAB allotments with other services, including television.

Protection ratios for T-DAB interfering with television and television interfering with T-DAB and the minimum field strength values for television in Annex 2 of WI95 are for analogue television only. In applying the procedures of WI95 in relation to television the appropriate protection ratios and minimum field strengths of DVB-T in a 7 MHz or a 8 MHz channel bandwidth should be used.

C4. PLANNING AND CO-ORDINATION 2

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C4. PLANNING AND CO-ORDINATION

C4.1 Introduction

The implementation of DVB-T will be undertaken in a series of phases, each of which will involve its own planning considerations:

I. the short term where digital assignments must be accommodated within the current analogue plan;

II. an intermediate stage where analogue stations will gradually be closed down;

III. the very long term with an all digital plan.

Each of the above may require rather different planning approaches. At this stage it is probably too soon to consider in any detail the planning approach for the all digital era. Therefore in the near future the planning approaches will need to be confined to the period when analogue and digital services will coexist and need not take detailed account of analogue station closures.

C4.2 Introductory Stages

The introduction of DVB-T in Europe will differ from country to country. This depends on the national requirements for portable and fixed reception of DVB-T, frequency availability and the economic situation.

After the start of DVB-T in a given country, analogue television services will continue in that country for some time. This transition period could range from less than 10 to more than 20 years. The situation may occur that one country, that started early with DVB-T, has transferred to digital television completely, while neighbouring countries have not yet started.

On a European scale it is therefore expected that the coexistence of analogue and digital terrestrial television will start from 1997 onwards and will continue until 2020 or thereafter.

C4.3 Frequency Availability

The frequency availability for DVB-T will differ greatly from country to country. A combination of the following situations may occur with regard to spectrum availability for DVB-T in a given country:

- unused analogue assignments;
- channels not used for television;
- "gaps" in the spectrum.

There are countries which have all the ST61 assignments in use, no unused channels and where all "gaps" have already been used for introduction of additional (e.g. local, commercial) television assignments. These countries already make intensive use of the television bands and clearly there is little possibility for the introduction of DVB-T as long as all analogue assignments remain in use.

In some other countries all three possibilities are open to a certain extent. These countries have greater opportunities for the introduction of DVB-T, mainly because the analogue television usage is relatively less dense.

C4.4 Particular Considerations for Channels Above 60

For channels above 60 the situation is particularly complex, some countries have analogue television assignments (which may or not be in use) whilst in others the current allocation to Other Services. Nevertheless, there are indications that various channels may become available for DVB-T in the next few years because:

- of closure of non-broadcast services;
- non-used analogue assignments are used for DVB-T;
- analogue services are converted to digital.

This release of channels is likely to vary from country to country thus making it difficult to prepare a coherent plan.

The challenge presented is to find some way of achieving a reasonable distribution of the resources potentially available above channel 60 while also taking due account of any existing analogue usage or plans and specific channel availability restrictions in individual countries. It seems unlikely that any single approach would be valid for all parts of Europe, especially in view of the large number of uncertainties which exist about the way in which DVB-T may be used in different countries.

If there were no timescale pressures - that is, some form of ideal world - it would be possible to collect the wishes of all countries in the form of detailed requirements for the channels above 60, which could include both allotments and assignments. These requirements could then be subject to a synthesis process to produce an optimised distribution. In practice, because some of the answers are required in the short term to provide an input for bi-lateral and multi-lateral negotiations, rather simpler approaches need to be examined. In particular, such approaches will need to be based on assumptions about planning requirements.

Two possible planning approaches for channels above 60 are described that facilitate an analysis of what might be achieved. In particular the approaches described are based on the high power (greater than or equal to 10 kW) ST61 assignments. These could form a basis for further negotiations between countries.

The two approaches are based on:

- an extrapolation from the ST61 Plan;
- a plan synthesis.

Both approaches assume that the frequency range 790 - 862 MHz is available for DVB-T planning.

C4.4.1 Stockholm 61 Extrapolation

A study (see **Annex C4.1**) has identified the theoretical geographical positions for the channels in the range 61 to 69 based on the channel distribution schemes used in ST61.
This information could form the basis for assignment implementation of DVB-T in countries that did not apply for channels in this range.

Benefits:

- it may be possible to reserve assignments for those countries that wish to make a later start based on nominal transmitter sites;
- could provide equal treatment for the introduction of DVB-T if all channels were available in all CEPT countries;
- the implied use of analogue planning parameters may give greater flexibility for conversion from analogue to digital assignments;
- it may be possible in larger countries to extend the area within a country to provide some form of SFN.

Disadvantages:

- the original channel distribution within the lattice has become considerably distorted and therefore the use of channels according to the theoretical lattice would be limited. A further limitation on the use of the theoretical lattice will be implied if not all of the channels are available;
- reduced possibility for large area SFNs;
- the result may be a sparsely filled lattice which would need to be filled-in by bi-lateral and multi-lateral negotiation.

C4.4.2 Plan Synthesis

The methods for this approach will need to be developed.

Assumptions that may be required to carry out this exercise include:

- use of existing television transmitter sites;
- an agreed C/N, of say, 20 dB;
- fixed antenna reception;
- protection of existing analogue assignments;

digital television coverage areas to be similar in size to those of analogue television coverage areas for the same transmitter site.

Benefits:

- it may be possible to reserve assignments for those countries that wish to make a later start based on nominal transmitter sites;
- should provide near optimal use of the spectrum available for DVB-T.

Disadvantages:

- result may leave less scope for later negotiations;
- the initial planning assumptions are unlikely to be universally acceptable.

C4.4.3 Conclusions

Using either of the planning approaches it may be possible to reserve assignments for those countries that wish to make a later start based on nominal transmitter sites.

The extrapolation of the original ST61 Plan for channels above 60 will be difficult to apply; the original channel distribution within the lattice has become considerably distorted because of extensive modifications to the plan during the past 35 years. Nevertheless, such an extension may provide a framework for discussion between administrations.

A plan synthesis should provide better starting conditions for DVB-T, but the result is less flexible than the extrapolation of the original ST61 Plan. Also, it must be noted that such a method would have to be developed and a full set of requirements for each country would be needed.

It should be noted that the full advantages of both planning approaches can only be gained if all channels above 60 are available for DVB-T planning.

ANNEX C4.1: UHF television channels 61 to 69 in Europe. Geographical locations.

1. Introduction

The television channels 61 to 69 are, in a number of countries in Europe, seen as the most suitable for introduction of digital television, particularly where these channels are still not used by television.

At the Stockholm Conference Lattice planning was used for the UHF bands in Western Europe, while the countries in Eastern Europe used a different channel distribution scheme for their part of the planning area. In the border area in Central Europe the two channel distribution schemes were adapted to each other by ßatch

The two channel distribution schemes are shown in **Figure CA4.1** and **Figure CA4.2** in **Appendix CA4.1**.

When using the Lattice Planning Method, the lattices are often distorted and / or scaled in accordance with the transmitter density in individual parts of the planning area. This was also the case in the planning work done for UHF television in Stockholm. Pushpins were set on a map over the planning area showing the locations of the transmitting stations and the required number of UHF channels per station. On this map sewing thread was drawn in segments of straight lines showing the actual positions and sizes of the lattice elements based on the required number of channels per area unit. A copy of this map is shown in **Appendix CA4.1**, **Figure CA4.3**.

In the following text the term ßcountry”refers to a country having its own country code in the original ST61 Plan.

2. List of European countries not having assignments above channel 60

From The Final Acts of the European VHF / UHF Broadcasting Conference, Stockholm 1961 it can be seen that the following (now existing) European countries do not have assignments above channel 60 in the Plan (the country codes used in parentheses are the original used in the Plan):

Covered by the frequency plan for Eastern Europe:
Bulgaria (BUL)
Estonia (in 1961: URS)
Germany, eastern part (in 1961: D_D)
Hungary (HNG)
Latvia (in 1961: URS)
Lithuania (in 1961: URS)
Moldavia (in 1961: URS)
Poland (POL)
Rumania (ROU)
Russian Federation (URS)

The Czech Republic (in 1961: TCH)
The Slovak Republic (in 1961: TCH)
Ukraine (UKR)
White Russia (BLR)

Covered by the Western European lattices:
Albania (ALB)
Austria (AUT)
Bosnia-Herzegovina (in 1961: YUG)
Croatia (in 1961: YUG)
Finland (FNL)
Germany, western part (in 1961: D)
Greece (GRC)
Italy (I) *)
Macedonia, Former Yugoslav Republic of (in 1961: YUG)
The Netherlands (HOL)
Portugal (POR)
Slovenia (in 1961: YUG)
Switzerland (SUI)
Turkey (TUR)
Yugoslavia, The [former] Republic of (in 1961: YUG)

Andorra (AND)
Cyprus (CYP)
Gibraltar (GIB)
Luxemburg (LUX)
Malta (MLT)
Monaco (MCO)
Vatican City State (CVA)

*) In ST61 6 assignments out of a total of 135 actually contain channels in the range 61 - 65 (incl.).

It is known that some of the above mentioned countries at a later time have co-ordinated a network-like set of stations with all of their neighbours and thus achieved a similar coverage as if the country had the assignments in the original Stockholm Plan. Such assignments have not been included in this analysis.

For countries in the last part of the above list (Andorra - Vatican City State), because of their geographical size, it is not clear whether they did not want channels above 60 or they in the planning process simply happened to get their requirements met without these channels.

3. Theoretical locations of the channels 61 to 69

For Eastern Europe it is generally possible by analysis of ST61 to identify most of the transmitter sites where channels in the range 61 to 69 could have been assigned, based on the channel distribution scheme given in **Figure CA4.2**, **Appendix CA4.1**.

For Western Europe it is not possible, on the basis of ST61, to give exact geographical co-ordinates for transmitter sites to which channels in the range 61 to 69 could have been assigned. The reason is that in the planning process the channels were grouped in sets of two, three or four according to the individual needs of the individual countries. In this process the stringent channel distribution scheme as shown in **Figure CA4.1**, **Appendix CA4.1**, was partly distorted. It is, however, possible to derive the theoretical locations where the channels 61 to 69 could have been assigned, by means of geometrical analyses.

The intention with the analyses is to indicate the amount of frequency resources per country in the form of the number of possible assignments in the range 61 to 69; it is not intended to show exactly where these channels would fit into the actual updated ST61.

3.1 Eastern Europe

The channel distribution scheme used for Eastern Europe (see **Figure CA4.2** in **Appendix CA4.1**) is based on a difference of 17 between channels numbers assigned to a particular station (for example, 21, 38, 55 and 72). This leads to 17 different channel groupings out of which 9 groupings contain channels in the range 61 to 69.

In the border area between Eastern Europe and Western Europe the effect of the "patch working" is clearly seen as the channel distribution scheme is distorted in the way that the channels assigned to a particular station are not separated by 17. This distortion makes it impossible to identify all of the transmitter sites in the original ST61, to which the channels 61 to 69 could have been assigned.

A number of stations, mainly in the former Soviet Union (URS) and Ukraine (UKR), have two channels separated by 12 instead of 17 or three channels separated by 12 plus 5 instead of 17 plus 17. In the first case no further channel could be identified according to the channel distribution scheme, whereas in the latter a channel 17 higher than the highest can be identified without violating the scheme.

In the same two countries a small number of stations have only one channel assigned. For obvious reasons no further channels can be identified for these stations on the basis of the channel distribution scheme.

In some countries in Eastern Europe stations have been identified having two assignments below channel 61 and separated by 34 channels. This implies that a

third channel below channel 61 could have been assigned to that station at the Stockholm Conference. These possible resources have not been considered in the present analysis as they are outside of the scope of the analysis.

Maps showing the possible locations of the channels above 60 according to the channel distribution scheme used for Eastern Europe can be found in Maps 5 to 8, **Appendix CA4.2**.

3.2 Western Europe

For Western Europe the geographical co-ordinates where the channels 61 to 69 could have been assigned according to the channel distribution scheme have been calculated based on the lattice channel distribution scheme. This has been done on the basis of the co-ordinates for the corners of the individual lattice elements.

Co-ordinates for the lattice corner points are listed in **Table CA4.1**, **Appendix CA4.1**. The numbering of the lattice elements has been done in order to facilitate the analysis only and does not refer to any official numbering.

The photo of the original map from Stockholm contains a number of incomplete lattices, mainly in the border area where the Western European lattices meet the Eastern European lattices. These lattices have been completed by extrapolation from the adjacent lattice sides and are clearly marked with notes in the table.

Lattice elements only covering countries where the channels above 60 were assigned at the Stockholm Conference and where these channels are already available for television are generally not considered here.

The geographical co-ordinates of the theoretical locations, where the channels 61 to 69 could have been assigned, were found by individual scaling and distortion of each lattice based on the geographical co-ordinates for the corners as listed in **Table CA4.1**, **Appendix CA4.1**.

Maps covering the relevant parts of Europe can be found in Maps 1 to 4, **Appendix CA4.2**. These maps show plots of the theoretical locations of channels above 60 for countries having no assignments in this range.

Appendix CA4.3 provides a list of the stations in each country in Eastern Europe as given in the original Stockholm 61 Plan. In some cases, the current country attribution has also been given.

Appendix CA4.4 provides a list of the geographic co-ordinates of the corner points and the nominal channel locations for the lattice cells used for Western Europe during the Stockholm 61 Conference.

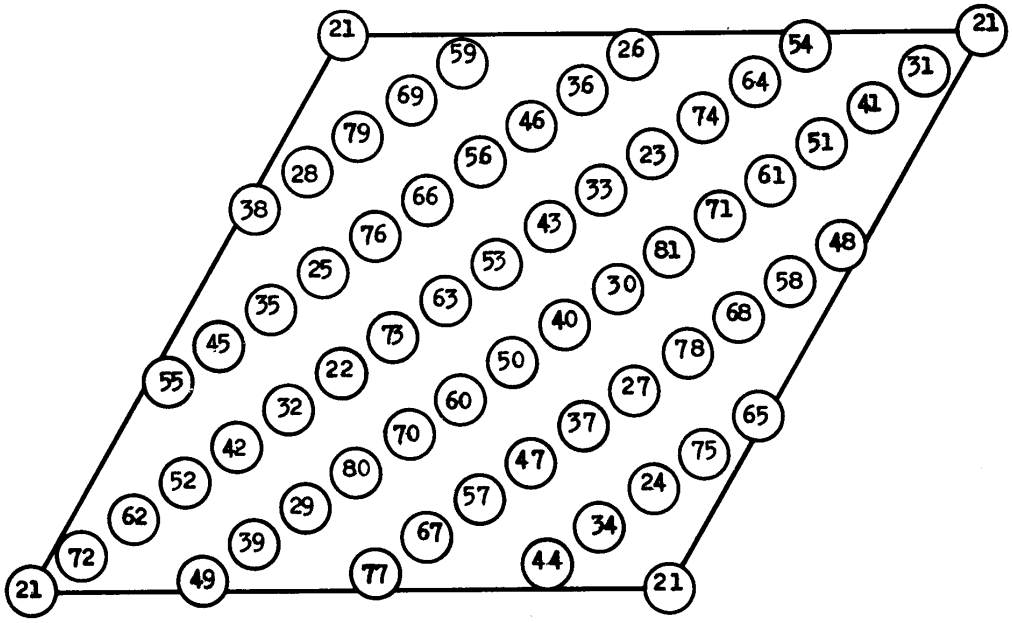


FIGURE 31

Theoretical apportionment of channels in Bands IV and V, proposed by the E.B.U.

Figure CA4.1. Channel distribution scheme used for Western Europe

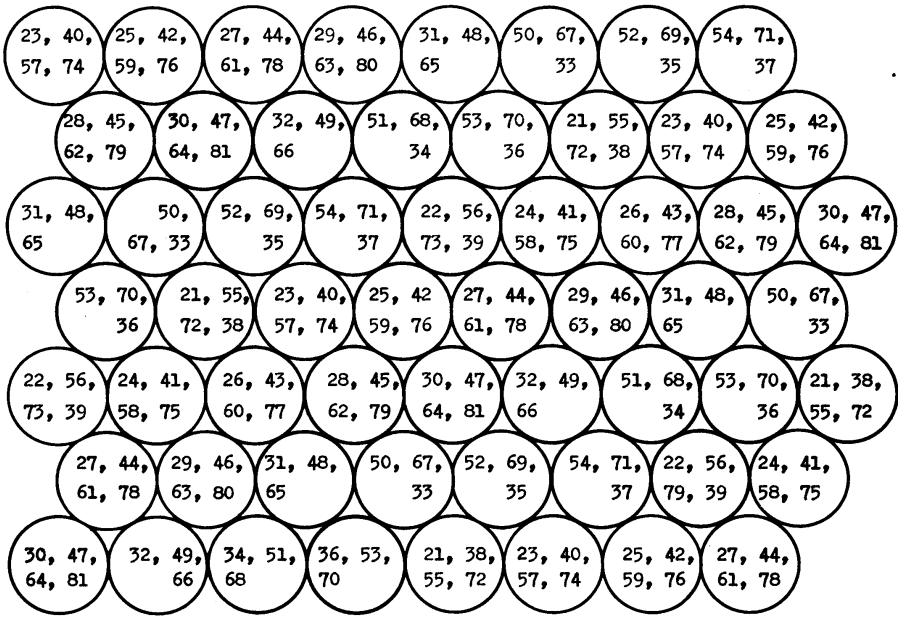


FIGURE 30

Theoretical apportionment of channels in Bands IV and V, in countries using the I.B.T.O. standard

Figure CA4.2. Channel distribution scheme used in Eastern Europe

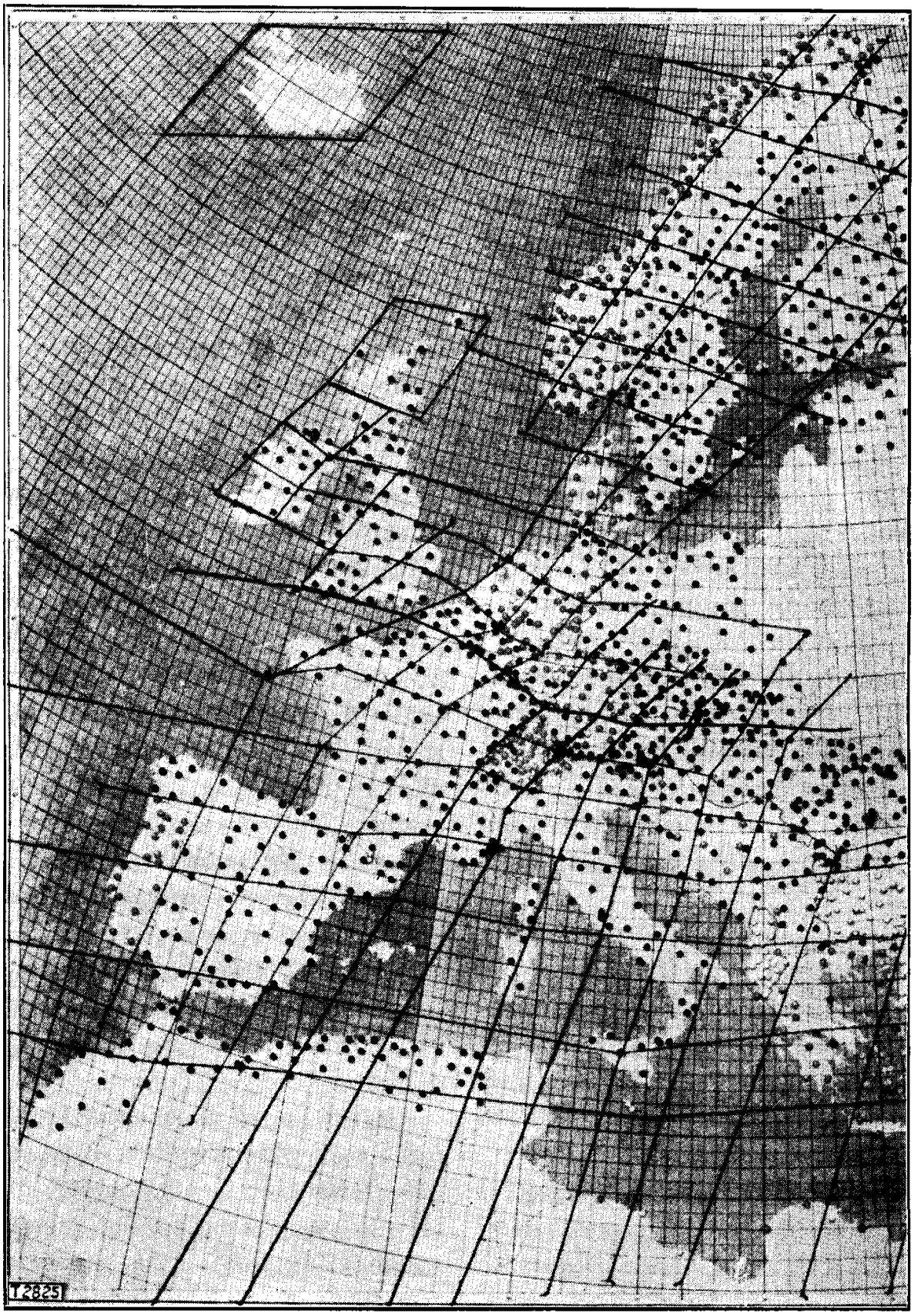


Figure CA4.3. Copy of the original lattice map used for Western Europe in Stockholm 1961.

Table CA4.1: Geographical co-ordinates for corners of a number of ST 61 UHF Lattices in Western and Southern Europe.

Lattice number	Geographical co-ordinates for lattice corners							
	NW		NE		SE		SW	
1	06E20	59N05	10E00	58N45	08E30	56N55	05E00	57N10
2	10E00	58N45	14E10	58N10	12E00	56N40	08E30	56N55
3	14E10	58N10	19E00	57N30	16E30	56N05	12E00	56N40
4	08E30	56N55	12E00	56N40	09E20	54N30	06E40	54N40
5	12E00	56N40	16E30	56N05	12E45	54N00	09E20	54N30
6 [1)]	***16E30***	***56N05***	***19E30***	***55N40***	***16E30***	***54N00***	***12E45***	***54N00***
7	06E40	54N40	09E20	54N30	07E30	52N40	05E30	53N05
8	09E20	54N30	12E45	54N00	10E00	52N10	07E30	52N40
9 [1)]	***12E45***	***54N00***	***16E30***	***54N00***	***13E30***	***52N15***	10E00	52N10
10	05E30	53N05	07E30	52N40	05E45	50N50	03E30	51N45
11	07E30	52N40	10E00	52N10	08E15	50N15	05E45	50N50
12	10E00	52N10	13E30	52N15	10E40	50N20	08E15	50N15
13 [1)]	13E30	52N15	***16E10***	***52N10***	13E30	50N15	10E40	50N20
14	03E30	51N45	05E45	50N50	03E15	50N15	00E45	50N30
15	05E45	50N50	08E15	50N15	06E20	49N30	03E15	50N15
16	08E15	50N15	10E40	50N20	08E45	48N30	06E20	49N30
17	10E40	50N20	13E30	50N15	11E30	48N30	08E45	48N30
18	13E30	50N15	16E00	50N10	13E20	48N20	11E30	48N30
19 [1)]	***16E00***	***50N10***	***18E10***	***50N00***	16E10	48N25	13E20	48N20
20	03E15	50N15	06E20	49N30	03E50	48N00	00E30	48N10
21	06E20	49N30	08E45	48N30	07E15	47N30	03E50	48N00
22	08E45	48N30	11E30	48N30	09E40	47N10	07E15	47N30
23	11E30	48N30	13E20	48N20	11E50	47N05	09E40	47N10
24	13E20	48N20	16E10	48N25	14E20	47N00	11E50	47N05
25	16E10	48N25	19E10	48N30	17E20	46N50	14E20	47N00
26	00E30	48N10	03E50	48N00	02E30	45N50	01W45	45N30
27	03E50	48N00	07E15	47N30	05E50	46N10	02E30	45N50
28	07E15	47N30	09E40	47N10	08E20	45N50	05E50	46N10
29	09E40	47N10	11E50	47N05	11E10	45N45	08E20	45N50
30	11E50	47N05	14E20	47N00	14E00	45N45	11E10	45N45
31	14E20	47N00	17E20	46N50	17E00	45N40	14E00	45N45
32	05W50	45N10	01W45	45N30	02W50	42N50	06W20	42N25
33	01W45	45N30	02E30	45N50	00E45	43N10	02W50	42N50
34	02E30	45N50	05E50	46N10	04E25	43N45	00E45	43N10
35 [2)]	05E50	46N10	***08E20***	***45N50***	***07E20***	***43N45***	04E25	43N45
36 [3)]	***08E20***	***45N50***	11E10	45N45	10E15	43N40	***07E20***	***43N45***
37	11E10	45N45	14E00	45N45	13E15	43N40	10E15	43N40
38	14E00	45N45	17E00	45N40	16E20	43N30	13E15	43N40
39	17E00	45N40	19E45	45N20	18E50	43N20	16E20	43N30
40 [4)]	***10W00***	***41N50***	06W20	42N25	06W55	40N00	***10W00***	***39N30***
41	06W20	42N25	02W50	42N50	03W40	40N30	06W55	40N00
42	02W50	42N50	00E45	43N10	00W10	41N00	03W40	40N30
43	00E45	43N10	04E25	43N45	03E10	41N20	00W10	41N00
44	04E25	43N45	07E20	43N45	06E05	41N20	03E10	41N20

45	07E20	43N45	10E15	43N40	09E25	41N15	06E05	41N20
46	10E15	43N40	13E15	43N40	12E40	41N20	09E25	41N15
47	13E15	43N40	16E20	43N30	15E30	41N20	12E40	41N20
48	16E20	43N30	18E50	43N20	18E00	41N20	15E30	41N20
49	18E50	43N20	23E10	43N35	21E55	41N20	18E00	41N20
50 [5)]	23E10	43N35	***27E30***	***43N45***	26E30	41N25	21E55	41N20
51 [4)]	***10W00***	***44N30***	05W50	45N10	06W20	42N25	***10W00***	***41N50***
52 [4)]	***10W00***	***39N30***	06W55	40N00	07W30	36N40	***10W20***	***36N10***
53	06W55	40N00	03W40	40N30	04W40	37N00	07W30	36N40
54	06E05	41N20	09E25	41N15	08E15	37N50	04E15	37N50
55	09E25	41N15	12E40	41N20	11E10	37N45	08E15	37N50
56	12E40	41N20	15E30	41N20	13E50	37N40	11E10	37N45
57	15E30	41N20	18E00	41N20	16E35	38N00	13E50	37N40
58	18E00	41N20	21E55	41N20	20E20	38N20	16E35	38N00
59	21E55	41N20	26E30	41N25	25E00	38N30	20E20	38N20
60	11E10	37N45	13E50	37N40	13E15	35N30	10E20	35N30
61	13E50	37N40	16E35	38N00	15E40	35N35	13E15	35N30
62	20E20	38N20	25E00	38N30	23E55	36N00	19E10	35N50
70	19E40	61N20	25E20	60N20	22E00	58N55	17E00	59N50
71	16E15	63N35	22E30	62N45	19E40	61N20	14E10	62N05
72	22E30	62N45	28E30	61N40	25E20	60N20	19E40	61N20
73	19E10	65N20	26E00	64N17	22E30	62N45	16E15	63N35
74 [1)]	26E00	64N17	***32E00***	***63N00***	28E30	61N40	22E30	62N45
75	23E00	67N20	31E10	66N20	26E00	64N17	19E10	65N20
76 [1)]	31E10	66N20	***37E15***	***65N10***	***32E00***	***63N00***	26E00	64N17
77	21E00	69N25	27E20	69N00	23E00	67N20	17E30	67N55
78 [1)]	27E20	69N00	***35E10***	***67N52***	31E10	66N20	23E00	67N20
81	26E30	41N25	30E36	41N34	29E06	38N45	25E00	38N30
82	25E00	38N30	29E06	38N45	27E30	35N47	23E55	36N00
83	30E36	41N34	35E24	41N34	34E00	38N55	29E06	38N45
84	29E06	38N45	34E00	38N55	32E35	35N33	27E30	35N47
85	35E24	41N34	40E25	41N15	39E02	38N45	34E00	38N55
86	34E00	38N55	39E02	38N45	37E20	35N05	32E35	35N33
87	40E25	41N15	46E18	40N29	44E42	38N03	39E02	38N45
88	39E02	38N45	44E42	38N03	42E35	34N18	37E20	35N05

Notes: All co-ordinates for corners found by extrapolation are printed in ***bold italics***.

1) Lattice elements completed by extension of the border lines of the adjacent lattice elements.

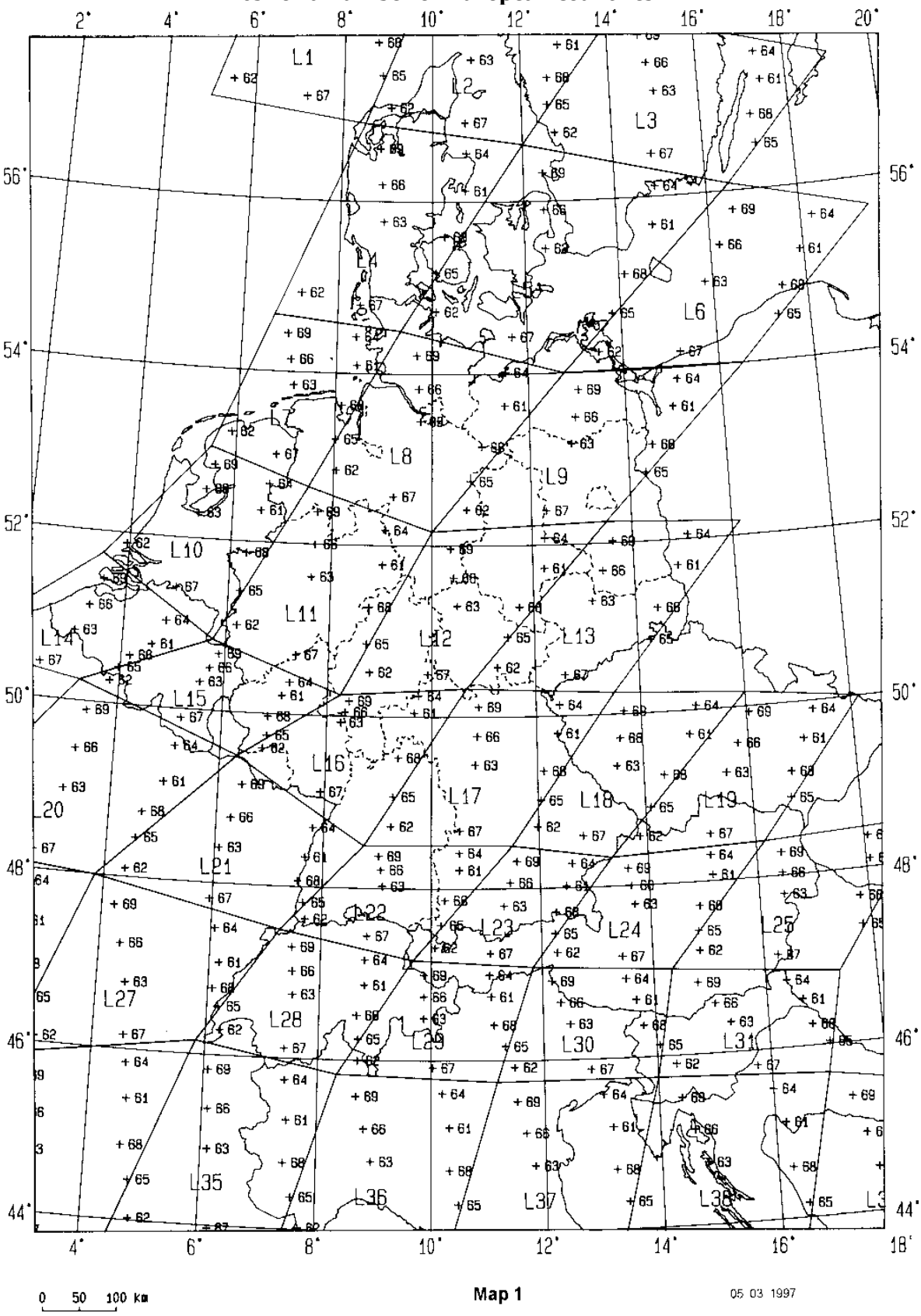
2) The eastern border line of this lattice element is bent at a point defined by the geographical co-ordinates: 07E35 45N00

3) The western border line of this lattice element is defined by the same line as described in 2).

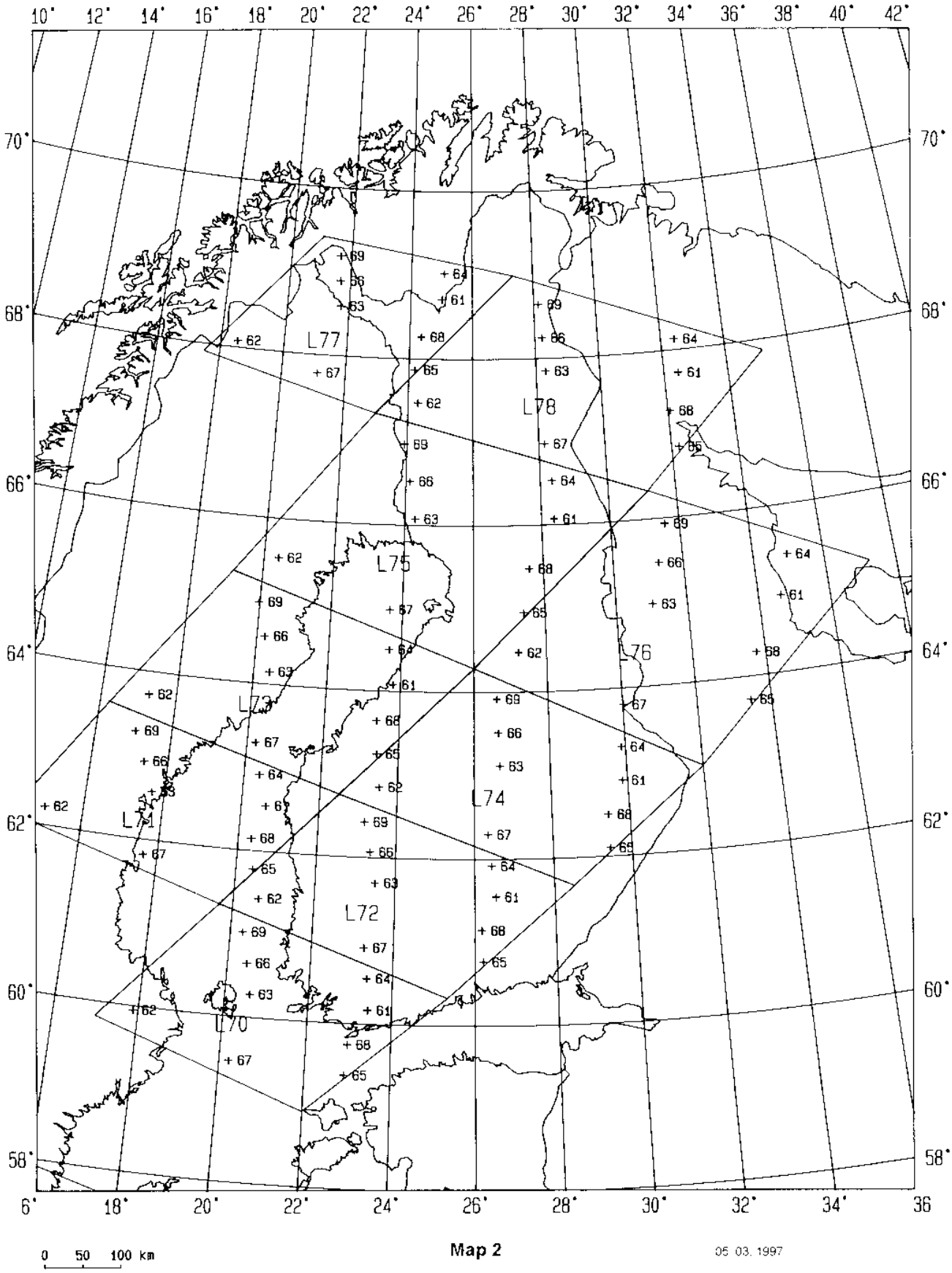
4) The western border of this lattice element has been defined so that the size of the lattice element becomes equal to its eastern neighbour.

5) The NW corner was found by extension of northern and eastern border line of the lattice element.

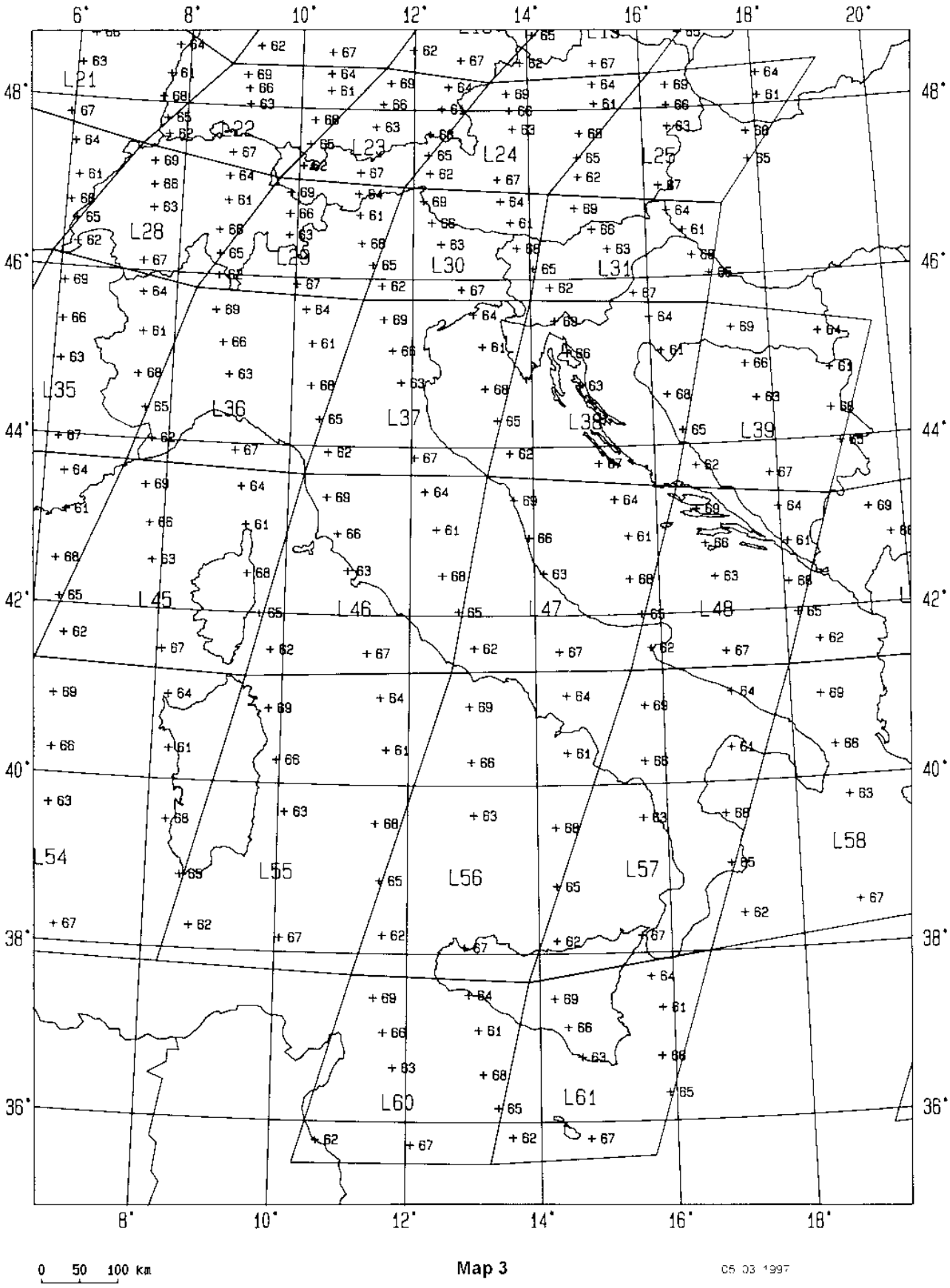
ANNEX CA4.2: Maps showing the theoretical geographical positions of channels 61 - 69 for a number of European countries



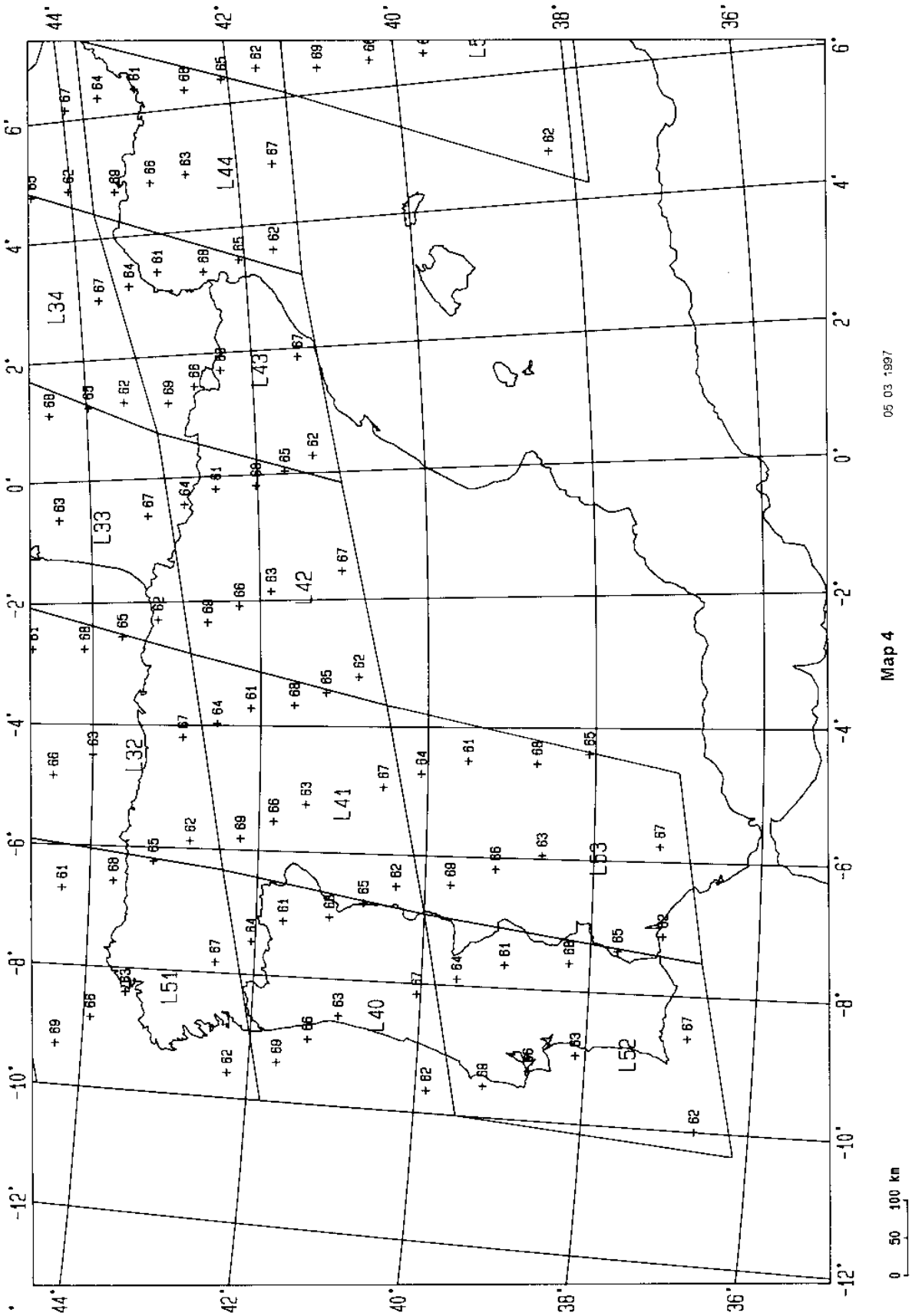
Map 1: Lattice in Central Europe



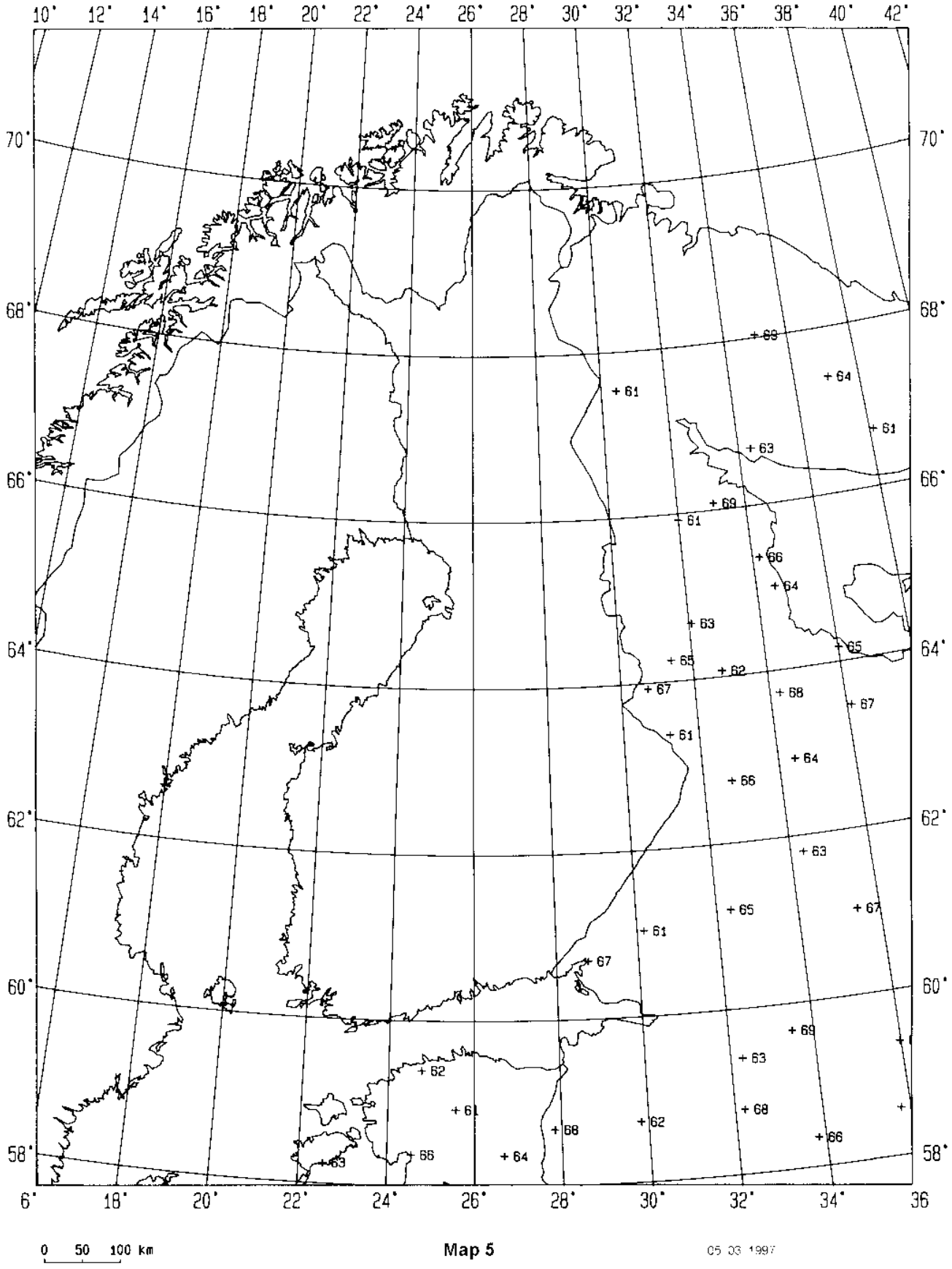
Map 2: Lattice in Finland



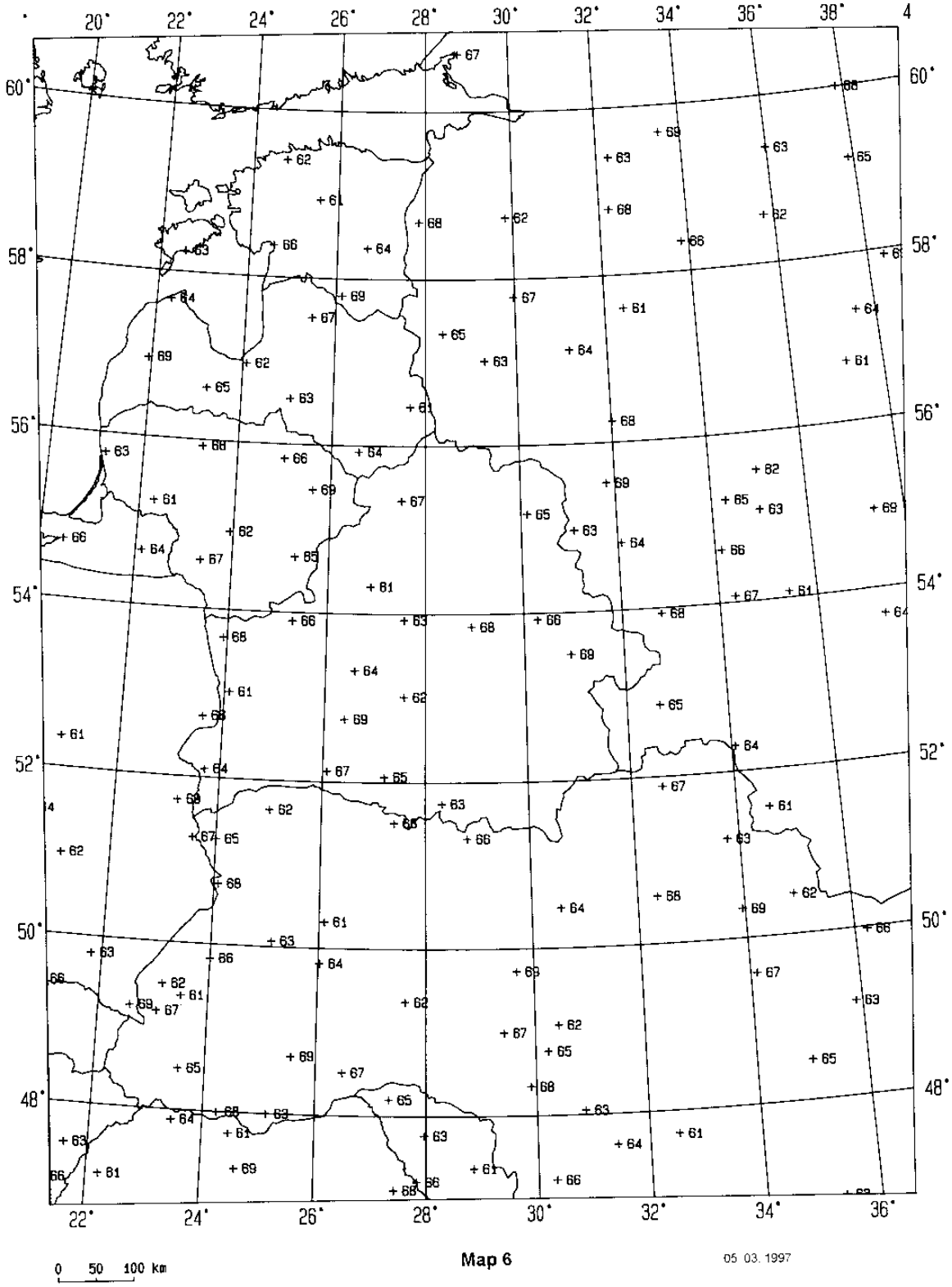
Map 3: Lattice in Italy, Slovenia, Croatia and Bosnia-Herzegovina



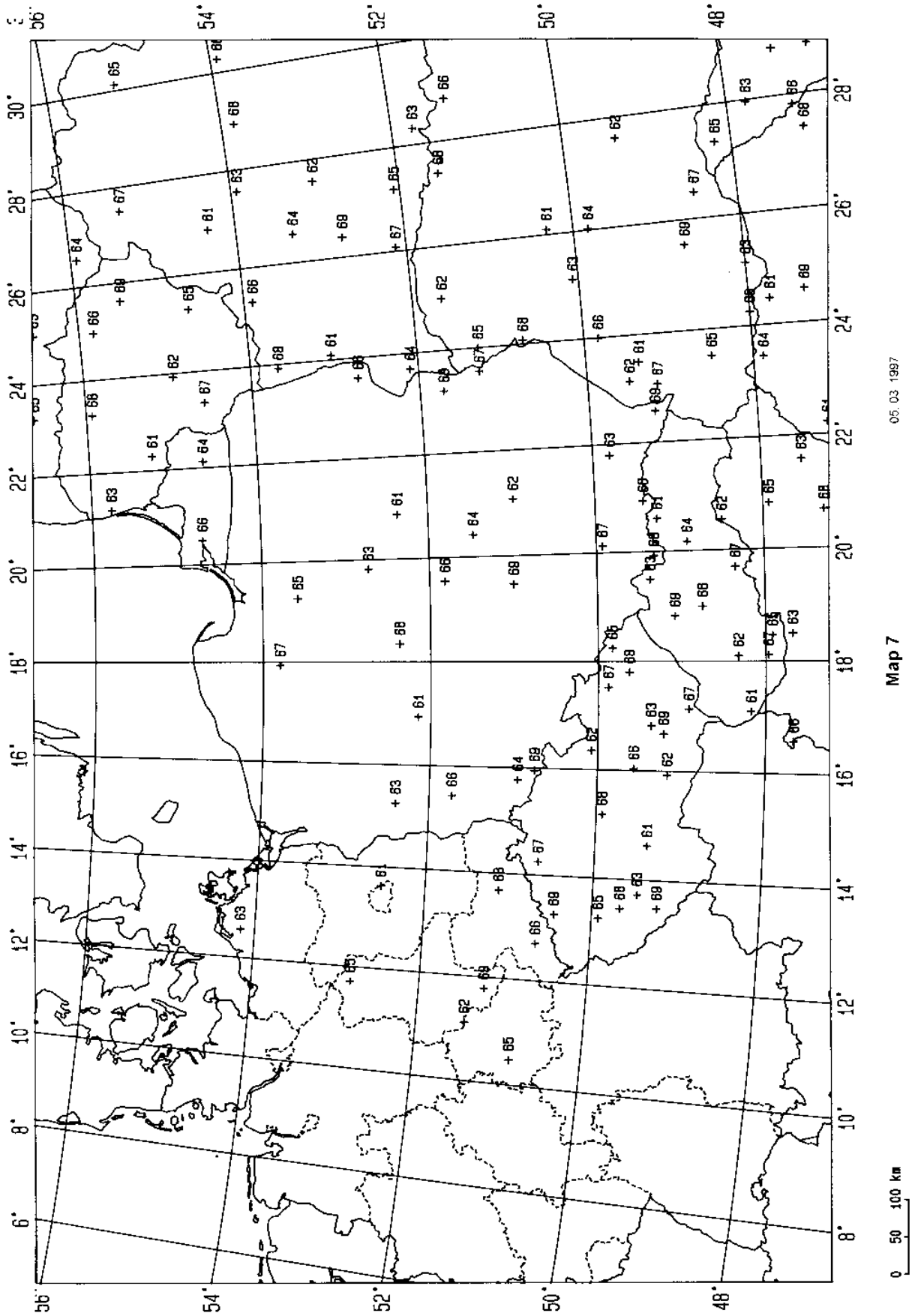
Map 4: Lattice in Portugal



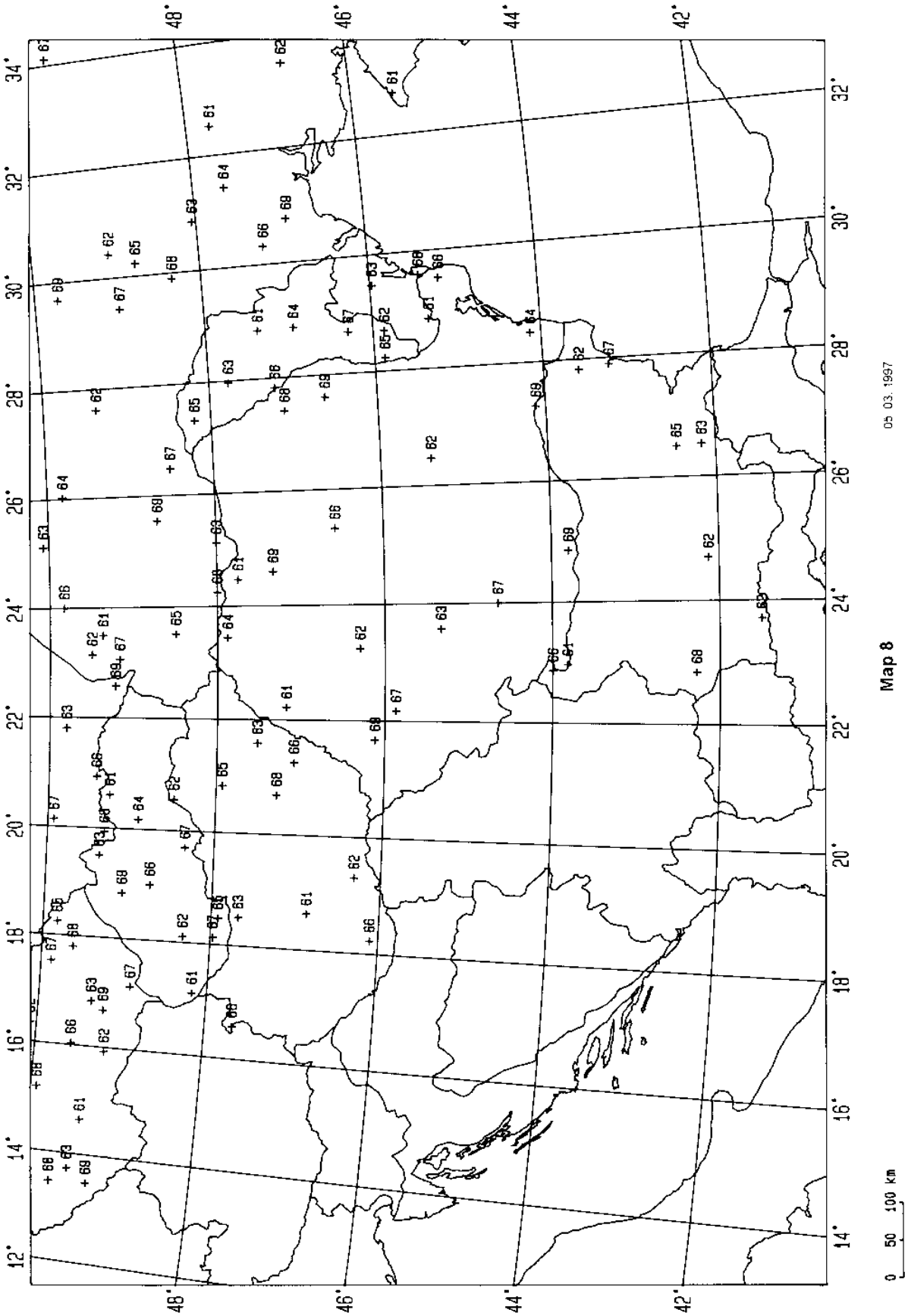
Map 5: Northwestern Russia



Map 6: The Baltic countries, White Russia, Western Russia and Northern Ukraine



Map 7: Eastern part of Germany, Poland, the Czech Republic and the Slovak Republic



Map 8: Hungary, Moldavia, Bulgaria and Southern Ukraine

ANNEX CA4.3: List of stations per country in Central and Eastern Europe.

The following table contains a list of stations in Eastern Europe from the original Stockholm Plan where a channel in the range 61 to 69 could have been assigned based on the channel distribution scheme used for Eastern Europe (see Figure CA4.2 in Annex CA4.1).

The table is sorted according to the country codes used in ST61.

Country code	Station Name	Channel	Longitude	Lattitude
BLR	MOLODETCHNO	61	26E53	54N20
BLR	SVISLOTCH	61	24E06	53N02
BLR	SLUCK	62	27E34	53N01
BLR	LELTCHYCY	63	28E19	51N45
BLR	MINSK	63	27E34	53N56
BLR	BREST	64	23E42	52N06
BLR	GORODEIA	64	26E35	53N20
BLR	DAVID GORODOK	65	27E12	52N04
BLR	VITEBSK	65	30E08	55N11
BLR	LIDA	66	25E18	53N54
BLR	MOGILEV	66	30E17	53N55
BLR	CHARKOVCHTINA	67	27E30	55N21
BLR	PINSK	67	26E05	52N08
BLR	BIEREZINO	68	28E56	53N51
BLR	GRODNO	68	23E55	53N40
BLR	GANTZEVITCHI	69	26E24	52N45
BLR	SLAVGOROD	69	30E56	53N30

Country code	Station Name	Channel	Longitude	Lattitude
BUL	ROUSSE	61	22E58	43N49
BUL	GOTZE DELTCHEV	62	23E43	41N30
BUL	PLOVDIV	62	24E42	42N08
BUL	TOLBOUCHIN	62	27E50	43N35
BUL	ELCHOVO	63	26E32	42N10
BUL	IAMBOL	65	26E30	42N28
BUL	VIDIN	66	22E52	44N00
BUL	VARNA	67	27E54	43N13
BUL	KIUSTENDIL	68	22E51	42N17
BUL	SILISTRA	69	27E16	44N07

Country code	Station Name	Channel	Longitude	Lattitude
	BERLIN OST	61	13E37	52N32

Country code	Station Name	Channel	Longitude	Lattitude
D-D	KULPENBERG	62	11E06	51N25
D-D	DRESDEN	63	13E40	51N07
D-D	MARLOW	63	12E34	54N10
D-D	DEQUEDE	65	11E42	52N49
D-D	INSELSBERG	65	10E28	50N51
D-D	KARL MARX STADT	66	12E42	50N39
D-D	FREYBURG	69	11E47	51N13

Country code	Station Name	Channel	Longitude	Lattitude
HNG	SARBOGARD	61	18E38	46N52
HNG	AGGTELEK	62	20E33	48N30
HNG	KISKUNHALAS	62	19E18	46N19
HNG	DEBRECEN	63	21E35	47N31
HNG	GERECSE	63	18E30	47N41
HNG	EMOD	65	20E49	47N56
HNG	PECS	66	18E13	46N06
HNG	SOPRON	66	16E34	47N40
HNG	SZEGHALOM	66	21E15	47N05
HNG	TOROKSZENTMIKLOS	68	20E41	47N17

Country code	Station Name	Channel	Longitude	Lattitude
POL	POZNAN	61	16E56	52N09
POL	WARSZAWA	61	20E52	52N22
POL	KIELCE	62	21E04	50N59
POL	PLOCK	63	19E49	52N44
POL	RZESZOW	63	21E48	49N48
POL	ZIELONA GORA	63	15E15	52N24
POL	JELENIA GORA	64	15E46	50N57
POL	OPOCZNO	64	20E25	51N28
POL	ILAWA	65	19E16	53N35
POL	HAJNOWKA	66	23E36	52N44
POL	KRYNICA	66	20E56	49N26
POL	LODZ	66	19E33	51N49
POL	ZAGAN	66	15E26	51N44
POL	CHELM LUB	67	23E33	51N17
POL	CZERSK POM	67	17E56	53N48
POL	KRAKOW	67	20E08	49N56
POL	KONIN	68	18E21	52N22
POL	ZAKOPANE	68	19E56	49N19
POL	BIESZCZADY	69	22E35	49N13
POL	KAMIENNA GORA	69	15E57	50N45
POL	PARCZEW	69	23E13	51N43
POL	RADOMSKO	69	19E28	51N00

Country code	Station Name	Channel	Longitude	Lattitude
ROU	ORADEA	61	22E13	47N11
ROU	VISEU	61	24E28	47N45
ROU	ABRUD	62	23E15	46N18
ROU	BUZAU	62	26E28	45N24
ROU	PETROSANI	63	23E35	45N20
ROU	CONSTANTA	64	28E30	44N08
ROU	OAS	64	23E27	47N53
ROU	ODORHEI	66	25E20	46N35
ROU	SULINA	66	29E32	45N11
ROU	BALCESTI	67	24E00	44N39
ROU	FAGET	67	22E10	45N52
ROU	IASI	68	27E25	47N07
ROU	LIPOVA	69	21E40	46N07
ROU	NASAUD	69	24E36	47N20
ROU	TURNUL MAGURELE	69	24E51	43N48
ROU	VASLUI	69	27E37	46N38

Country code	Station Name	Channel	Longitude	Lattitude
TCH/SVK	BRATISLAVA	61	17E06	48N11
TCH/SVK	STARA LUBOVNA	61	20E36	49N16
TCH/CZE	TABOR	61	14E38	49N23
TCH/SVK	NITRA	62	18E06	48N20
TCH/CZE	RYCHNOV N. KNEZNOU	62	16E21	50N05
TCH/CZE	TREBIC	62	15E55	49N10
TCH/CZE	BLATNA	63	13E43	49N28
TCH/CZE	BRNO	63	16E49	49N22
TCH/SVK	NAMESTOVO	63	19E30	49N22
TCH/SVK	POPRAD	64	20E10	48N55
TCH/CZE	OSTRAVA	65	18E15	49N50
TCH/CZE	PLZEN	65	13E15	49N55
TCH/SVK	STUROVO	65	18E28	47N55
TCH/SVK	BANSKA BYSTRICA	66	19E00	48N45
TCH/CZE	ZDAR N. SAZAVOU	66	16E02	49N34
TCHCZE	BRUNTAL	67	17E31	49N53
TCH/CZE	HODONIN	67	17E08	48N55
TCH/SVK	LUCENEC	67	19E42	48N21
TCH/SVK	NOVE ZAMKY	67	18E07	47N58
TCH/CZE	USTI N. LABEM	67	14E15	50N40
TCH/CZE	KOLIN	68	15E11	49N56
TCH/CZE	NOVY JICIN	68	17E48	49N38
TCH/CZE	PLZEN-MESTO	68	13E27	49N40
TCH/CZE	BRNO-MESTO	69	16E40	49N13
TCH/CZE	CHOMUTOV	69	13E16	50N27
TCH/CZE	SUSICE	69	13E29	49N14
TCH/SVK	ZILINA	69	18E50	49N05

Country code	Station Name	Channel	Longitude	Lattitude
UKR	CHEPIETOVKA	61	26E06	50N19
UKR	DROGOBYTCH	61	23E30	49N22
UKR	IZMAIL	61	28E51	45N20
UKR	NOVY BUG	61	32E31	47N43
UKR	TCHERNOMORSKOIE	61	32E43	45N30
UKR	BUKI	62	30E26	49N05
UKR	KAKHOVKA	62	33E29	46N47
UKR	KAMEN K	62	25E00	51N39
UKR	LETICHEV	62	27E37	49N22
UKR	NOVO PSKOV	62	39E08	49N32
UKR	SAMBOR	62	23E09	49N30
UKR	TROSTYANETS	62	34E56	50N29
UKR	ARTSIS	63	29E29	45N59
UKR	BRODY	63	25E07	50N04
UKR	BURYN	63	33E46	51N12
UKR	MELITOPOL	63	35E22	46N50
UKR	PIERVOMAISK	63	30E52	48N03
UKR	PUTILA	63	25E08	48N00
UKR	SAHNOVSHINA	63	35E53	49N08
UKR	BORSTCHEV	64	26E02	49N49
UKR	KERTCH	64	36E28	45N22
UKR	KIEV	64	30E33	50N29
UKR	VOZNESENSK	64	31E25	47N38
UKR	DNEPROPETROVSK	65	35E00	48N29
UKR	LUBOML	65	24E00	51N16
UKR	MIEZGORIE	65	23E31	48N30
UKR	SEVASTOPOL	65	33E32	44N34
UKR	UMAN	65	30E14	48N46

Country code	Station Name	Channel	Longitude	Lattitude
UKR	ZHDANOV	65	37E31	47N08
UKR	JOVTIEN	66	30E19	47N14
UKR	KHARKOV	66	36E14	49N58
UKR	KRASNO PEREKOPSK	66	33E48	45N57
UKR	LVOV	66	24E00	49N50
UKR	OVRUTCH	66	28E48	51N20
UKR	DACHEV	67	29E26	49N00
UKR	DJANKOI	67	34E23	45N41
UKR	HOLMY	67	32E36	51N53
UKR	HOTIN	67	26E29	48N31
UKR	RESHETILOVKA	67	34E07	49N34
UKR	TURKA	67	23E04	49N10
UKR	GAIVORON	68	29E54	48N21
UKR	GENICHESK	68	34E48	46N12
UKR	GLINNOIE	68	27E24	51N31
UKR	NOVOVOLYNSK	68	24E05	50N44
UKR	PRILUKI	68	32E22	50N34
UKR	RAKOV	68	24E15	48N00
UKR	SLAVYANSK	68	37E35	48N51
UKR	VILKOVO	68	29E36	45N25
UKR	GADYACH	69	33E57	50N21
UKR	GORODIENKA	69	25E33	48N42
UKR	KAMYSH ZARYA	69	36E47	47N21
UKR	PIETROVKA	69	30E46	46N56
UKR	SIMFEROPOL	69	34E02	44N58
UKR	SKVIR	69	29E41	49N44

Country code	Station Name	Channel	Longitude	Lattitude
URS	DEMYANSK	61	32E25	57N36
URS	DOUBNO	61	37E12	56N43
URS	KOVDOR	61	30E28	67N32
URS	LENDERI	61	31E14	63N22
URS	LUDZA	61	27E40	56N28
URS	ORGUEEV	61	28E51	47N23
URS	PAJDE	61	25E34	58N56
URS	PRIOZERSK	61	30E10	61N02
URS	RILSK	61	34E38	51N33
URS	SLUDIANKA	61	38E07	66N41
URS	SOUHINITSHI	61	35E26	54N04
URS	TAURAGUE	61	22E18	55N15
URS	VOKSHOZERO	61	32E00	65N55
URS	VORONEG	61	39E14	51N38
URS	GJATSK	62	35E00	55N33
URS	KAUNAS	62	23E56	54N56
URS	LUGA	62	29E50	58N44
URS	PERTOMINSK	62	38E27	64N48
URS	PESTOVO	62	35E46	58N34
URS	RIGA	62	24E05	56N57
URS	RJAZAN	62	39E45	54N35
URS	RUGOZERO	62	32E47	64N04
URS	TALLIN	62	24E46	59N24
URS	TARAKLIA	62	28E42	45N52
URS	TIEMRUK	62	37E24	45N17
URS	BABAIEVO	63	35E59	59N22
URS	BELTZY	63	27E58	47N46
URS	KINGISEPP	63	22E33	58N15
URS	KLAIPEDA	63	21E12	55N46

Country code	Station Name	Channel	Longitude	Lattitude
URS	KOHTLA YARVE	63	32E17	59N24
URS	LESNOI	63	34E22	66N41
URS	NOVORGEV	63	29E18	57N01
URS	PAVLOVSKAJA	63	39E47	46N08
URS	PERESLAVL ZALESKIJ	63	38E51	56N44
URS	PETROZAVODSK	63	34E19	61N48
URS	ROUDNJA	63	31E06	54N58
URS	TEMKINO	63	35E00	55N04
URS	USHKOZERO	63	32E04	64N40
URS	YAUNPIEDALGA	63	25E04	56N33
URS	ARSENJEVO PLAVSK	64	37E19	53N41
URS	DAUGAVPILS	64	26E35	55N56
URS	HOLM	64	31E10	57N08
URS	KASHIN	64	37E34	57N19
URS	KEM	64	34E31	65N00
URS	KISHINEV	64	28E52	46N57
URS	KRASNOTSCHELJE	64	37E03	67N24
URS	MAGUIRBE	64	22E19	57N40
URS	MEDVEGEGORSK	64	34E26	62N56
URS	S. OSKOL	64	37E49	51N17
URS	SMOLENSK	64	32E04	54N48
URS	SOUZEMKA	64	34E04	52N18
URS	TARTU	64	26E41	58N22
URS	TCHERNYAKHOVSK	64	22E08	54N39
URS	DOBELE	65	23E15	56N38
URS	EDINTSI	65	27E20	48N12
URS	KAGUL	65	28E14	45N53
URS	KOLTSHOUGINO	65	39E21	56N19
URS	LUVOZERO	65	31E25	64N15
URS	OSTROV	65	28E23	57N21
URS	TSHEREPOVETS	65	37E53	59N08
URS	UNETSHA	65	32E39	52N51
URS	VIDLIZA	65	32E21	61N12
URS	VILNUS	65	25E18	54N40
URS	VIRANDOZERO	65	36E01	64N10
URS	VJAZMA	65	34E18	55N13
URS	BOROVITSHI	66	33E50	58N21
URS	KALININGRAD	66	20E30	54N42
URS	KUPISHKIS	66	25E00	55N50
URS	KUZEMA	66	34E12	65N22
URS	OUNGENY	66	27E50	47N13
URS	PJARNU	66	24N33	58N23
URS	POROSOZERO	66	32E44	62N45
URS	TAGANROG	66	38E53	47N13
URS	VSHODI	66	34E08	54N38
URS	DNO	67	29E58	57N47
URS	EFREMOV	67	38E06	53N07
URS	EJSK	67	38E15	46N41
URS	KAPSUKAS	67	23E21	54N35
URS	KIROV	67	34E20	54N04
URS	KOMRAT	67	28E43	46N18
URS	REBOLI	67	30E44	63N56
URS	SHATOURA	67	39E33	55N34
URS	TSHELOZERO	67	36E07	63N28
URS	VALMIJERA	67	25E29	57N32
URS	VIBORG	67	28E46	60N42
URS	VOSNESENJE	67	35E27	61N02
URS	YAROSLAVL	67	39E50	57N34

Country code	Station Name	Channel	Longitude	Lattitude
URS	BELOOZERSK	68	37E50	60N00
URS	GDOV	68	27E51	58N41
URS	LIVNI	68	37E36	52N26
URS	MALAYA VISHERA	68	32E13	58N47
URS	ROSLAVL	68	32E48	53N56
URS	SEGEJA	68	34E16	63N44
URS	SHAULYAJ	68	23E15	55N56
URS	TUAPSE	68	39E05	44N01
URS	ZAP DVINA	68	32E01	56N15
URS	ZARAJSK	68	38E54	54N44
URS	ELETS	69	38E31	52N38
URS	KULDIGA	69	21E56	56N57
URS	LOUHI	69	33E04	66N05
URS	LOVOZERO	69	35E00	68N02
URS	ONEGA	69	38E10	63N57
URS	SERPOUHOV	69	37E22	54N56
URS	SLOBODA	69	31E49	55N31
URS	TIHVIN	69	33E30	59N40
URS	UST LABINSK	69	39E40	45N15
URS	UTENA	69	25E37	55N28
URS	VALGA	69	26E08	57N48
URS	VOLGA	69	38E22	57N56

ANNEX CA4.4: Theoretical geographical locations for the channels 61 - 69 according to the channel distribution scheme used for UHF television in Western Europe at the Stockholm Conference 1961.

Note: The lattice numbering has been done for convenience only and does not refer to any official numbering.

Lattice number: 1		
NW corner	06E20	59N05
NE corner	10E00	58N45
SE corner	08E30	56N55
SW corner	05E00	57N10
Channel 61	8E52	58N19
Channel 62	5E30	57N23
Channel 63	7E06	58N03
Channel 64	8E45	58N42
Channel 65	8E53	57N29
Channel 66	6E56	58N26
Channel 67	7E10	57N13
Channel 68	8E46	57N52
Channel 69	6E47	58N49

Lattice number: 2		
NW corner	10E00	58N45
NE corner	14E10	58N10
SE corner	12E00	56N40
SW corner	08E30	56N55
Channel 61	12E52	57N50
Channel 62	9E05	57N06
Channel 63	10E53	57N40
Channel 64	12E45	58N13
Channel 65	12E35	57N08
Channel 66	10E42	58N04
Channel 67	10E44	56N56
Channel 68	12E36	57N27
Channel 69	10E31	58N27

Lattice number: 3		
NW corner	14E10	58N10
NE corner	19E00	57N30
SE corner	16E30	56N05
SW corner	12E00	56N40
Channel 61	17E25	57N16
Channel 62	12E44	56N48
Channel 63	15E00	57N14
Channel 64	17E20	57N36
Channel 65	17E11	56N32
Channel 66	14E52	57N34
Channel 67	14E51	56N30
Channel 68	17E08	56N52
Channel 69	14E43	57N54

Lattice number: 4		
NW corner	08E30	56N55
NE corner	12E00	56N40
SE corner	09E20	54N30
SW corner	06E40	54N40
Channel 61	10E43	56N08
Channel 62	7E13	54N56
Channel 63	8E57	55N46
Channel 64	10E45	56N34
Channel 65	10E05	55N11
Channel 66	8E54	56N12
Channel 67	8E28	54N48
Channel 68	10E16	55N36
Channel 69	8E51	56N37

Lattice number: 5		
NW corner	12E00	56N40
NE corner	16E30	56N05
SE corner	12E45	54N00
SW corner	09E20	54N30
Channel 61	14E47	55N40
Channel 62	10E05	54N44
Channel 63	12E27	55N27
Channel 64	14E53	56N07
Channel 65	13E49	54N40
Channel 66	12E26	55N54
Channel 67	11E41	54N26
Channel 68	14E07	55N07
Channel 69	12E26	56N20

Lattice number: 6		
NW corner	16E30	56N05
NE corner	19E30	55N40
SE corner	16E30	54N00
SW corner	12E45	54N00
Channel 61	17E55	55N15
Channel 62	13E30	54N14
Channel 63	15E50	54N58
Channel 64	18E15	55N38
Channel 65	17E20	54N31
Channel 66	16E12	55N23
Channel 67	15E12	54N11
Channel 68	17E28	54N51
Channel 69	16E33	55N47

Lattice number: 7

NW corner	06E40	54N40
NE corner	09E20	54N30
SE corner	07E30	52N40
SW corner	05E30	53N05
Channel 61	8E26	54N06
Channel 62	5E54	53N16
Channel 63	7E08	53N51
Channel 64	8E24	54N26
Channel 65	8E01	53N14
Channel 66	7E03	54N09
Channel 67	6E50	53N02
Channel 68	8E08	53N38
Channel 69	6E58	54N27

Lattice number: 8

NW corner	09E20	54N30
NE corner	12E45	54N00
SE corner	10E00	52N10
SW corner	07E30	52N40
Channel 61	11E30	53N38
Channel 62	8E03	52N52
Channel 63	9E46	53N27
Channel 64	11E32	54N01
Channel 65	10E47	52N45
Channel 66	9E44	53N50
Channel 67	9E13	52N34
Channel 68	11E01	53N09
Channel 69	9E41	54N13

Lattice number: 9

NW corner	12E45	54N00
NE corner	16E30	54N00
SE corner	13E30	52N15
SW corner	10E00	52N10
Channel 61	14E58	53N33
Channel 62	10E42	52N25
Channel 63	12E51	53N10
Channel 64	15E06	53N52
Channel 65	14E20	52N48
Channel 66	12E57	53N29
Channel 67	12E18	52N24
Channel 68	14E30	53N07
Channel 69	13E02	53N48

Lattice number: 10

NW corner	05E30	53N05
NE corner	07E30	52N40
SE corner	05E45	50N50
SW corner	03E30	51N45
Channel 61	6E34	52N22
Channel 62	3E57	51N53
Channel 63	5E19	52N18
Channel 64	6E43	52N41
Channel 65	6E14	51N25
Channel 66	5E27	52N35
Channel 67	4E59	51N25
Channel 68	6E19	51N52
Channel 69	5E36	52N52

Lattice number: 11

NW corner	07E30	52N40
NE corner	10E00	52N10
SE corner	08E15	50N15
SW corner	05E45	50N50
Channel 61	9E01	51N47
Channel 62	6E12	51N01
Channel 63	7E37	51N37
Channel 64	9E04	52N11
Channel 65	8E44	50N51
Channel 66	7E40	52N00
Channel 67	7E22	50N42
Channel 68	8E46	51N17
Channel 69	7E42	52N23

Lattice number: 12

NW corner	10E00	52N10
NE corner	13E30	52N15
SE corner	10E40	50N20
SW corner	08E15	50N15
Channel 61	12E14	51N44
Channel 62	8E48	50N31
Channel 63	10E30	51N18
Channel 64	12E15	52N05
Channel 65	11E29	50N56
Channel 66	10E26	51N38
Channel 67	9E55	50N30
Channel 68	11E43	51N17
Channel 69	10E22	51N58

Lattice number: 13

NW corner	13E30	52N15
NE corner	16E10	52N10
SE corner	13E30	50N15
SW corner	10E40	50N20
Channel 61	14E52	51N42
Channel 62	11E16	50N35
Channel 63	13E09	51N20
Channel 64	15E06	52N03
Channel 65	14E15	50N51
Channel 66	13E23	51N41
Channel 67	12E34	50N29
Channel 68	14E25	51N13
Channel 69	13E36	52N01

Lattice number: 14

NW corner	03E30	51N45
NE corner	05E45	50N50
SE corner	03E15	50N15
SW corner	00E45	50N30
Channel 61	4E35	50N44
Channel 62	1E19	50N35
Channel 63	3E04	50N49
Channel 64	4E50	51N01
Channel 65	3E58	50N26
Channel 66	3E19	51N08
Channel 67	2E27	50N25
Channel 68	4E10	50N35
Channel 69	3E33	51N27

Lattice number: 15

NW corner	05E45	50N50
NE corner	08E15	50N15
SE corner	06E20	49N30
SW corner	03E15	50N15
Channel 61	7E08	50N13
Channel 62	3E49	50N16
Channel 63	5E33	50N20
Channel 64	7E16	50N23
Channel 65	6E52	49N45
Channel 66	5E43	50N30
Channel 67	5E14	49N54
Channel 68	6E53	49N58
Channel 69	5E53	50N40

Lattice number: 16

NW corner	08E15	50N15
NE corner	10E40	50N20
SE corner	08E45	48N30
SW corner	06E20	49N30
Channel 61	9E40	50N03
Channel 62	6E48	49N36
Channel 63	8E16	49N56
Channel 64	9E45	50N15
Channel 65	9E17	49N05
Channel 66	8E21	50N03
Channel 67	7E55	49N07
Channel 68	9E22	49N32
Channel 69	8E25	50N11

Lattice number: 17

NW corner	10E40	50N20
NE corner	13E30	50N15
SE corner	11E30	48N30
SW corner	08E45	48N30
Channel 61	12E24	49N48
Channel 62	9E15	48N44
Channel 63	10E50	49N27
Channel 64	12E27	50N08
Channel 65	12E03	49N02
Channel 66	10E52	49N47
Channel 67	10E32	48N41
Channel 68	12E07	49N22
Channel 69	10E54	50N07

Lattice number: 18

NW corner	13E30	50N15
NE corner	16E00	50N10
SE corner	13E20	48N20
SW corner	11E30	48N30
Channel 61	14E54	49N43
Channel 62	11E59	48N43
Channel 63	13E30	49N24
Channel 64	15E03	50N03
Channel 65	14E06	48N54
Channel 66	13E35	49N43
Channel 67	12E49	48N36
Channel 68	14E23	49N16
Channel 69	13E40	50N02

Lattice number: 19

NW corner	16E00	50N10
NE corner	18E10	50N00
SE corner	16E10	48N25
SW corner	13E20	48N20
Channel 61	17E03	49N34
Channel 62	13E52	48N34
Channel 63	15E33	49N15
Channel 64	17E16	49N54
Channel 65	16E43	48N54
Channel 66	15E48	49N35
Channel 67	15E10	48N33
Channel 68	16E46	49N12
Channel 69	16E03	49N56

Lattice number: 20

NW corner	03E15	50N15
NE corner	06E20	49N30
SE corner	03E50	48N00
SW corner	00E30	48N10
Channel 61	4E59	49N09
Channel 62	1E08	48N22
Channel 63	3E07	48N59
Channel 64	5E09	49N34
Channel 65	4E32	48N28
Channel 66	3E17	49N27
Channel 67	2E40	48N14
Channel 68	4E37	48N47
Channel 69	3E26	49N54

Lattice number: 21

NW corner	06E20	49N30
NE corner	08E45	48N30
SE corner	07E15	47N30
SW corner	03E50	48N00
Channel 61	7E40	48N21
Channel 62	4E23	48N06
Channel 63	6E05	48N25
Channel 64	7E48	48N42
Channel 65	7E39	47N49
Channel 66	6E16	48N47
Channel 67	5E57	47N49
Channel 68	7E33	48N04
Channel 69	6E27	49N10

Lattice number: 22

NW corner	08E45	48N30
NE corner	11E30	48N30
SE corner	09E40	47N10
SW corner	07E15	47N30
Channel 61	10E31	48N13
Channel 62	7E42	47N38
Channel 63	9E06	48N02
Channel 64	10E31	48N25
Channel 65	10E11	47N35
Channel 66	9E04	48N13
Channel 67	8E50	47N27
Channel 68	10E15	47N52
Channel 69	9E02	48N23

Lattice number: 23		
NW corner	11E30	48N30
NE corner	13E20	48N20
SE corner	11E50	47N05
SW corner	09E40	47N10
Channel 61	12E29	48N01
Channel 62	10E04	47N19
Channel 63	11E20	47N48
Channel 64	12E36	48N17
Channel 65	12E15	47N28
Channel 66	11E27	48N04
Channel 67	11E04	47N15
Channel 68	12E17	47N43
Channel 69	11E35	48N19

Lattice number: 24		
NW corner	13E20	48N20
NE corner	16E10	48N25
SE corner	14E20	47N00
SW corner	11E50	47N05
Channel 61	15E10	48N04
Channel 62	12E17	47N15
Channel 63	13E43	47N47
Channel 64	15E09	48N18
Channel 65	14E51	47N26
Channel 66	13E40	48N00
Channel 67	13E27	47N11
Channel 68	14E54	47N43
Channel 69	13E37	48N12

Lattice number: 25		
NW corner	16E10	48N25
NE corner	19E10	48N30
SE corner	17E20	46N50
SW corner	14E20	47N00
Channel 61	18E04	48N06
Channel 62	14E51	47N12
Channel 63	16E27	47N47
Channel 64	18E04	48N22
Channel 65	17E50	47N21
Channel 66	16E27	48N02
Channel 67	16E15	47N05
Channel 68	17E50	47N41
Channel 69	16E27	48N16

Lattice number: 26		
NW corner	00E30	48N10
NE corner	03E50	48N00
SE corner	02E30	45N50
SW corner	01W45	45N30
Channel 61	2E36	47N23
Channel 62	1W09	45N50
Channel 63	0E41	46N51
Channel 64	2E36	47N51
Channel 65	2E49	46N30
Channel 66	0E44	47N21
Channel 67	0E49	45N56
Channel 68	2E35	46N52
Channel 69	0E47	47N51

Lattice number: 27		
NW corner	03E50	48N00
NE corner	07E15	47N30
SE corner	05E50	46N10
SW corner	02E30	45N50
Channel 61	6E11	47N05
Channel 62	2E59	46N04
Channel 63	4E31	46N47
Channel 64	6E04	47N29
Channel 65	6E12	46N34
Channel 66	4E23	47N14
Channel 67	4E33	46N10
Channel 68	6E05	46N47
Channel 69	4E14	47N40

Lattice number: 28		
NW corner	07E15	47N30
NE corner	09E40	47N10
SE corner	08E20	45N50
SW corner	05E50	46N10
Channel 61	8E48	46N53
Channel 62	6E15	46N18
Channel 63	7E31	46N45
Channel 64	8E48	47N10
Channel 65	8E42	46N15
Channel 66	7E30	47N01
Channel 67	7E24	46N07
Channel 68	8E40	46N32
Channel 69	7E29	47N18

Lattice number: 29		
NW corner	09E40	47N10
NE corner	11E50	47N05
SE corner	11E10	45N45
SW corner	08E20	45N50
Channel 61	11E05	46N45
Channel 62	8E42	46N00
Channel 63	9E52	46N30
Channel 64	11E03	47N00
Channel 65	11E19	46N10
Channel 66	9E52	46N45
Channel 67	10E02	45N55
Channel 68	11E07	46N25
Channel 69	9E52	47N00

Lattice number: 30		
NW corner	11E50	47N05
NE corner	14E20	47N00
SE corner	14E00	45N45
SW corner	11E10	45N45
Channel 61	13E40	46N40
Channel 62	11E29	45N55
Channel 63	12E29	46N25
Channel 64	13E30	46N55
Channel 65	14E03	46N08
Channel 66	12E19	46N40
Channel 67	12E50	45N53
Channel 68	13E47	46N22
Channel 69	12E10	46N55

Lattice number: 31

NW corner	14E20	47N00
NE corner	17E20	46N50
SE corner	17E00	45N40
SW corner	14E00	45N45
Channel 61	16E38	46N33
Channel 62	14E20	45N54
Channel 63	15E20	46N21
Channel 64	16E22	46N47
Channel 65	17E03	46N02
Channel 66	15E04	46N35
Channel 67	15E45	45N49
Channel 68	16E46	46N15
Channel 69	14E47	46N50

Lattice number: 32

NW corner	05W50	45N10
NE corner	01W45	45N30
SE corner	02W50	42N50
SW corner	06W20	42N25
Channel 61	2W45	44N43
Channel 62	5W53	42N49
Channel 63	4W30	44N00
Channel 64	3W04	45N11
Channel 65	2W33	43N39
Channel 66	4W51	44N28
Channel 67	4W12	42N56
Channel 68	2W45	44N06
Channel 69	5W13	44N55

Lattice number: 33

NW corner	01W45	45N30
NE corner	02E30	45N50
SE corner	00E45	43N10
SW corner	02W50	42N50
Channel 61	1E17	45N05
Channel 62	2W17	43N13
Channel 63	0W38	44N23
Channel 64	1E04	45N32
Channel 65	1E13	43N59
Channel 66	0W54	44N50
Channel 67	0W36	43N19
Channel 68	1E07	44N27
Channel 69	1W10	45N16

Lattice number: 34

NW corner	02E30	45N50
NE corner	05E50	46N10
SE corner	04E25	43N45
SW corner	00E45	43N10
Channel 61	4E41	45N26
Channel 62	1E17	43N33
Channel 63	2E55	44N43
Channel 64	4E38	45N51
Channel 65	4E47	44N29
Channel 66	2E53	45N09
Channel 67	2E59	43N46
Channel 68	4E37	44N53
Channel 69	2E50	45N35

Lattice number: 35

NW corner	05E50	46N10
NE corner	08E20	45N50
SE corner	07E20	43N45
SW corner	04E25	43N45
Channel 61	7E28	45N17
Channel 62	4E50	44N02
Channel 63	6E07	44N54
Channel 64	7E26	45N45
Channel 65	7E35	44N23
Channel 66	6E06	45N22
Channel 67	6E11	43N58
Channel 68	7E26	44N47
Channel 69	6E05	45N50

Lattice number: 36

NW corner	08E20	45N50
NE corner	11E10	45N45
SE corner	10E15	43N40
SW corner	07E20	43N45
Channel 61	10E19	45N13
Channel 62	7E43	44N01
Channel 63	8E57	44N49
Channel 64	10E12	45N37
Channel 65	10E28	44N19
Channel 66	8E49	45N12
Channel 67	9E06	43N55
Channel 68	10E19	44N43
Channel 69	8E41	45N35

Lattice number: 37

NW corner	11E10	45N45
NE corner	14E00	45N45
SE corner	13E15	43N40
SW corner	10E15	43N40
Channel 61	13E11	45N12
Channel 62	10E38	43N56
Channel 63	11E49	44N46
Channel 64	13E02	45N35
Channel 65	13E25	44N19
Channel 66	11E40	45N09
Channel 67	12E03	43N53
Channel 68	13E13	44N42
Channel 69	11E31	45N31

Lattice number: 38

NW corner	14E00	45N45
NE corner	17E00	45N40
SE corner	16E20	43N30
SW corner	13E15	43N40
Channel 61	16E11	45N08
Channel 62	13E37	43N56
Channel 63	14E48	44N44
Channel 64	16E00	45N32
Channel 65	16E29	44N10
Channel 66	14E36	45N07
Channel 67	15E05	43N48
Channel 68	16E15	44N36
Channel 69	14E24	45N30

Lattice number: 39

NW corner	17E00	45N40
NE corner	19E45	45N20
SE corner	18E50	43N20
SW corner	16E20	43N30
Channel 61	18E59	44N50
Channel 62	16E40	43N45
Channel 63	17E44	44N31
Channel 64	18E50	45N16
Channel 65	19E04	43N57
Channel 66	17E34	44N56
Channel 67	17E52	43N37
Channel 68	18E57	44N21
Channel 69	17E22	45N22

Lattice number: 40

NW corner	10W00	41N50
NE corner	06W20	42N25
SE corner	06W55	40N00
SW corner	10W00	39N30
Channel 61	7W07	41N41
Channel 62	9W39	39N52
Channel 63	8W35	40N58
Channel 64	7W28	42N03
Channel 65	6W47	40N44
Channel 66	8W59	41N19
Channel 67	8W10	40N03
Channel 68	7W02	41N08
Channel 69	9W23	41N40

Lattice number: 41

NW corner	06W20	42N25
NE corner	02W50	42N50
SE corner	03W40	40N30
SW corner	06W55	40N00
Channel 61	3W43	42N07
Channel 62	6W30	40N21
Channel 63	5W15	41N27
Channel 64	3W58	42N31
Channel 65	3W28	41N13
Channel 66	5W32	41N50
Channel 67	4W57	40N32
Channel 68	3W40	41N36
Channel 69	5W49	42N13

Lattice number: 42

NW corner	02W50	42N50
NE corner	00E45	43N10
SE corner	00W10	41N00
SW corner	03W40	40N30
Channel 61	0W12	42N30
Channel 62	3W13	40N50
Channel 63	1W51	41N52
Channel 64	0W26	42N53
Channel 65	0E03	41N40
Channel 66	2W05	42N15
Channel 67	1W33	41N01
Channel 68	0W10	42N01
Channel 69	2W20	42N38

Lattice number: 43

NW corner	00E45	43N10
NE corner	04E25	43N45
SE corner	03E10	41N20
SW corner	00W10	41N00
Channel 61	3E23	43N03
Channel 62	0E17	41N20
Channel 63	1E43	42N23
Channel 64	3E11	43N24
Channel 65	3E29	42N04
Channel 66	1E29	42N42
Channel 67	1E52	41N27
Channel 68	3E20	42N30
Channel 69	1E14	43N01

Lattice number: 44

NW corner	04E25	43N45
NE corner	07E20	43N45
SE corner	06E05	41N20
SW corner	03E10	41N20
Channel 61	6E24	43N07
Channel 62	3E36	41N39
Channel 63	4E56	42N37
Channel 64	6E19	43N34
Channel 65	6E24	42N05
Channel 66	4E51	43N03
Channel 67	4E58	41N35
Channel 68	6E18	42N32
Channel 69	4E45	43N29

Lattice number: 45

NW corner	07E20	43N45
NE corner	10E15	43N40
SE corner	09E25	41N15
SW corner	06E05	41N20
Channel 61	9E20	43N03
Channel 62	6E31	41N39
Channel 63	7E51	42N35
Channel 64	9E14	43N30
Channel 65	9E36	42N00
Channel 66	7E46	43N01
Channel 67	8E05	41N32
Channel 68	9E23	42N28
Channel 69	7E40	43N28

Lattice number: 46

NW corner	10E15	43N40
NE corner	13E15	43N40
SE corner	12E40	41N20
SW corner	09E25	41N15
Channel 61	12E25	43N02
Channel 62	9E48	41N34
Channel 63	11E00	42N32
Channel 64	12E14	43N29
Channel 65	12E47	42N03
Channel 66	10E49	42N58
Channel 67	11E20	41N33
Channel 68	12E31	42N29
Channel 69	10E38	43N24

Lattice number: 47

NW corner	13E15	43N40
NE corner	16E20	43N30
SE corner	15E30	41N20
SW corner	12E40	41N20
Channel 61	15E32	42N56
Channel 62	13E02	41N37
Channel 63	14E09	42N30
Channel 64	15E19	43N22
Channel 65	15E42	42N00
Channel 66	13E55	42N56
Channel 67	14E23	41N34
Channel 68	15E32	42N25
Channel 69	13E41	43N23

Lattice number: 48

NW corner	16E20	43N30
NE corner	18E50	43N20
SE corner	18E00	41N20
SW corner	15E30	41N20
Channel 61	18E06	42N48
Channel 62	15E50	41N36
Channel 63	16E54	42N25
Channel 64	17E59	43N13
Channel 65	18E12	41N57
Channel 66	16E46	42N49
Channel 67	17E01	41N32
Channel 68	18E05	42N19
Channel 69	16E39	43N14

Lattice number: 49

NW corner	18E50	43N20
NE corner	23E10	43N35
SE corner	21E55	41N20
SW corner	18E00	41N20
Channel 61	22E02	43N00
Channel 62	18E31	41N37
Channel 63	20E06	42N30
Channel 64	21E44	43N21
Channel 65	22E13	42N02
Channel 66	19E47	42N50
Channel 67	20E22	41N35
Channel 68	22E01	42N27
Channel 69	19E27	43N09

Lattice number: 50

NW corner	23E10	43N35
NE corner	27E30	43N45
SE corner	26E30	41N25
SW corner	21E55	41N20
Channel 61	26E17	43N08
Channel 62	22E29	41N39
Channel 63	24E14	42N36
Channel 64	26E02	43N32
Channel 65	26E43	42N08
Channel 66	23E59	42N59
Channel 67	24E39	41N38
Channel 68	26E23	42N34
Channel 69	23E44	43N22

Lattice number: 51

NW corner	10W00	44N30
NE corner	05W50	45N10
SE corner	06W20	42N25
SW corner	10W00	41N50
Channel 61	6W43	44N20
Channel 62	9W36	42N15
Channel 63	8W24	43N31
Channel 64	7W08	44N45
Channel 65	6W14	43N15
Channel 66	8W51	43N55
Channel 67	7W50	42N28
Channel 68	6W34	43N43
Channel 69	9W19	44N19

Lattice number: 52

NW corner	10W00	39N30
NE corner	06W55	40N00
SE corner	07W30	36N40
SW corner	10W20	36N10
Channel 61	7W39	39N01
Channel 62	10W00	36N39
Channel 63	8W58	38N07
Channel 64	7W54	39N35
Channel 65	7W22	37N41
Channel 66	9W15	38N40
Channel 67	8W38	36N48
Channel 68	7W35	38N15
Channel 69	9W31	39N12

Lattice number: 53

NW corner	06W55	40N00
NE corner	03W40	40N30
SE corner	04W40	37N00
SW corner	07W30	36N40
Channel 61	4W31	39N31
Channel 62	7W07	37N09
Channel 63	5W57	38N37
Channel 64	4W44	40N05
Channel 65	4W24	38N05
Channel 66	6W11	39N10
Channel 67	5W46	37N13
Channel 68	4W33	38N42
Channel 69	6W27	39N42

Lattice number: 54

NW corner	06E05	41N20
NE corner	09E25	41N15
SE corner	08E15	37N50
SW corner	04E15	37N50
Channel 61	8E16	40N22
Channel 62	4E47	38N17
Channel 63	6E28	39N39
Channel 64	8E13	41N00
Channel 65	8E32	38N53
Channel 66	6E27	40N18
Channel 67	6E40	38N12
Channel 68	8E17	39N32
Channel 69	6E25	40N56

Lattice number: 55

NW corner	09E25	41N15
NE corner	12E40	41N20
SE corner	11E10	37N45
SW corner	08E15	37N50
Channel 61	11E39	40N25
Channel 62	8E42	38N17
Channel 63	10E06	39N40
Channel 64	11E33	41N02
Channel 65	11E34	38N52
Channel 66	9E57	40N17
Channel 67	10E04	38N10
Channel 68	11E30	39N33
Channel 69	9E48	40N53

Lattice number: 56

NW corner	12E40	41N20
NE corner	15E30	41N20
SE corner	13E50	37N40
SW corner	11E10	37N45
Channel 61	14E29	40N23
Channel 62	11E37	38N13
Channel 63	13E01	39N39
Channel 64	14E29	41N03
Channel 65	14E17	38N48
Channel 66	12E59	40N17
Channel 67	12E52	38N05
Channel 68	14E17	39N30
Channel 69	12E57	40N56

Lattice number: 57

NW corner	15E30	41N20
NE corner	18E00	41N20
SE corner	16E35	38N00
SW corner	13E50	37N40
Channel 61	17E02	40N24
Channel 62	14E16	38N09
Channel 63	15E38	39N36
Channel 64	17E04	41N03
Channel 65	16E57	39N02
Channel 66	15E41	40N16
Channel 67	15E33	38N12
Channel 68	16E54	39N37
Channel 69	15E42	40N55

Lattice number: 58

NW corner	18E00	41N20
NE corner	21E55	41N20
SE corner	20E20	38N20
SW corner	16E35	38N00
Channel 61	20E43	40N29
Channel 62	17E07	38N26
Channel 63	18E49	39N46
Channel 64	20E34	41N05
Channel 65	20E44	39N15
Channel 66	18E39	40N22
Channel 67	18E53	38N31
Channel 68	20E36	39N47
Channel 69	18E28	40N58

Lattice number: 59

NW corner	21E55	41N20
NE corner	26E30	41N25
SE corner	25E00	38N30
SW corner	20E20	38N20
Channel 61	25E08	40N38
Channel 62	20E58	38N45
Channel 63	22E55	39N58
Channel 64	24E56	41N10
Channel 65	25E22	39N24
Channel 66	22E42	40N30
Channel 67	23E10	38N45
Channel 68	25E07	39N56
Channel 69	22E29	41N01

Lattice number: 60

NW corner	11E10	37N45
NE corner	13E50	37N40
SE corner	13E15	35N30
SW corner	10E20	35N30
Channel 61	13E05	37N06
Channel 62	10E41	35N47
Channel 63	11E48	36N39
Channel 64	12E56	37N31
Channel 65	13E22	36N10
Channel 66	11E39	37N04
Channel 67	12E04	35N44
Channel 68	13E09	36N34
Channel 69	11E30	37N29

Lattice number: 61

NW corner	13E50	37N40
NE corner	16E35	38N00
SE corner	15E40	35N35
SW corner	13E15	35N30
Channel 61	15E50	37N21
Channel 62	13E35	35N49
Channel 63	14E37	36N46
Channel 64	15E40	37N43
Channel 65	15E54	36N20
Channel 66	14E25	37N08
Channel 67	14E44	35N48
Channel 68	15E48	36N46
Channel 69	14E13	37N28

Lattice number: 62

NW corner	20E20	38N20
NE corner	25E00	38N30
SE corner	23E55	36N00
SW corner	19E10	35N50
Channel 61	23E44	37N49
Channel 62	19E45	36N11
Channel 63	21E34	37N14
Channel 64	23E26	38N16
Channel 65	24E10	36N46
Channel 66	21E16	37N40
Channel 67	22E00	36N12
Channel 68	23E49	37N14
Channel 69	20E58	38N05

Lattice number: 70

NW corner	19E40	61N20
NE corner	25E20	60N20
SE corner	22E00	58N55
SW corner	17E00	59N50
Channel 61	23E26	60N10
Channel 62	17E53	59N57
Channel 63	20E36	60N17
Channel 64	23E23	60N33
Channel 65	22E55	59N23
Channel 66	20E28	60N39
Channel 67	20E14	59N28
Channel 68	22E59	59N45
Channel 69	20E18	61N01

Lattice number: 71

NW corner	16E15	63N35
NE corner	22E30	62N45
SE corner	19E40	61N20
SW corner	14E10	62N05
Channel 61	20E38	62N33
Channel 62	15E02	62N13
Channel 63	17E41	62N35
Channel 64	20E24	62N55
Channel 65	20E25	61N47
Channel 66	17E23	62N56
Channel 67	17E39	61N49
Channel 68	20E20	62N09
Channel 69	17E03	63N17

Lattice number: 72

NW corner	22E30	62N45
NE corner	28E30	61N40
SE corner	25E20	60N20
SW corner	19E40	61N20
Channel 61	26E32	61N33
Channel 62	20E37	61N26
Channel 63	23E30	61N42
Channel 64	26E26	61N55
Channel 65	26E12	60N46
Channel 66	23E21	62N04
Channel 67	23E17	60N55
Channel 68	26E10	61N09
Channel 69	23E11	62N26

Lattice number: 73

NW corner	19E10	65N20
NE corner	26E00	64N17
SE corner	22E30	62N45
SW corner	16E15	63N35
Channel 61	23E48	64N05
Channel 62	17E16	63N44
Channel 63	20E26	64N09
Channel 64	23E40	64N30
Channel 65	23E26	63N15
Channel 66	20E13	64N34
Channel 67	20E14	63N18
Channel 68	23E24	63N39
Channel 69	19E59	64N59

Lattice number: 74

NW corner	26E00	64N17
NE corner	32E00	63N00
SE corner	28E30	61N40
SW corner	22E30	62N45
Channel 61	29E52	62N54
Channel 62	23E32	62N51
Channel 63	26E41	63N07
Channel 64	29E54	63N18
Channel 65	29E27	62N06
Channel 66	26E39	63N31
Channel 67	26E21	62N18
Channel 68	29E27	62N30
Channel 69	26E37	63N55

Lattice number: 75

NW corner	23E00	67N20
NE corner	31E10	66N20
SE corner	26E00	64N17
SW corner	19E10	65N20
Channel 61	28E22	66N04
Channel 62	20E25	65N32
Channel 63	24E18	66N05
Channel 64	28E21	66N32
Channel 65	27E24	64N57
Channel 66	24E07	66N32
Channel 67	23E39	64N59
Channel 68	27E36	65N29
Channel 69	23E55	66N58

Lattice number: 76

NW corner	31E10	66N20
NE corner	37E15	65N10
SE corner	32E00	63N00
SW corner	26E00	64N17
Channel 61	34E37	64N55
Channel 62	27E14	64N28
Channel 63	31E02	64N59
Channel 64	34E58	65N24
Channel 65	33E27	63N43
Channel 66	31E18	65N28
Channel 67	30E01	63N48
Channel 68	33E45	64N17
Channel 69	31E35	65N56

Lattice number: 77

NW corner	21E00	69N25
NE corner	27E20	69N00
SE corner	23E00	67N20
SW corner	17E30	67N55
Channel 61	25E01	68N43
Channel 62	18E32	68N05
Channel 63	21E44	68N36
Channel 64	25E05	69N02
Channel 65	24E11	67N52
Channel 66	21E41	68N54
Channel 67	21E07	67N47
Channel 68	24E22	68N16
Channel 69	21E38	69N12

Lattice number: 78

NW corner	27E20	69N00
NE corner	35E10	67N52
SE corner	31E10	66N20
SW corner	23E00	67N20
Channel 61	32E27	67N43
Channel 62	24E18	67N28
Channel 63	28E18	67N51
Channel 64	32E26	68N08
Channel 65	32E13	66N50
Channel 66	28E14	68N15
Channel 67	28E10	66N58
Channel 68	32E04	67N16
Channel 69	28E09	68N39

Lattice number: 81

NW corner	26E30	41N25
NE corner	30E36	41N34
SE corner	29E06	38N45
SW corner	25E00	38N30
Channel 61	29E21	40N47
Channel 62	25E34	38N54
Channel 63	27E21	40N07
Channel 64	29E11	41N18
Channel 65	29E29	39N37
Channel 66	27E10	40N37
Channel 67	27E30	38N57
Channel 68	29E17	40N07
Channel 69	27E00	41N07

Lattice number: 82

NW corner	25E00	38N30
NE corner	29E06	38N45
SE corner	27E30	35N47
SW corner	23E55	36N00
Channel 61	27E56	38N01
Channel 62	24E26	36N21
Channel 63	26E03	37N26
Channel 64	27E43	38N29
Channel 65	27E55	36N42
Channel 66	25E48	37N51
Channel 67	26E08	36N11
Channel 68	27E49	37N17
Channel 69	25E33	38N16

Lattice number: 83

NW corner	30E36	41N34
NE corner	35E24	41N34
SE corner	34E00	38N55
SW corner	29E06	38N45
Channel 61	34E01	40N51
Channel 62	29E44	39N08
Channel 63	31E43	40N16
Channel 64	33E46	41N22
Channel 65	34E20	39N44
Channel 66	31E28	40N46
Channel 67	32E03	39N08
Channel 68	34E02	40N13
Channel 69	31E13	41N16

Lattice number: 84

NW corner	29E06	38N45
NE corner	34E00	38N55
SE corner	32E35	35N33
SW corner	27E30	35N47
Channel 61	32E34	38N06
Channel 62	28E10	36N12
Channel 63	30E13	37N26
Channel 64	32E20	38N39
Channel 65	32E55	36N36
Channel 66	29E58	37N57
Channel 67	30E34	36N01
Channel 68	32E36	37N16
Channel 69	29E43	38N27

Lattice number: 85

NW corner	35E24	41N34
NE corner	40E25	41N15
SE corner	39E02	38N45
SW corner	34E00	38N55
Channel 61	39E01	40N39
Channel 62	34E39	39N14
Channel 63	36E40	40N13
Channel 64	38E44	41N09
Channel 65	39E22	39N32
Channel 66	36E22	40N43
Channel 67	37E02	39N06
Channel 68	39E03	40N01
Channel 69	36E04	41N14

Lattice number: 86

NW corner	34E00	38N55
NE corner	39E02	38N45
SE corner	37E20	35N05
SW corner	32E35	35N33
Channel 61	37E36	37N54
Channel 62	33E14	35N59
Channel 63	35E15	37N17
Channel 64	37E20	38N33
Channel 65	37E46	36N14
Channel 66	34E58	37N54
Channel 67	35E29	35N41
Channel 68	37E32	36N59
Channel 69	34E40	38N31

Lattice number: 87

NW corner	40E25	41N15
NE corner	46E18	40N29
SE corner	44E42	38N03
SW corner	39E02	38N45
Channel 61	44E43	40N01
Channel 62	39E46	39N01
Channel 63	42E02	39N48
Channel 64	44E22	40N33
Channel 65	45E05	38N49
Channel 66	41E38	40N20
Channel 67	42E28	38N38
Channel 68	44E45	39N22
Channel 69	41E14	40N51

Lattice number: 88

NW corner	39E02	38N45
NE corner	44E42	38N03
SE corner	42E35	34N18
SW corner	37E20	35N05
Channel 61	43E03	37N15
Channel 62	38E05	35N30
Channel 63	40E24	36N47
Channel 64	42E48	38N00
Channel 65	43E08	35N29
Channel 66	40E05	37N31
Channel 67	40E34	35N03
Channel 68	42E56	36N17
Channel 69	39E46	38N14

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C5. SCENARIO FOR PLANNING DVB-T

C5.1 Introduction

Full advantage of the spectrum opportunities offered by DVB-T can only be achieved after a complete revision of the ST61 Plan for the all digital era. This revision should take place when there is enough experience gained from the initial introduction of DVB-T to establish well tested criteria. Also, there should be a clear idea on the commercial requirements for DVB-T in the future. This should be seen in relation to the commercial aspects and spectrum requirements of other services wishing to make use of the current television bands.

At present such a revision of the ST61 Plan is expected to take place around 2005. In line with previous broadcast conferences this ITU conference should consist of two parts; a first part to agree on the technical parameters and planning principles and a second part to produce a DVB-T plan.

In order to prepare for such a conference, Resolution 2 has been adopted in Chester. This Resolution is:

"RESOLUTION 2.

Follow-up CEPT activities in advance of a possible future ITU Conference to revise ST61

The Multilateral Coordination Meeting, Chester, 25 July 1997,

considering

a) that, in accordance with its agenda, it has adopted a Multilateral Coordination Agreement relating to Technical Criteria, Coordination Principles and Procedures for the introduction of DVB-T in Europe in the Frequency Bands 174 to 230 MHz and 470 to 862 MHz;

b) that DVB-T will be introduced by coordination of assignments on the basis of the above Criteria or by conversion of analogue television assignments into digital television assignments;

c) that analogue television and DVB-T will co-exist in a transition period;

d) that in some countries the channels above channel 60 will be a very important means for the introduction of DVB-T;

e) that administrations having no assignments in ST61 for channels above channel 60 may wish to coordinate such assignments on the basis of equitable access;

noting

that the implementation of DVB-T on the basis of the Stockholm Plan, including extrapolations to this Plan, may not lead to an optimum solution with respect to frequency efficiency (including SFNs), reception conditions and network economy;

resolves

1 that the CEPT should follow the growth of DVB-T and arrange a preparatory planning meeting as soon as practicable when a significant degree of penetration has been reached;

2 that the CEPT preparatory planning meeting should prepare for the establishing of a frequency plan for DVB-T only, including the rules for the transition to all-digital terrestrial television."

C5.2 Co-ordinations after July 1997

All countries that wish to introduce DVB-T before the revision of the ST61 Plan, foreseen around 2005, should investigate the possibilities for DVB-T assignments or allotments, even if the exact service requirements are not yet known. These preliminary assignments, or allotment requirements, could then be used in bi- or multilateral planning meetings.

In preparation for past planning meetings, such as the Stockholm Conference 1961 or the Geneva 84 Conference or various multilateral agreements, not all service requirements were known. Nevertheless, some assignment characteristics were requested in order to ensure equitable access to the frequency range under consideration.

As the pace of introduction of DVB-T is likely to be different in the various parts of Europe, planning will probably concentrate on those areas where the need arises. The results of such bi- or multilateral planning meetings will then be coordinated by means of the procedures agreed at the Chester 97 meeting.

The results of these coordinations should not prejudice the outcome of the revision of the ST61 Plan foreseen around 2005.

C5.3 Equitable Access

In an extreme case the result of the coordination process could be that a country has more DVB-T networks than its equitable share in the revision of the ST61 Plan could ever accomplish. In order to avoid this situation an upper limitation of the number of DVB-T channels per area to six in the period between July 1997 and the foreseen revision of ST61 around 2005, could be used by administrations in their negotiations.

C5.4 Maintenance of the Plan

C5.4.1 Introduction

Data bases of analogue television stations, digital television stations and stations of other services have to be maintained. Furthermore databases containing test points, and reference data are required.

The ERO will assist administrations in maintaining up to date databases.

C5.4.2 Work performed by the ITU

The tasks of the ITU are described in Article 4 of the Stockholm agreement and are related to:

- publication of requests for coordination of television assignments in the shared bands and -assignments with an effective antenna height of more than 1200 m;
- publication of characteristics of agreed new or modified television assignments;
- updating the Stockholm Plan;
- on request assist administrations in reaching a coordination agreement.

The ITU can do these tasks also for DVB-T assignments that will be coordinated under Article 4 of the Stockholm agreement.

It should be noted that the Stockholm agreement does not contain a method for assessing compatibility, for that reason the ITU has no information on testpoints and interference levels to be protected.

It should also be noted that the (updated) Stockholm Plan contains many assignments that will never come into operation for a variety of reasons (for instance the station is replaced by other assignments and the original never deleted, or simply mistakes).

In practice it has been difficult to get an up-to-date version of the Stockholm Plan, this was only published from time to time and the data format is not user friendly.

C5.4.3 ERO tasks after the Chester 97 meeting

Following the Chester 97 meeting it is expected that administrations will co-ordinate DVB-T assignments. This can be done by correspondence or in bi- or multi-lateral meetings. To support these co-ordinations the latest update of the database of broadcasting assignments and other service assignments as well as up-to-date data on test points and interference levels at these test points will be needed. **Annex C5.1** provides a copy of the timetable for the initial establishment of this information. The information contained in **Annex C5.1** is provided in diagrammatic form in Fig. C1.10. The results of the co-ordinations should be recorded in the data base.

Resolution 1 of the CH97 deals with tasks for the ERO. This resolution is:

RESOLUTION 1

Invitation to the CEPT European Radiocommunications Committee (ERC) to assign tasks to the European Radiocommunications Office (ERO)

The Multilateral Coordination Meeting, Chester, 25 July 1997,

considering

a) that, in accordance with its agenda, it has adopted a Multilateral Coordination Agreement relating to Technical Criteria, Coordination Principles and Procedures for the introduction of DVB-T in Europe in the frequency bands 174 to 230 MHz and 470 to 862 MHz;

b) that the assistance of the ERO should be sought to assist in implementing the procedures of the Agreement, in particular to carry out the following tasks:

i) collecting data on television stations from administrations, performing validation checks and resolving format problems;

ii) collecting data on other services from administrations, performing validation checks and resolving format problems;

iii) maintaining databases of television stations and stations of other services relevant to DVB-T planning;

iv) providing software support to administrations to facilitate data collection;

v) co-operating with the EBU on compatibility calculations to allow administrations to utilise the results of these calculations and to gain access to principal software blocks used for calculations;

vi) providing software support to administrations to facilitate basic compatibility calculations; and

vii) circulating data contained in the databases to administrations;

noting

that any request for assistance from the ERO will have resource implications;

resolves

to invite the CEPT/ERC to consider assigning to the ERO the tasks identified in *considering* b) above."

Fig. C1.1 Coordination Procedure A: Procedure for analogue television stations (Article 4 Part A)

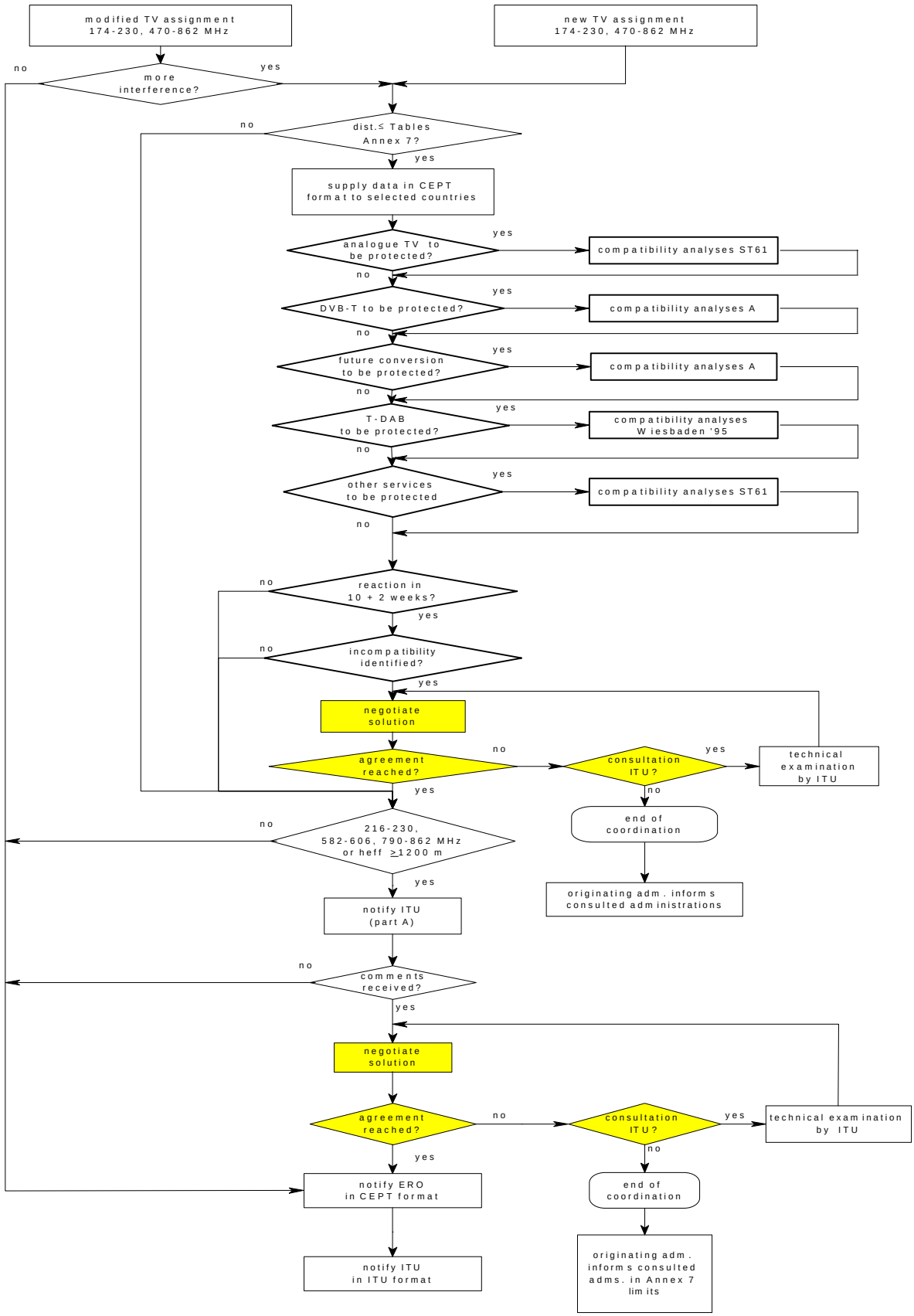


Fig. C1.2 Coordination Procedure B: Procedure for DVB-T stations or SFNs (Article 4 Part B)

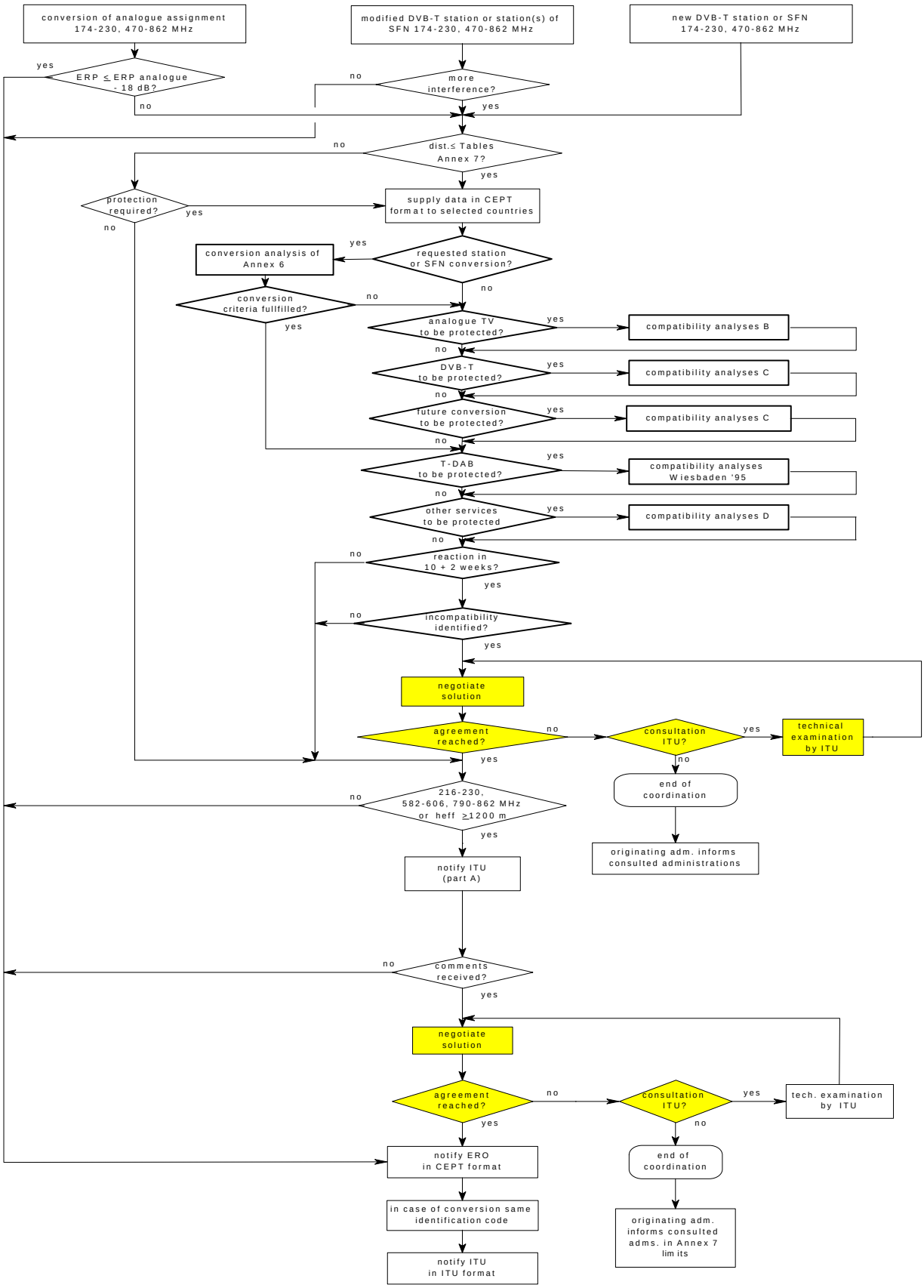


Fig. C.1.3 Coordination procedure C:Procedure for stations of services other than broadcasting having primary status(Article 4 Part C)

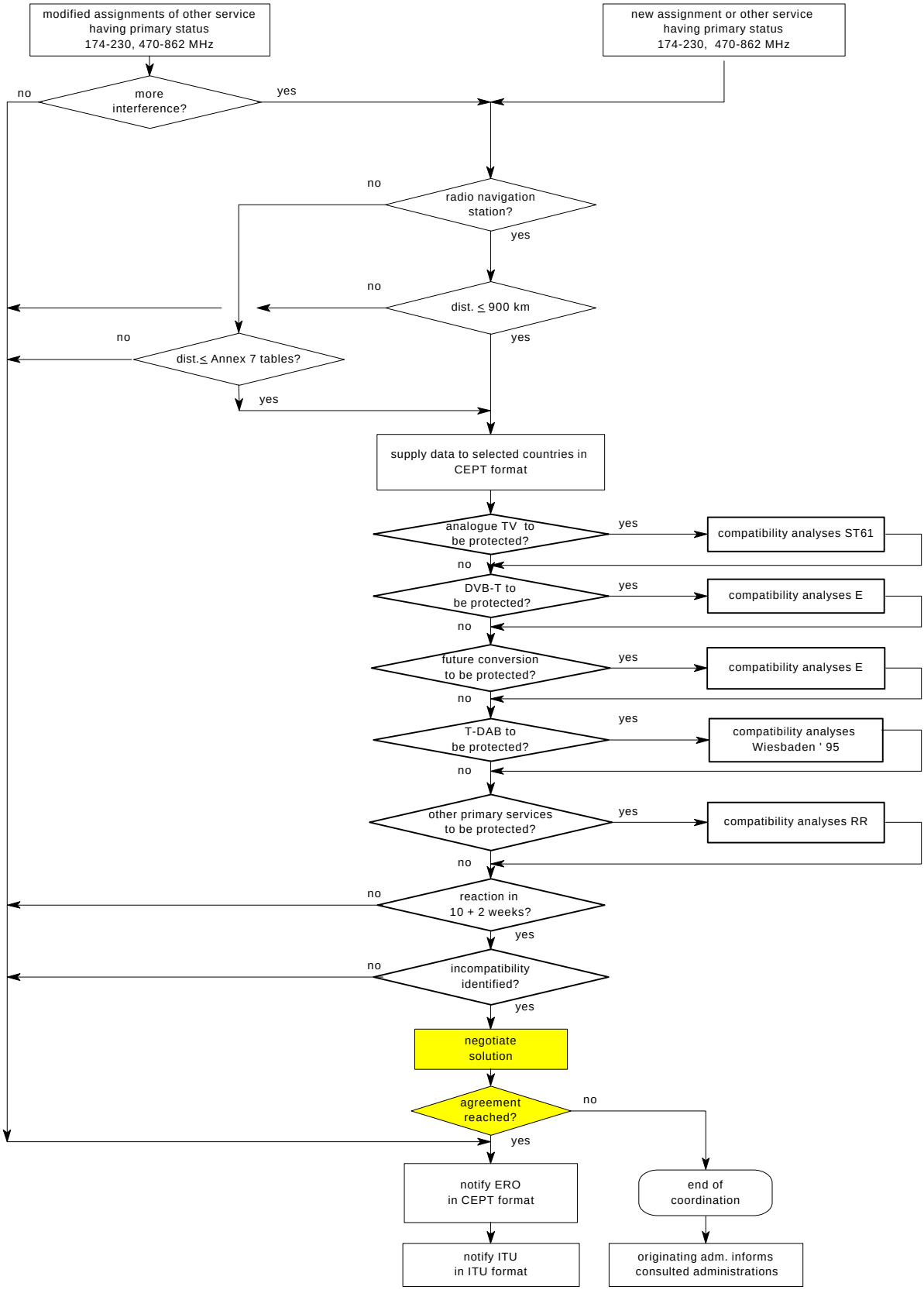


Fig. C1.4 Conversion of an analogue assignment into a DVB-T station or SFN (Annex 6)

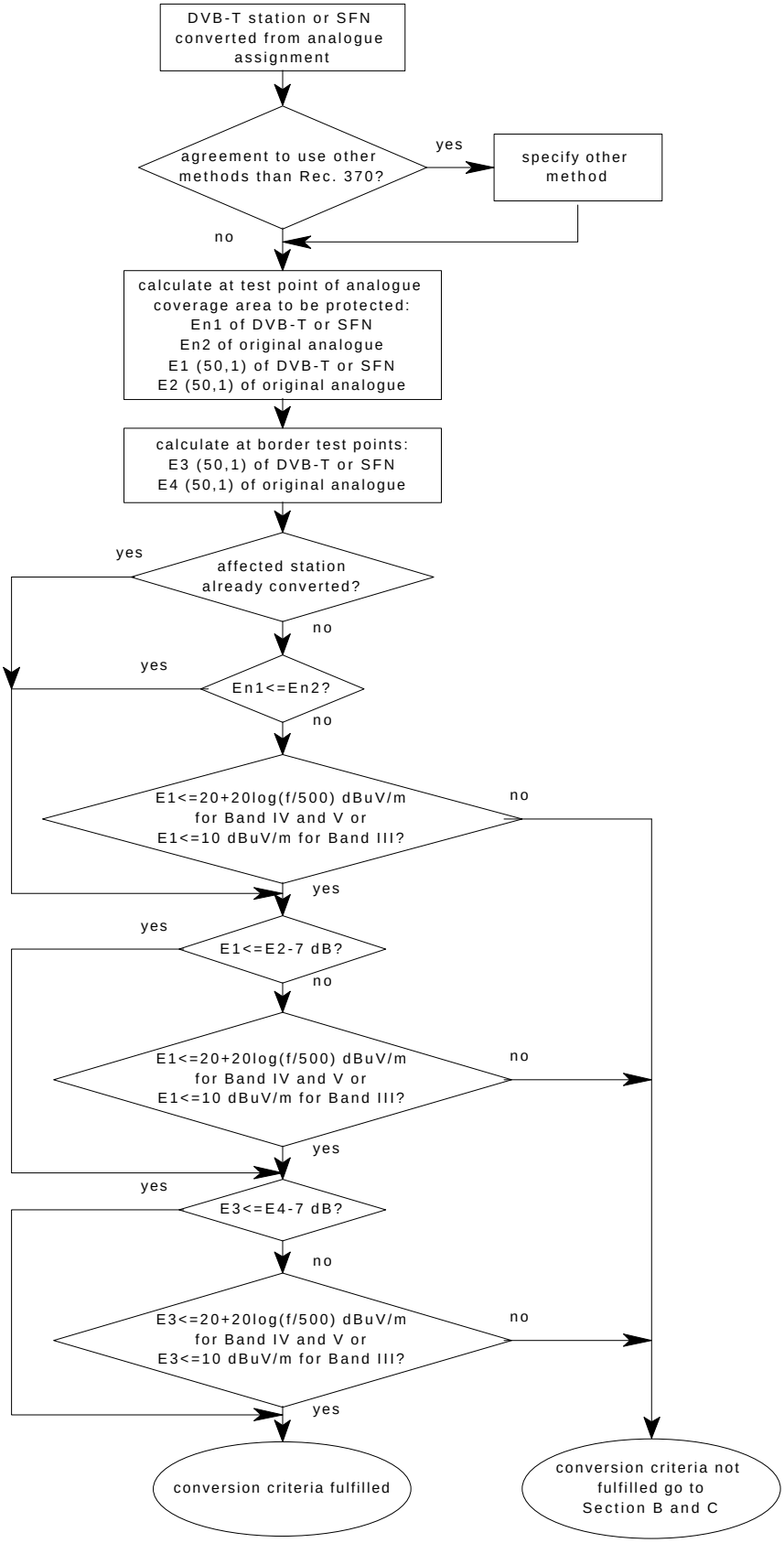


Fig. C1.5 Compatibility analysis A/C: DVB-T interfered with by analogue television and DVB-T interfered with by DVB-T (Annex 4 Section A and C)

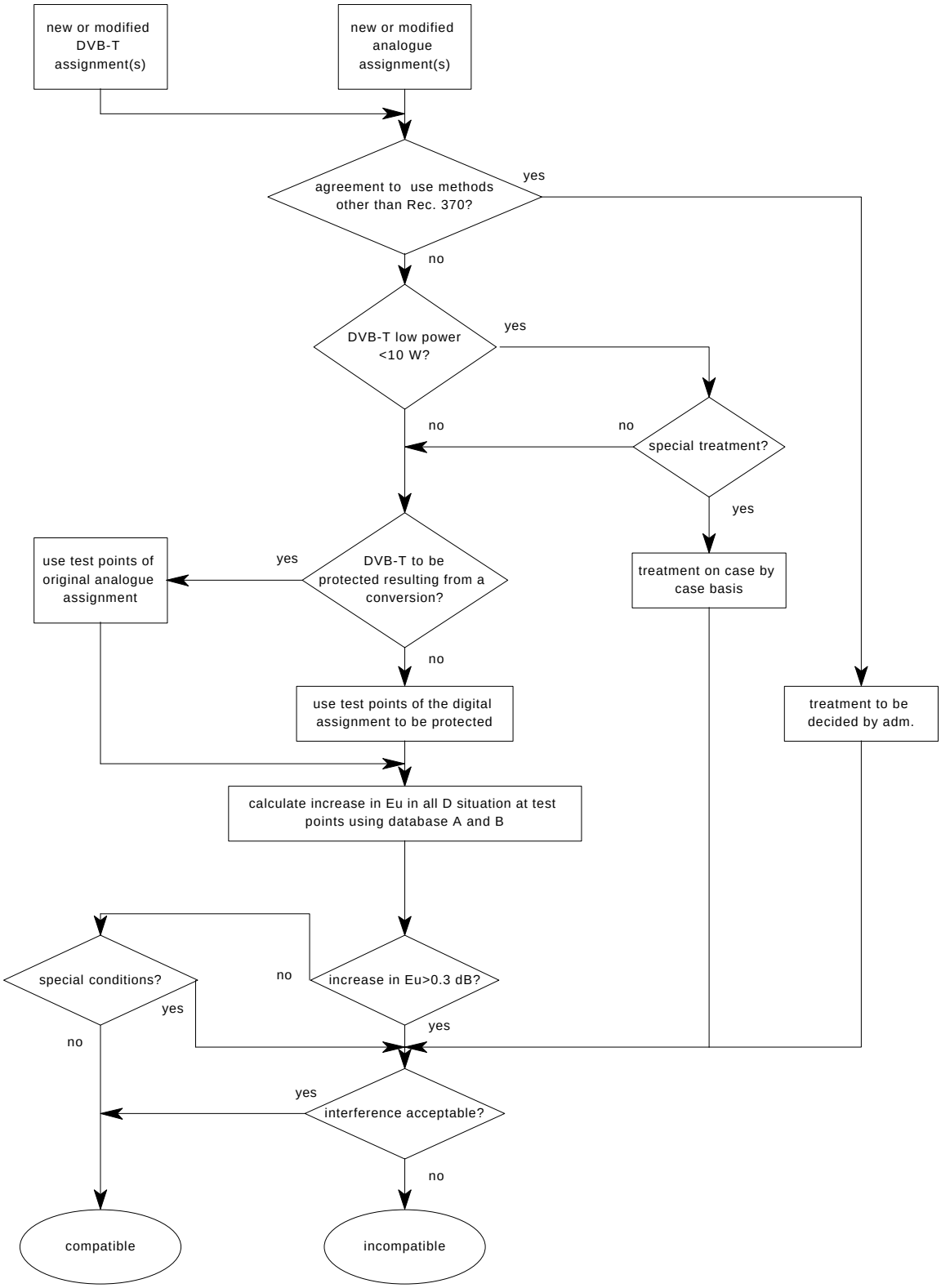


Fig. C1.6 Compatibility analysis B: Analogue TV interfered with by DVB-T (Annex 4 Section B)

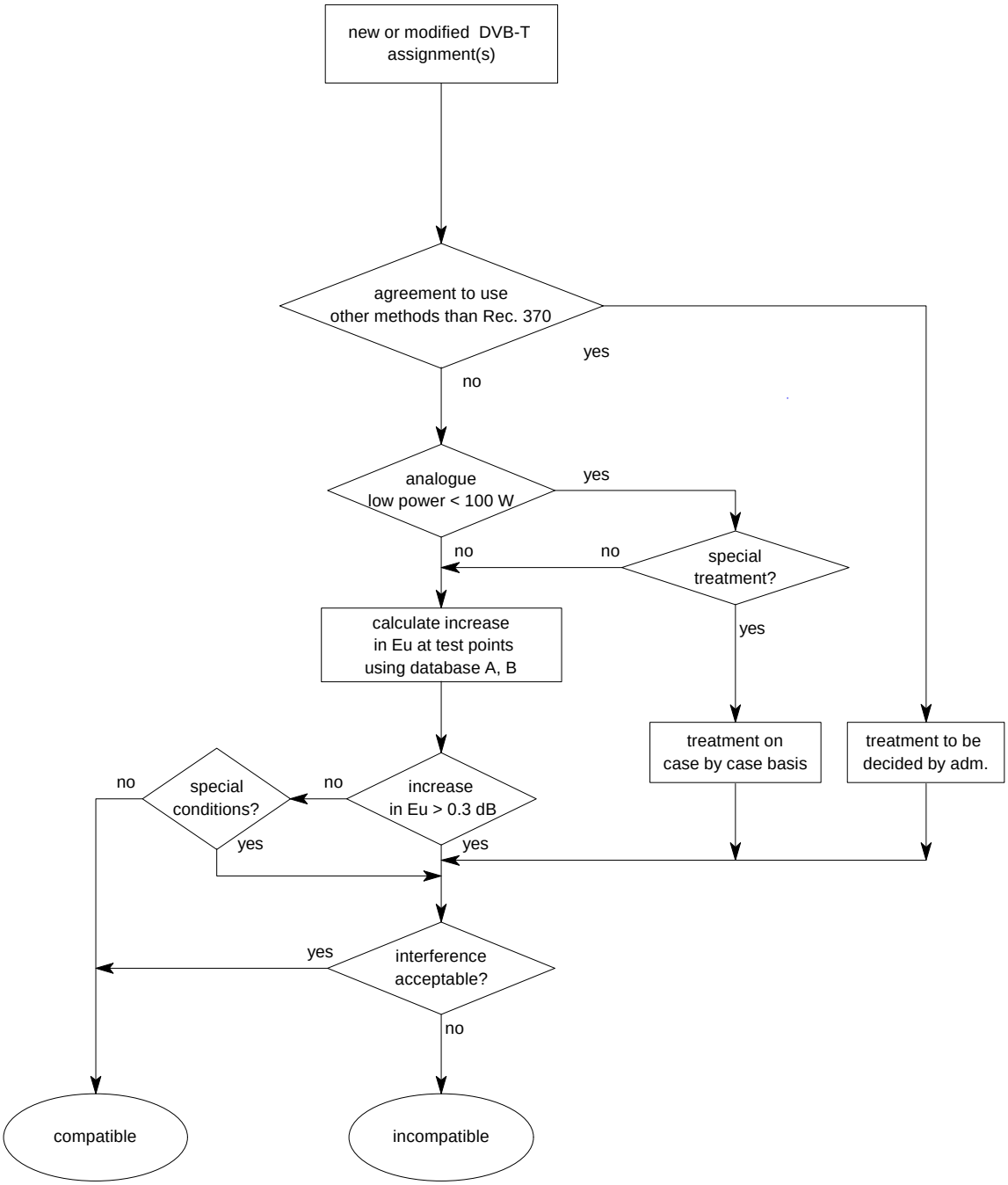


Fig. C1.7 Compatibility analysis D: Services other than broadcasting having primary status interfered with by DVB-T (Annex 4 Section D)

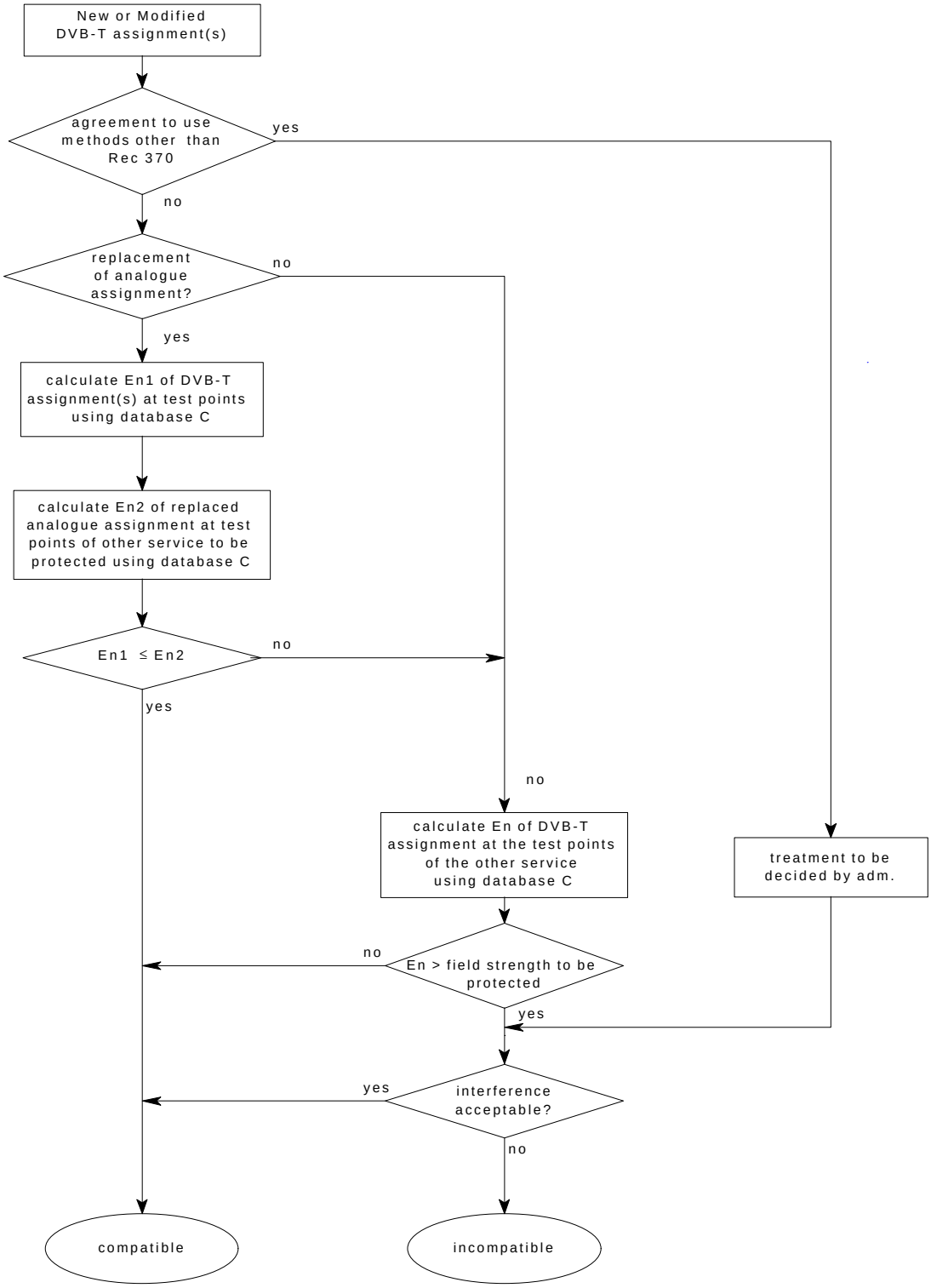


Fig. C1.8 Compatibility analysis E: DVB-T interfered with by services other than broadcasting having primary status (Annex 4 Section E)

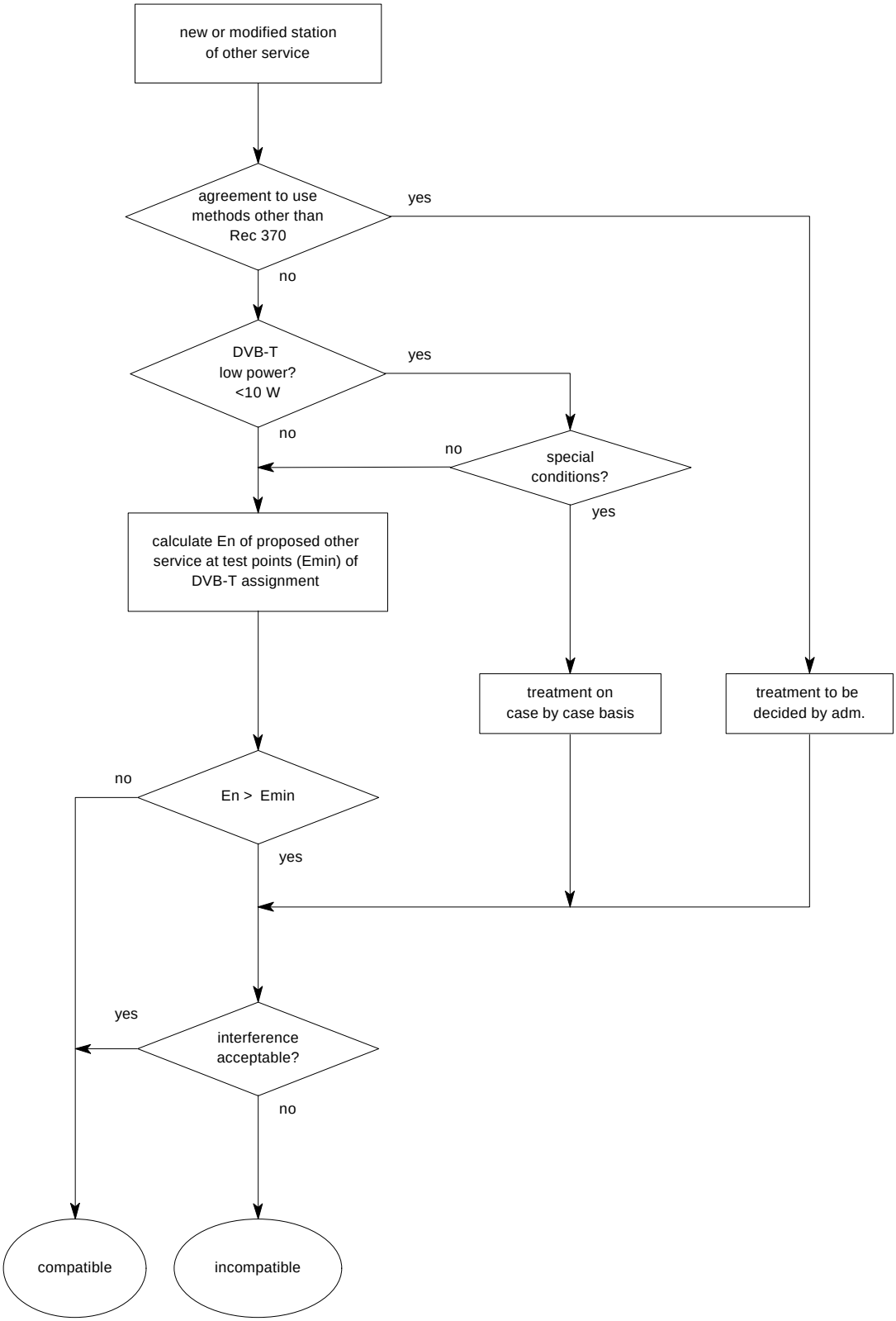


Fig. C1.9 CEPT databases to be used in compatibility analysis

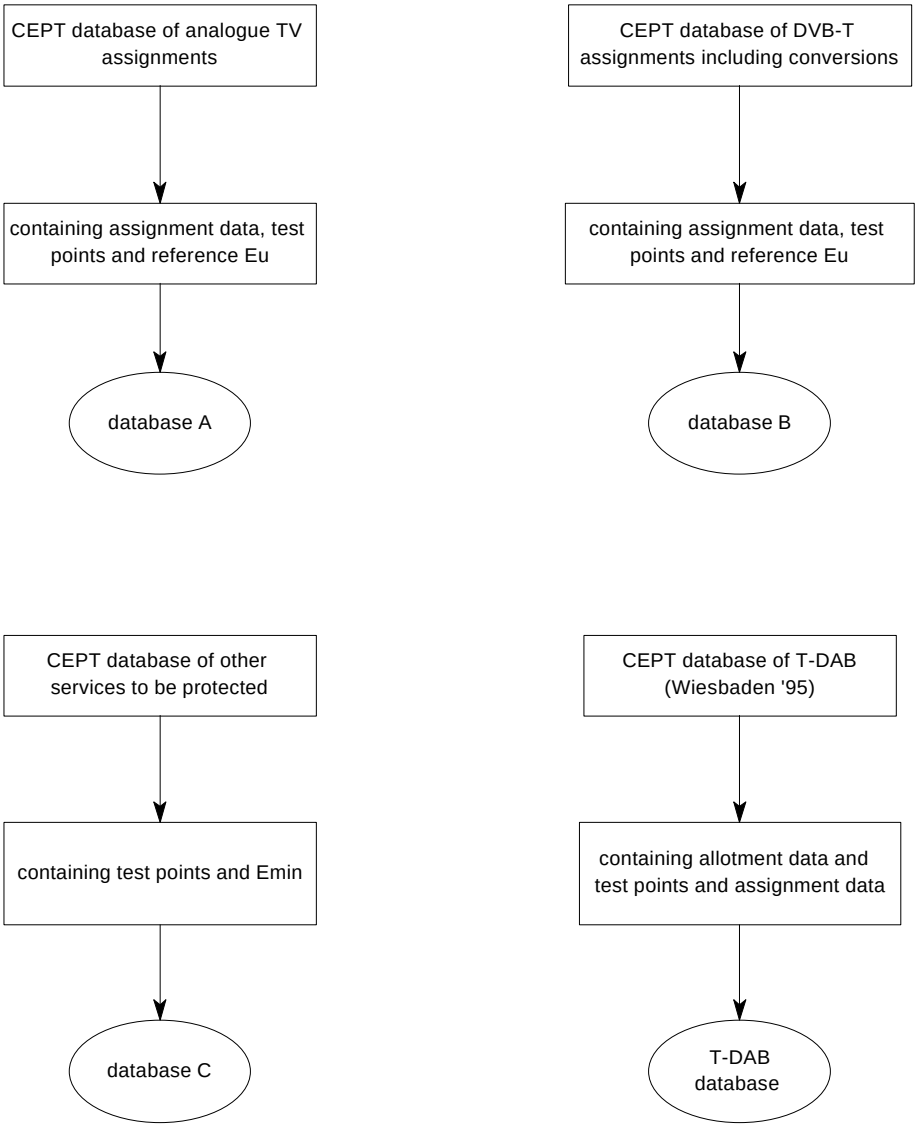
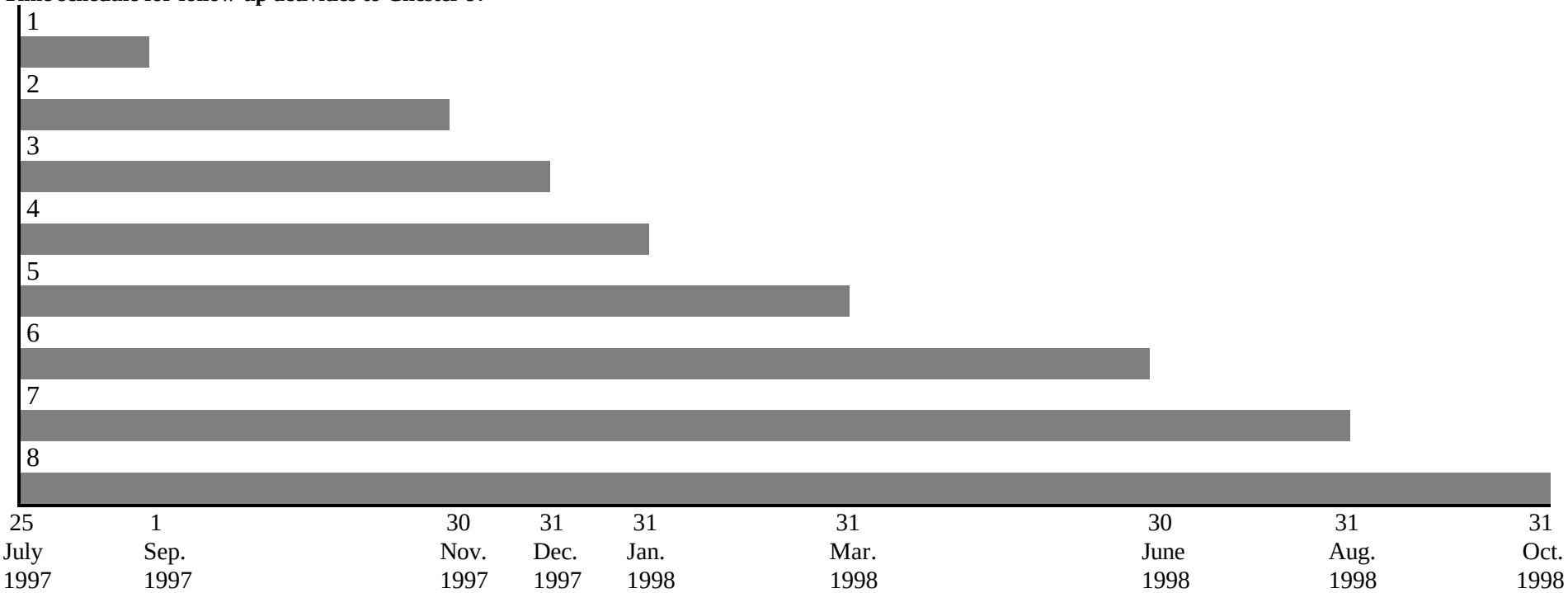


Fig. C1.10
Time schedule for follow-up activities to Chester 97



Activity list:

1. The ERO sends the ST61 in electronic format to all administrations involved.
2. The ERO sends out country boundary test points generated on the basis of the ITU digitised world map and the administrations send data for as many television stations as possible to the ERO.
3. The ERO sends out lists containing preliminary coverage area test points for all stations for which data has been received. These points are calculated in co-operation with the EBU.
4. Deadline for submission of data for television stations to the ERO.
5. Bilaterally coordinated and approved country boundary test points are returned to the ERO.
6. Deadline for submission to the ERO of data for television stations not earlier coordinated.
7. The ERO sends out lists containing the finally calculated test points for the coverage areas of all registered television stations.
8. Administrations submit corrected and approved coverage area test points for their stations to the ERO and the ERO calculates the reference interference at each test point.

Annex C5.1: Annex to CH97, Resolution 5

Time schedule for submission of data to the ERO and for the calculation of reference interference situations

1. Reference date for calculation of reference situations

For all coordinated television stations (including stations contained in ST61) within the relevant frequency bands the reference interference situation is calculated on the basis of the situation at 25/7/97. After submission of all relevant and approved data, as described below, to the ERO, a final reference calculation is done after 31/10/98 based on the submitted data and the interference situation at 25/7/97.

2. Television assignment data and test points

Databases containing transmitter data, coverage area test points and country boundary test points will take some time to establish. Therefore the following course of action is proposed:

1. All data exchange will be done by electronic means.

2. The ERO will send to all administrations a copy of the updated ST61 Plan, in the CEPT format, by 1/9/97. On the same date, the ERO will send to all administrations a set of software intended to assist in the preparation of the data files which administrations will need to send to the ERO.

3. Data in accordance with the CEPT data format should be sent to the ERO for as many as possible of all coordinated television stations (including stations contained in ST61) before 30/11/97. This will permit initial calculation of test points and detection of errors. Data for all television assignments should be sent to the ERO before 31/1/98. These data are sent by the ERO to the administrations of all countries for checking and agreement. Cases where there are disagreements should be clarified between the administrations concerned and cases where data errors were detected and corrected by the administration concerned should be sent to the ERO before 30/6/98.

4. Country boundary test points will be provisionally chosen by the ERO on the basis of the ITU Digital World Map before 30/11/97 and sent to all administrations. The country boundary test points will be checked, modified where appropriate and finally agreed as common boundary test points by the administrations sharing any given boundary. After bilateral acceptance the test points will be sent to the ERO before 31/3/98.

5. An initial set of coverage area test points for all assignments will be generated automatically by the ERO in cooperation with the EBU and sent to all administrations before 31/12/97. A revised set of coverage area test points will be generated before 31/8/98 on the basis of the final assignment data and taking account any comments received from administrations.

6. The revised set of coverage area test points calculated under 5 will be checked by the administrations concerned and any modifications to the test point locations, will be sent to the ERO before 31/10/98.

3. Data and test points for stations of services other than broadcasting

Databases containing receiver and transmitter data and test points will take some time to establish. Therefore the following course of action is proposed:

1. All data exchange will be done by electronic means.

2. Data in accordance with the CEPT data format should be sent to the ERO for as many as possible of all stations of services other than broadcasting before 30/11/97, including the locations of test points. This will permit initial detection of errors. Data for all other service stations should be sent to the ERO before 31/1/98. These data are sent by the ERO to the administrations of all countries for checking and agreement. Cases where there are disagreements should be clarified between the administrations concerned and cases where data errors were detected and corrected by the administration concerned should be sent to the ERO before 30/6/98.

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D0. INTRODUCTION

DVB-T will be implemented in some countries in the near future, e.g. in 1998 in the UK, Spain and Sweden and around 1999 in some other countries.

Important for the introduction of DVB-T is the environment in which this takes place:

- the present usage of the spectrum by analogue television;
- competition from satellite and cable broadcasting;
- readiness of viewers to accept new digital media and to spend money for them.

Terrestrial digital television networks have features which terrestrial analogue networks can not provide, such as:

- portable reception;
- more programme services;
- greater flexibility for local programming;
- a great variety of data services with flexible data rates,

since one digital multiplex occupying the same spectrum as one analogue television channel can carry three or more programme services.

D1. COMMERCIAL ASPECTS

D1.1 The overall television broadcast environment

D1.1.1 Analogue Television

The broadcast spectrum in Bands I, III, IV and V in most countries in Europe has been used to provide national or regional analogue television coverage of three or four programmes to a very high percentage of the population (typically greater than 99%). Some countries have been able to fit in two to four additional (local) analogue services in the more densely populated areas, but these have lower population coverage than the national or regional services.

D1.1.2 Development of cable and satellite

The limited number of analogue programme services that can be transmitted in these bands (which occupy almost half the spectrum below 1 GHz) has given rise to extensive cable networks in a number of European countries as a means of providing the viewer with greater choice. It has also directly contributed to the development of analogue television broadcasting by satellite.

D1.1.3 Interworking with satellite, cable and MVDS Systems

The competitive environment into which a DVB-T system will be introduced is shown in **Figure 1**. In Europe the existing analogue terrestrial, cable and satellite services are well established. Analogue MVDS is also used. Digital satellite services are currently being introduced and it is expected that digital services on cable will follow shortly.

MVDS is a cellular based terrestrial multi-channel television delivery system. The high frequencies used (between about 2.5 and 40 GHz) imply that the coverage radius is small (from about 50 km down to 2 km). MVDS can be used as an alternative to cable for areas where the cost of cable distribution network would be prohibitive.

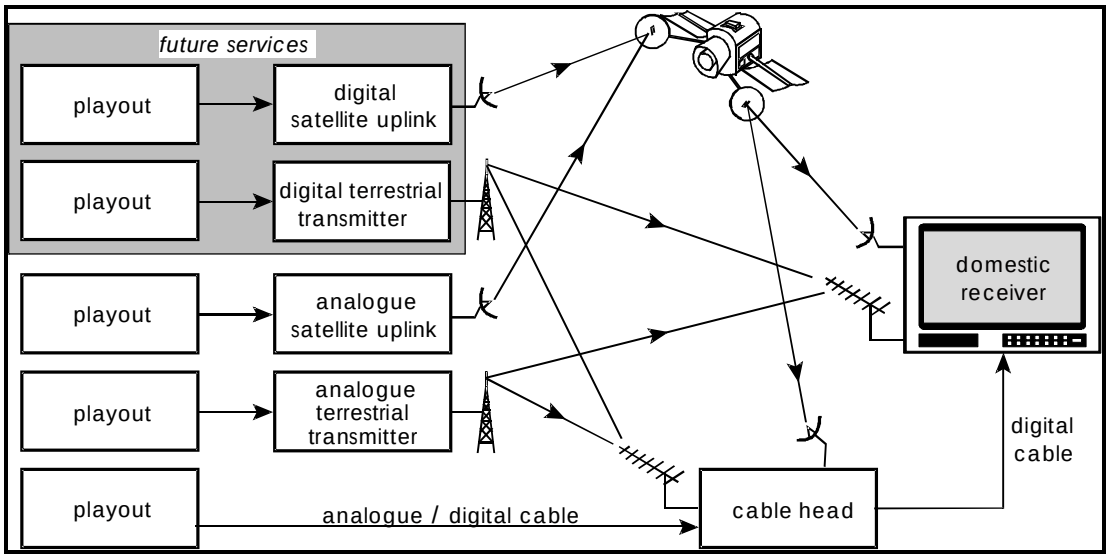

Figure 1 The broadcast environment

It follows therefore, that DVB-T will be introduced into an environment that has existing analogue terrestrial and analogue and digital satellite services. Also, due to the large numbers of viewers using cable in many European countries, it will be necessary for terrestrial digital services to be delivered by cable and master antenna systems.

D1.1.4 Alternative distribution systems

A number of distribution systems will be used for the delivery of digital television services. These systems, copper cable, MVDS, satellite, and optical fibre networks will have their own intrinsic limitations on transmission channel performance. Even in the longer term when it is envisaged that optical fibre networks are widely available throughout Europe, DVB-T will have an important role in providing ßplug free"reception.

Ultimately from the standpoint of the viewer, it is important that the received quality be independent of the delivery medium.

D1.1.5 Digital Video Broadcasting - DVB-T

The trend today is towards digital systems with a convergence of television (entertainment) and computer technologies, as exemplified by multimedia. The types of DVB systems proposed for Europe and the commercial factors relating to DVB, and DVB-T in particular, are set out briefly in this section.

D1.1.5.1 Types of DVB systems

A family of standards have been adopted by ETSI for digital television transmission in Europe. These include systems for:

- satellite transmission (DVB-S);
- MVDS transmission above 10 GHz (DVB-MS) and below 10 GHz (DVB-MC);
- cable distribution (DVB-C);
- terrestrial transmission in the VHF and UHF frequency bands presently used for analogue television transmission (DVB-T).

The DVB-S, DVB-M(C/S) and DVB-C standards all modulate the television signals onto a single carrier. The DVB-T standard has been based on a more complex OFDM multi-carrier transmission system developed under the Eureka 147 programme for a new generation of terrestrial digital audio broadcasting (T-DAB). This is to enable DVB-T to cope with the difficult propagation conditions encountered in terrestrial broadcasting.

D1.1.5.2 Terrestrial Digital Television (DVB-T)

For the first time, DVB-T gives the broadcaster (or multiplex service provider) the opportunity to increase the number of programmes and ancillary services that can be offered to the viewer without a comparable increase in the amount of spectrum needed. The digital multiplex, which occupies an 8 MHz (or 7 MHz) television channel (presently carrying one analogue programme) can carry between 1 and about 6 digital programmes. However, there can be a multi-way trade-off between number of programmes per multiplex, picture quality, ruggedness of transmission and percentage of locations covered. Any spare capacity not required for television programmes and their associated sound channels can be used for data transmission or to increase the ruggedness of the transmission system, thereby extending the percentage of locations covered for fixed and portable reception. .

During the introduction of DVB-T there will be severe limitations on the number of digital channels that can be accommodated in the available spectrum. This is mainly a consequence of the need to adequately protect the existing analogue television services.

D1.1.6 The multiplex provider

In some countries in Europe, the same organisation has produced the programmes and provided a transmitter network. Because with DVB-T, more than one programme can be carried on a multiplex, a separation of programme production from the transmission network may be necessary. A new commercial relationship will develop between the programme makers and the multiplex providers.

To fund its operations, a multiplex provider is likely to need sources of revenue other than those from transmitting programmes of the existing terrestrial broadcasters. Additional revenue could come, inter alia, from

- subscription television services;
- pay-per-view television services;
- data services.

D1.2 The generic benefits of Terrestrial Digital Television

D1.2.1 The benefits of digitisation

There are many benefits associated with moving from analogue to digital broadcasting techniques.

D1.2.1.1 Delivery of a larger number of services

Digitisation allows the total number of broadcast services delivered to the home to be increased as a result of:

- powerful real-time digital processing to reduce the required bit rate per programme;
- dynamic selection of bit rate per programme (statistical multiplexing).

Consequently, a much greater number of services can be delivered using a given bandwidth allocation.

D1.2.1.2 Enhanced picture quality

Digital transmission can also deliver high picture and sound quality and the capacity for advanced television features such as widescreen (16:9 aspect-ratio) and high-definition television. Terrestrial digital reception, under the same conditions as analogue, requires a lower signal strength and does not suffer from the impairments (e.g. echoes) that are common to terrestrial analogue reception - the digital signal is either decoded perfectly or not at all.

D1.2.1.3 Flexibility

For broadcasters and multiplex service providers, the digitisation of television transmission offers increased flexibility by allowing important service trade-offs. For example, treating coverage as a constant, a choice can be made between the number of services delivered and picture quality. In general, television services with higher picture quality require more capacity within the multiplex (i.e. higher bit-rate) whilst those with lower picture quality require less capacity.

Trade-offs can also be made between on the one hand a fixed number and quality of services and on the other, the coverage and robustness of transmission. The robustness of the system can be selected by the choice of coding rate (error correction) and modulation scheme. For a given transmitter power, the more robust the signal is, the greater the coverage achieved. The most robust signal may also be received using smaller antenna such as the indoor, set-top

types. This extra robustness, however, reduces the available capacity for programme transmission.

D1.2.1.4 Delivery of additional services

The multiplex service provider considers the total transmission capacity of each multiplex as a "data container" which may contain sets of different kinds of service being transmitted simultaneously.

The merits of the MPEG standard are that all data can be flexibly used. It allows for the possibility of a number of other services to be transmitted together with the television programmes. Based on the MPEG2 standard, examples of the various kinds of data that can be transported are:

- video programme data;
  - sound associated to the video;
  - data accompanying the video programme;

- audio programme data;
  - data accompanying the sound programme;

- music channels, for independent audio programmes;

- data associated with the video and audio programmes;
  - programme added data (PAD);
  - electronic programme guides (EPG);

- general data independent of video and sound programmes, for example
  - navigation systems;
  - general information channels;
  - data destined for non-entertainment purposes.

These different services can be de-coded using information contained in the Service Information channel of the multiplex. There is now an ETSI standard covering the Service Information channel.

D1.2.1.5 Facilitator for the Information Highway

Digital television broadcasting is likely to place an intelligent set-top box or integrated digital television set in a large number of homes. Even the most basic of these boxes will have some computing and memory capacity together with a modem. This could provide a connection for accessing the Information Highway. Such set-top boxes may enter homes that would not have purchased a PC. Furthermore, accessing information via the television and making use of user-friendly navigation systems designed primarily for entertainment services, allows digital television to make the accessing of 'on-line' information (e.g. Electronic Programme Guides) very much easier and more attractive for many households.

D1.2.2 The benefits of terrestrial digital television

D1.2.2.1 Portable (plug-free) reception

D1.2.2.1.1 Portable reception

One of the advantages of the DVB-T systems is the possibility to receive programmes on a portable television set. Portable reception is characterised by very hostile reception conditions due to multipath propagation. One of the main advantages of OFDM systems as used in the DVB-T system is that receivers can work in bad reception conditions with a large number of echoes.

Because it uses the OFDM modulation technique, the DVB-T system is particularly suitable for "plug-free" reception. It thus has the potential to free the viewer from the "static" television receiver connected to a cable/antenna socket on the wall, with the advantages of:

- enabling the viewer to watch television where it is convenient, in the same way as the listener does with his radio;
- minimal installation cost, as there is no need for an external antenna or cabling to wall mounted RF sockets;
- ghost free reception.

Consequently, terrestrial digital television has many unique advantages compared with other delivery platforms. It is, for example, a cost-effective means of delivering reception to portable television sets, requiring a set-top antenna only, instead of connection to either cable or a satellite dish. This reduces the cost of reaching second and third sets in the home by eliminating the need for in-home wiring. A significant proportion of "main" television sets use set-top antennas and reception for these may be improved.

Thus the possible ease of reception offered by DVB-T could radically change the way in which people watch television, in the same way as a transistor portable radio and "Walkman" have changed listening habits.

D1.2.2.1.2 Mobile reception

Mobile reception was not an explicit user requirement for DVB-T. Nevertheless tests carried out by Deutsche Telekom in Cologne/Germany in January 1997 with a 2k system compliant with the DVB-T specification showed excellent mobile performance up to high speed.

D1.2.2.2 Regional and local broadcasting

Terrestrial digital television is probably the most cost-effective method of delivering regional and local variation in television services. Cable networks offer similar potential for regionality, but at a higher cost than terrestrial in most European markets. Satellites cannot deliver regional variation without using large amounts of transponder capacity.

D1.2.2.3 Radio spectrum efficiency

Of significant long-term economic value is the UHF radio spectrum that may potentially be released if all broadcasting is gradually transferred from analogue to digital. Due to the

multiplexing capabilities and the possible use of SFNs, DVB-T will allow spare capacity to be released for other commercial activities - including additional broadcast services or telecommunications.

D1.2.2.4 Cost advantages of implementation

DVB-T is likely to have very significant cost advantages compared with other digital delivery platforms. For a wide range of market circumstances, recent studies have shown that the costs of adapting a transmission and distribution network for digital terrestrial are lower than for any other distribution system. This cost advantage for the operator is made possible by the re-use of existing analogue terrestrial infrastructure, including transmission sites and masts and for the viewer by the use of existing antennas or ‘plug-free’ reception.

D1.2.2.5 Digital universal service obligations

Because of the ability of terrestrial digital television to cover large numbers of households at low cost, it offers considerable potential for ensuring that a basic set of free-to-air digital television services are made available to a high proportion of television households. Such universal service (or access) obligations may be determined and imposed by national governments and are likely to be based upon a core of public service broadcasting channels.

D1.2.2.6 Network security and control

The distribution of programmes and the operation of terrestrial transmitters provides a high degree of security and flexibility with regard to programme transmission. Even if control of part of the network is lost, this does not represent loss of control over all of the programmes which will be transmitted and seen throughout a country (unless primary distribution is by satellite).

Commercial control by some multi-national media consortia of the satellite transmission chain from the programme source to the conditional access system may also be a reason that Governments prefer terrestrial networks.

D1.2.2.7 Flexible investment

Terrestrial digital television has unique investment characteristics which may be attractive to potential investors in digital delivery platforms. Investment in it is scaleable and non-linear with population coverage. A few large transmitters in or near major conurbations can reach over 50% of the total population of a country.

Based on the use of existing transmitter sites, a network covering some 90% of the population can be built at reasonable cost and in a relatively short time (2 - 5 years). As is the case for analogue services, a very large number of low power transmitters would be required to approach 100% of any population and would take many years to accomplish.

It is worth noting that satellite cannot provide 100% population coverage because of natural or man-made obstacles in the path between the satellite and the receive aerial (especially at high latitudes) and environmental planning constraints on the siting of the receive dishes. These factors limit coverage from satellite to between 80% and 95% of the population.

D1.3 The need for simulcasting

The smooth arrival of the all-digital era requires a period of simulcasting for existing viewers. Consumers will not switch to digital unless they can access their favourite programming. Consumers would then continue to receive their familiar set of services, but enhanced through improved picture and sound quality, better reception, etc. In addition, they would receive more services. Since a core set of services would be free at the point of use there would be every incentive to switch to and remain with terrestrial digital television.

An implication of imposing simulcasting requirements upon broadcasters is that they need to be given incentives if they are to co-operate. The obvious way in which this would be done is to offer capacity on the digital frequencies to the existing broadcasters. This is the approach advocated in the UK and Sweden. The implicit advantage of granting capacity to the existing broadcasters is that they provide valuable brand names and programming capability for the launch of digital television.

In any case the percentage of simulcast analogue programmes will be governed by the introduction strategy a country has adopted. Such a strategy may include decisions on industry policy, media policy and spectrum policy, which may differ in various countries.

Currently in Europe, Sweden and UK have the most advanced published plans for the introduction of DVB-T.

> A report on the introduction of DVB-T in Sweden prepared by a Governmental Commissioner talks about the need of a simulcast period of a maximum of 10 years for all existing analogue programmes, starting at the beginning of an operational DVB-T service.
>
> In the UK an official Government proposal also describes needs for simulcast. The analogue switch-off will depend on the success of terrestrial digital television, and in particular the take-up of set-top boxes or digital sets. The analogue services can only be switched off when people are able to receive digital services. The situation will be reviewed after 5 years into the first licence period or when 50% of homes have terrestrial digital sets or set-top boxes, whichever is the sooner.

D1.4 The importance of programme content

For DVB-T to compete successfully in the fragmented television marketplace of the future, the programme content of the DVB-T multiplexes must be of high quality to attract the audience. Some of the multiplexes can be "anchored" by one or more of the existing terrestrial analogue programmes and be available free of charge (or at the same cost of the current television licence fee).

The sports organisations, which in recent years have migrated to satellite, because of the money available by satellite subscription channels, could be attracted back to terrestrial television . The multiplex service providers will have the ability (with subscription and pay-per-view) to offer a better deal to the organisations than satellite as regional audiences can be targeted.

DVB-T will probably offer the lowest cost for distribution of local programmes (news, current events etc.) which are very relevant to the viewer. The success of local radio is a pointer in this direction.

Using the news gathering capabilities of the terrestrial analogue broadcasters, a rolling news service could be provided. The archives of these broadcasters will also permit themed channels (childrens, soaps etc.) to be assembled at relatively low cost.

Thus DVB-T should have the best content of any delivery system, i.e.

- the best of the current analogue programmes;
- sports (subscription and pay-per-view);
- local programmes;
- themed channels.

D1.5 Costs

D1.5.1 Costs to the viewer

In addition to the attraction of the services delivered (new programmes, enhanced picture definition, additional services, etc.), another key factor for a successful introduction of terrestrial digital television is the cost to the viewer for receiving the new programmes.

For portable reception, viewers will require a set-top aerial and an integrated digital television receiver or a DVB-T set-top box (digital converter and decoder).

For fixed aerial reception, viewers may additionally require

- a roof-top antenna;
- an amplification/distribution system.

D1.5.1.1 Fixed receiving installation costs

Even though the installation cost of a fixed receive aerial is not large compared to that of a set-top box, a significant cost advantage to the viewer could follow from the use of the same transmitting sites that are currently radiating analogue programmes as viewers will have antennas pointed at these sites. Furthermore, if adjacent channels are used, a significant proportion of viewers may be able to receive the new programmes without any modification of their current antenna system. No additional installation cost is expected if wide band UHF antennas are employed.

The use of existing sites and adjacent channels are particularly important in the case of collective receiving installations, for which modification is generally difficult. It is still to be verified if the current amplifiers and distribution networks (coaxial cable, splitters, television sockets, etc.) are able to carry the DVB-T signal without appreciable degradation.

In the best scenario, the customer could probably receive the digital signal at no additional cost (if a wide-band antenna is already used for reception of the analogue television services). On the other hand, both the complexity and the cost of the fixed receiving installation may be significant.

D1.5.1.2 Digital set-top-box costs

Undoubtedly the major investment the viewer has to bear is the purchase of the digital set-top box - the equipment needed to transform the received MPEG bit-stream into a signal compatible with an analogue television receiver.

To assure the market penetration of DVB-T standard, the price of the set-top-box has to be comparable to that of competitive delivery media (e.g. cable and satellite), especially if a migration toward digital reception is to be encouraged. The duration of the transition period critically depends on the speed of digital reception equipment penetration into the consumer market.

The terrestrial receiver is more complex than satellite and cable receivers, therefore its cost is currently expected to be somewhat higher. In the DVB User Requirements, the technical Commercial Module (TCM) group expressed the request for an additional cost to the viewer at introduction of no more than 450 ECU compared to an analogue receiver. Within two years of introduction, the retail price difference between digital equipment and the corresponding analogue set should be less than 200 ECU.

D1.5.2 Costs for broadcasting

The main conclusion of a recent study is that Terrestrial Digital Television is the lowest cost delivery system at a national aggregate level for all levels of achievable penetration. This cost advantage is nearly matched by cable for low levels of penetration and satellite for high levels of penetration. When all factors are taken into account, the cost of digitising the main television set in each household, will, on average, be slightly lower for terrestrial digital than for satellite digital or cable digital. This conclusion is valid for a wide range of the main variables.

D1.6 Policy and regulation

Decisions of Governments will be crucial in determining the environment in which the terrestrial digital television industry will develop.

Key policy considerations will include:

- the management and allocation of spectrum to allow digital services to be launched;
- the maintenance of universal service obligations in the transition to digital;
- completion of the digital transition via the closure of analogue transmissions.

A regulatory framework that is conducive to both investment and competition will be crucial. Areas of particular concern include:

- conditional access;
- media ownership implications;
- regulation of programme providers;
- regulation of the multiplex service providers.

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D2. EXISTING SITUATION (for the implementation of terrestrial digital television)

D2.1 Introduction

The evolution in broadcasting, in past decades, has been very extensive both in the technical and service areas. One crucial requirement in this evolution was the need to maintain compatibility, at least partially, with existing systems and services.

From the frequency spectrum management point of view the following factors arise in considering the introduction of digital broadcasting:

- spectrum availability;
- specific behaviour of signals in the area covered by the broadcasting transmitter (particularly the rapid failure characteristic of digital systems);
- compatibility issues.

It is therefore essential that appropriate spectrum planning techniques and co-ordination procedures are developed.

D2.1.1 Terrestrial Digital Television (DVB-T)

With careful planning no major compatibility problems are foreseen in the co-existence between analogue and terrestrial digital television (DVB-T) signals within the same allocation - providing the RF channel bandwidths are comparable with existing television systems.

DVB-T is will be more spectrally efficient than its analogue counterpart. The impact of this spectrum efficiency improvement on frequency spectrum utilisation depends on the way DVB-T will be introduced.

For administrations an improvement in the spectral efficiency of terrestrial television is only to be encouraged. At some time in the future it should be possible on technical and political grounds to make an objective choice on whether to authorise a significant increase in the number of available television programmes, or to consider reallocating spectrum to other services, including services ancillary to broadcasting (SAB).

In any consideration of the introduction of a digital system it is necessary to ensure adequate reception quality of all the current modes of receiver usage. One such issue is the use of set top antennas to provide flexibility in siting receivers in the household. This again must be considered since any decision to delay the transfer to digital, or to increase transmitter powers to facilitate portable (plug-free) reception, is an issue of crucial importance.

Lastly, except for the case of portable and set-top reception, it is clear that cable (fibre or coaxial) and direct to home satellite broadcasting provide an effective alternative to national or geographically large regional terrestrial TV broadcasting.

The inhibitors to using such alternatives for broadcasting are:

- the need to ensure continuity of broadcasting in national emergencies;
- potential installations which are shielded from the geostationary orbit;
- programme copyright for larger coverages.

It will be some years before most homes are connected to a cable/fibre optic circuit.

D2.2 Spectrum Availability

Within CEPT countries frequencies in the following bands are available for terrestrial television broadcasting:

Table D2.1
Frequency bands for terrestrial television broadcasting

Frequency range (MHz)	Status (in Europe)	Notes
47.00 - 68.00	Primary	Also allocated to land mobile services on a primary basis in some countries
68.00 - 74.00	Primary in some countries	
76.00 - 87.50	Primary in some countries	
87.50 - 100.00	Primary	Mainly sound broadcasting
174.00 - 223.00	Primary	Also allocated to land mobile services on a primary basis in some countries. Frequencies in this range are also allocated to T-DAB.
223.00 - 230.00	Primary	Also allocated to fixed and mobile services on a primary basis in some countries. Frequencies in this range are also allocated to T-DAB.
470.00 - 790.00	Primary	
790.00 - 862.00	Primary	Also allocated to the FIXED and MOBILE service on a co-primary basis.
11700.00 - 12500.00	Primary	Primary with fixed services
40500.00 - 42500.00	Primary	MVDS (CEPT harmonized band)
84000.00 - 86000.00	Primary	

It should be noted that use of some of the frequency bands are subject to the provisions of broadcasting frequency planning conferences e.g. Stockholm 61, Geneva 84, Wiesbaden 95, and recently Chester 97 for the introduction of DVB-T are the Bands III, IV and V.

Due to long distance propagation effects and the high man-made-noise level, Band I is not considered suitable for DVB-T.

The allocation at Band II is only relevant to the Eastern parts of Europe and is used elsewhere for VHF/FM sound broadcasting. Indeed, even in most countries in Eastern Europe this band

is now being used for VHF/FM. Its possible use for digital television thus need not be considered further.

Other (non-harmonised) frequency bands are used or planned for MVDS in some countries (e.g. 2,520 to 2,670 MHz in Ireland and 3,600 to 3,800 MHz in France).

Information about satellite broadcasting are contained in §D2.6.

The requirements for MVDS are currently subject to a study by CEPT Project Team FM-PT 29.

D2.3 Current terrestrial analogue broadcasting coverage philosophy

In most countries in Europe, the analogue broadcast networks have evolved to maximise the number of programme services obtainable from the VHF/UHF allocations and to maximise "national" coverage. The exact situation varies from country to country. Details about the number of programme chains, transmitters and receivers in operation, and population coverage are given in Annex 2.1.

Most countries in Europe have, at least for public broadcasting, adopted the philosophy of universal coverage, i.e. coverage of at least 98% of the population rather than just covering the population centres. Analogue frequency planning constraints limit the maximum number of programme services (with this level of coverage) to three or four. In some countries only one or two programmes are available, but this is more a matter of national resources than of any planning constraints. Many countries aim for greater than 99% population coverage, but the problems and the number of relay stations increase rapidly as the population coverage approaches 100%.

The above type of coverage is usually referred to as "national", but there is a related variant, called "regional". This recognises that different parts of a country may need different programmes.

In both cases it is likely that coverage is provided to populated areas right to the borders of a country or region within a country. This inevitably means that there are coverage overlaps in the border areas, and it then becomes necessary to protect the additional services against interference in the same way that the existing service is protected. This places additional constraints on planning in or near border areas.

A further planning concept is that of "local" or "private" services. These are primarily intended to cover only the more densely populated areas, with no regard to the interference they may experience in the regions between the commercially-attractive densely populated areas. Of course, the planning of these local services must also ensure the continued protection of the national or regional services in all parts of their coverage areas. It is not uncommon for the maximum coverage of a fully developed set of local stations in a given country to be in the region of 70% to 80% of the population. However, there are differences between countries and between different local programme chains in a given country.

An important result of these planning philosophies is that a large number of transmitters are needed to provide coverage.

D2.4 Frequency planning considerations for the introduction of DVB-T

For terrestrial channels an important distinction is to be drawn between the potential for the introduction of digital services alongside the existing analogue transmissions, and the long-term aim of closing down the analogue transmitters and having only digital transmission in the VHF and UHF spectrum allocated to broadcasting.

Various studies have shown that there are possibilities for the introduction of digital transmissions in the frequency bands allocated to terrestrial television. It has been established that there are short term as well as longer term possibilities.

In the short term there are limitations because of the need to protect existing analogue services. Nevertheless, preliminary studies have indicated that digital television services could be implemented on some channels at existing analogue station sites, with coverage similar to that of analogue services. The picture quality would be at least that provided by the analogue services but without degradation due to delayed images.

In the longer term, when analogue services can be closed down, there are possibilities for many more digital services, higher definition services, or combination of both.

The planning options for the introduction of digital television are explained in §B.

D2.4.1 Channel rasters

In Bands I - III different television channel rasters are used across Europe. In Eastern Europe, France and Ireland, channels are 8 MHz wide, in other countries the channel width is 7 MHz. In addition, there are different channel rasters in countries using 7 MHz channels (e.g. Italy). This means that, in the VHF Bands, there is no alignment of channel edges between countries using 7 MHz channels and those using 8 MHz channels.

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. The only differences are in the use of channels in the upper end of the Band V and in the frequency separation between the sound and vision carriers.

The channel positions and systems used in Europe are shown in Annex D2.2 and details of channel frequencies in Annex D2.3.

It is partly because of the complexity of overlapping channels in both Bands I and III that studies concerning the possible introduction of digital television in Europe have mainly concentrated on the possibilities offered within Bands IV and V. Although this results in some potential loss of digital coverage, Bands IV and V have four times the capacity of Bands I and III. Nevertheless, planning provisions for Band III are made in the Chester 97 Agreement.

Furthermore, 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.

D2.4.2 Possibilities for the UHF television bands

Not all of the UHF spectrum identified in Table D2.1 is actually available for television broadcasting in all CEPT countries. While there are specific restrictions in many countries, there are also some restrictions which are relatively common.

Channels 35 to 37 in Band V, (582 to 606 MHz) have been used for airport radar installations in some countries and this has caused restrictions both to them and to neighbouring countries. These restrictions have now been lifted apart from the continuing use of channel 36 for airport radar in the United Kingdom.

Part of channel 38, 608 to 614 MHz, is used in some countries by Radio Astronomers. This usage demands a very high degree of protection resulting in severe restrictions over a wide area.

Finally, channels above 60 in Band V, that is from 790 MHz upwards (channels 61 - 69), are allocated to other users in a number of countries. Some of these services require a high degree of protection and the result is that the use of these channels is subject to severe restrictions in most European countries. In the final report based on the second DSI it is recommended that the channels 61 - 69 are made available for television and that all new channels becoming available for television should be used for digital television only. Use of these channels could facilitate the introduction of the more frequency efficient digital television services, e.g. SFNs

Details on the spectrum availability in various CEPT countries are given in Annex D2.4.

A pictorial representation of the usage of each channel is given in **Figures Annex D2.4.1 and Annex D2.4.2**. The impact of the restrictions discussed above can be clearly seen.

D2.4.3 Protection of existing analogue services

The primary source of interference in any European country is co-channel. Consequently, the main aim in planning is to keep the impairment caused by co-channel interference at:

- no worse than ITU-R Impairment Grade 4 for any interference which is continuous, presently for 50% of time;
- no worse than Grade 3 for interference which is present for only 1% of the time (5% in a few countries).

The latter requirement is usually the more difficult to meet. Few problems are experienced with other interference mechanisms and they now offer few constraints on planning, either for the choice of channels at a given station, or much more importantly, for the choice of channels for overlapping coverages from adjacent stations. The last point is particularly important. Within Europe, there are extensive coverage overlaps from adjacent stations in most countries and, indeed, any channel relationship in overlap areas can be found except for co-channel.

Although the directional properties of a domestic receiving antenna help to reduce the levels of unwanted signals, it is very important to note that where the programmes from adjacent stations are different, viewers will use both, usually with separate antennas (but not always!).

In the case where the overlapping services use adjacent channels, the field strength of the wanted signal can be more than 20 dB below that of the unwanted signal. This has important implications in the case where additional (for example, digital) adjacent channel transmissions are proposed from a given transmitting station.

There have traditionally been some planning constraints regarding the channels to be used at a given station. For example, adjacent channels, channels subject to local oscillator interference, or image channels had to be avoided in the past (although not in all countries). As the performance of television receivers has improved, these constraints have been removed.

The last constraint to go has been the use of adjacent channels at a given site (although this is now happening), partly because of the difficulties of obtaining:

- enough suppression of spurious components in the lower adjacent channel (a major problem with high efficiency klystron transmitters);
- enough isolation between transmitters to avoid inter-modulation problems.

However, the use of separate, but nearby, sites for adjacent analogue channel transmissions has proved successful. One benefit for the viewer is the possibility to use a single receiving antenna. This requires the transmitting sites to be sufficiently close together to ensure that the received field strengths are within a few dB of one another.

D2.5 Examples of existing situations in various countries

D2.5.1 United Kingdom

Planning for analogue television in Bands IV and V has provided four services, each covering 99.4% of the UK population. Generally, all four services are radiated from each transmitter site. The channels are grouped in the form n, n+3, n+6, n+10, for Band IV and lower Band V, and n, n+4, n+7, n+10 for upper Band V. These groupings were chosen to avoid reception problems from adjacent channel, image channel, and local oscillator interference. Additionally, a fifth national analogue network has recently been introduced based mainly on the use of channel 37 - a channel previously not allocated to television in the UK.

Planning for a digital terrestrial service, using MFNs interleaved with analogue services, is well advanced with 6 UHF channels identified for almost all of the 51 main stations and 30 relay station sites. Digital services are expected to be introduced in mid 1998.

D2.5.2 Germany

The VHF/UHF bands (I, III and IV/V) are used by analogue television services. Full area coverage with the public programmes is provided, which requires the operation of roughly 290 high power transmitters and in addition 8000 fill-in stations. Moreover about 200 private stations are operated in areas with a high population density. Channels 61 - 69 are not used by television services for the time being. Some part of this spectrum will be available in the near future for DVB-T, subject to a government decision. If this part of the spectrum can be made available for broadcasters, it may offer a good chance for a start with digital terrestrial television.

D2.5.3 Denmark

There is currently an almost complete set of UHF channels not used yet. According to a government decision this set of channels is reserved for digital television. Further possibilities for digital television may be found above channel 60 depending on the result of ERO DSI Phase 2 and subject to government decision. Assignments above channel 60 are in the Stockholm Plan.

D2.5.4 Sweden

The introduction of digital terrestrial services seems to be viable without changing current PAL broadcast networks. The presumption made in the preliminary studies is that each of the current networks should have the possibility to be "simulcast" with the same coverage area in a digital format. The single frequency option is interesting, particularly the concept of local single frequency networks for channels below 60, giving the possibility of rather sharply defined regions for regional broadcasts. The channels above 60 are available and they may be used for e.g. SFNs.

D2.5.5 France

Bands I, III, IV and V (up to 854 MHz) are presently used to broadcast 6 networks. Band III and the upper part of Band V (830 - 854 MHz) are shared with land mobile services and no possibility exists in these bands at present. The percentages of coverage are 99.9% for networks 1, 2, 3 and around 85% for networks 4, 5 and 6. Provisional studies on the possibility of introducing digital television in the UHF band are now been carried out on the adjacent channels of the three first networks.

D2.5.6 Spain

The five national programmes use Bands IV and V. In addition, the first public programme (TVE-1) also uses Bands I and III. The two public networks reach 99% and 96% coverage respectively. The three private networks reach 93% coverage. Although all television stations at present allocated in Bands I and III must emigrate to the UHF bands before the beginning of 2000, leaving them free for other services, studies have confirmed that there will be a certain number of free and interleaved channels available to start with digital broadcasting, giving the possibility to simulcast the five current PAL programmes with national coverage. The recently passed Law on Local TV Stations could represent an inconvenience in some urban areas.

D2.5.7 Italy

The channel occupancy in the VHF/UHF bands is very close to spectrum saturation. Planning criteria, derived from the Stockholm Plan, make use of interleaved channels with protection ratios updated to the improved performance of new generation receivers. It is unlikely to be possible to introduce Single Frequency Networks (SFN) on a nation-wide basis, at least in the initial phase. Instead, there are opportunities of finding frequency assignments on a local basis in urban areas.

D2.5.8 The Netherlands

Currently there are three national television networks in operation with near complete coverage. A fourth network for regional coverage will probably start before 1999.

The channels above 60 are not used for broadcasting at present.

The channels 63 to 67, unused ST61 assignments, plus a number of additional channels which have not yet been used, could be used for the introduction of DVB-T.

Annex D2.1: Programme chains, transmitters and receivers in Europe

Details about number of programme chains, transmitters and receivers in use and coverage in a number of European countries (as of 25-07-97)

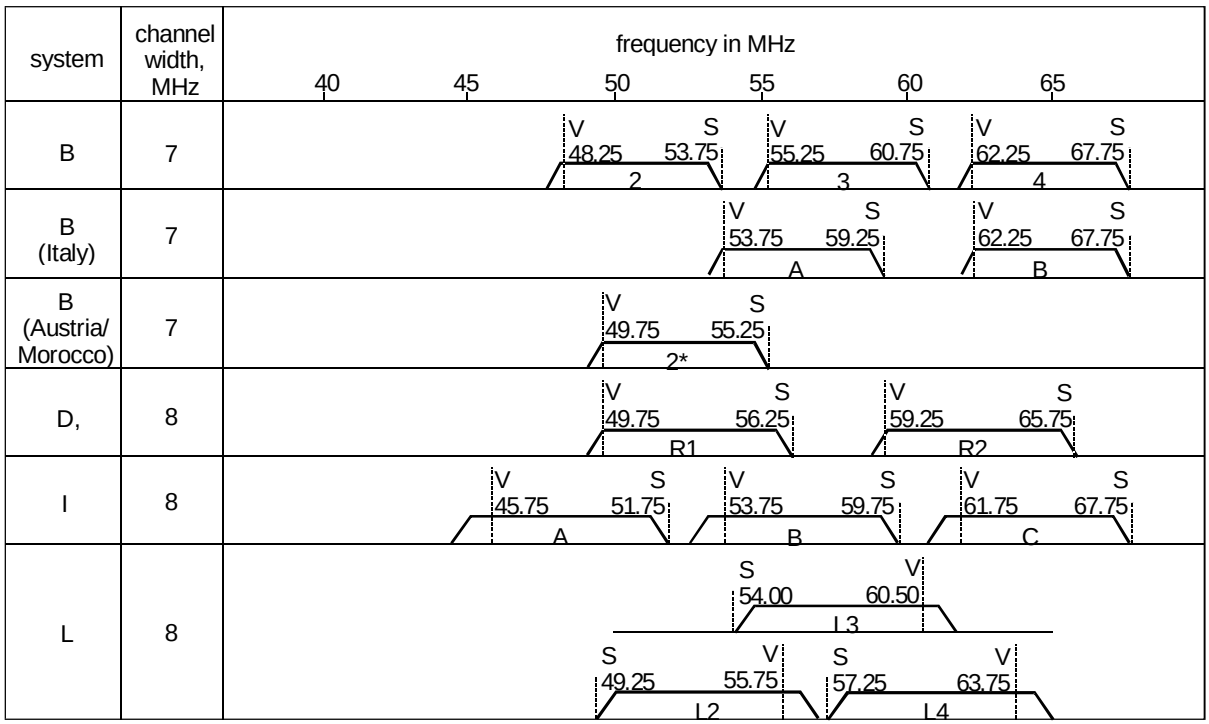
Code	Country or Territory	Service	Number of VHF Transmitters	Number of UHF Transmitters	Percentage Population Coverage	Number of receiver households (millions)
ALB	Albania	ATV	263	4		
AUT	Austria	ORF1	233	345	95.7	2.630
		ORF2	64	532	94.5	
BEL	Belgium	BRTN 1	3	2	99.8	3.350
		BRTN 2	0	4	99.8	
		RTBF 1	10	4	98.0	
		RTBF 2	0	7	95.0	
		Canal Plus	0	4	95.0	
		Arte	0	1	2.0	
		Guest Forces	0	3	8.0	
		TELE Brussels	0	1	8.0	
BIH	Bosnia & Herzegovina	BHTV-1	133	24		0.390
		BHTV-2		150		
		BHTV-3		1		
BUL	Bulgaria	Bal. Tele1	14			3.127
		Bal. Tele2		268		
		Russian TV				
		TV5 Europe				
CVA	Vatican City					
CYP	Cyprus	CBC				0.234
		BFBS(SSVC)				
CYP	Cyprus (Northern)	Bay R & TV Corp.				0.075
CZE	Czech Republic	CT1	0	456	98.0	
		CT2	1	155	89.0	
		NOVA	530	42	98.0	
		PRIMA	0	103	58.0	3.400
D	Germany	ARD-1	1424	1363	99.3	31.510
		ZDF	3	2895	99.1	
		ARD-3	6	3082	98.7	
		Private	8	243		
		Guest Forces	1	175		
DNK	Denmark	DR TV	31	5	99.9	2.100
		TV 2	0	35	99.8	
		Private Local	0	16	52.0	
E	Spain	TVE-1	573	1670	99.0	11.200
		TVE-2	0	1670	97.6	
		Regional	0	1617	97.4	
		Tele-5	0	1263	93.0	
		Antenna 3TV	0	1263	93.0	
		Canal+	0	1263	93.0	

Code	Country or Territory	Service	Number of VHF Transmitters	Number of UHF Transmitters	Percentage Population Coverage	Number of receiver households (millions)
EST	Estonia	ETV	11	0	99.0	1.300
		EVTV + RTV	4	10	78.0	
		K2 + K6	6	3	78.0	
F	France	TF1	0	3396	99.9	20.900
		FR2	0	3531	99.9	
		FR3	0	3579	99.9	
		Canal Plus	204	31	87.2	
		ARTE + La Cinq	0	586	85.0	
		M6	0	930	85.0	
FIN	Finland	YLE 1	58	136	99.5	1.900
		YLE 2	28	166	99.5	
		MTV 3	12	182	99.0	
		SVT-4	0	10	32.0	
G	United Kingdom	BBC-1	0	1048	99.4	20.330
		BBC-2	0	1044	99.4	
		ITV	0	1004	99.4	
		CH4/S4C	0	1002	99.4	
		CH5	0	33	71	
GIB	Gibraltar	GBC TV				0.007
GRC	Greece	ET 1	354	454	98.5	2.300
		ET 2	4	422	96.2	
		ET 3	0	108	70.2	
HNG	Hungary	MTV1	7	11	97	4.261
		MTV2	1	12	92	
HOL	Netherlands	Ned-1	4	10	99.0	6.400
		Ned-2	0	15	99.0	
		Ned-3	0	15	99.0	
HRV	Croatia	HTV1				0.750
		HTV2				
		HTV3				
I	Italy	RAI-1	1677	0	99.3	15.220
		RAI-2	0	1637	99.0	
		RAI-3	0	1578	95.1	
IRL	Ireland	RTE-1	19	80	99.0	0.940
		Network 2	19	80	99.0	
		TnaG	0	55	90.0	
ISL	Iceland	INT				0.076
LIE	Liechtenstein					
LTU	Lithuania	LTV-1	13	3	96.0	1.700
		LTV-2	8	6	96.0	
		LTV-3	5	10	85.0	
		Local	5	3	30.0	
LUX	Luxembourg	RTL Television 1	1	0	99.9	0.200
		RTL 9	0	1	80.0	
		RTL Télé Lëtzebuerg	0	1	99.9	
		Club RTL	0	1	99.9	
		RTL 4	0	1	25.0	
		RTL 5	0	1	10.0	

Code	Country or Territory	Service	Number of VHF Transmitters	Number of UHF Transmitters	Percentage Population Coverage	Number of receiver households (millions)
LVA	Latvia	L 1	7	5	98.0	1.400
		L 2	8	5	98.0	
		L 3	7	6	85.0	
		Local	30	7	63.0	
MCO	Monaco	TMC-France	1	2	99.8	0.020
		TMC-Italie	0	2	99.0	
MDA	Moldova	TV Moldova				
MKD	The Former Yugoslav	JRT				1.642
		Montenegro				
		Serbia/Beograd				
		Serbia/Pristina				
		Serbia/Novi Sad				
		TV Art				
		TV Palma				
MLT	Malta	Xandir TV				0.133
NOR	Norway	NRK1	2197	318	99.8	1.500
		NRK2	0	25	55.0	
		TV 2	1	427	88.0	
		Private Local	0	41	37.0	
POL	Poland	TVP 1	79	93	99.0	10.000
		TVP 2	9	151	87.0	
		Regional	3	8		
		POLSAT	2	48	50.0	
		Private	4	38		
POR	Portugal	RTP-1	52	76	98.26	3.000
		RTP-2	4	113	88.35	
		SIC	1	79	87.08	
		TVI	0	26	?	
		RTP-Acores	17	11	96.05	
		RTP-Madera	11	9	99.05	
ROU	Romania	RTVR1				4.000
		RTVR2				
		Antena Indep.				
RUS	Russian Federation	OK-1				
		OK-4				
		VGTRK				
		RTV				
		TV-P				
S	Sweden	SVT-1	233	292	99.8	3.330
		SVT-2	55	614	99.8	
		YLE/S	0	3	20.0	
		TV-4	0	77	98.0	
SMR	San Marino	RTV				
SUI	Switzerland	DRS			99.8	2.560
		TSR	261	1089	97.0	
		TSI			97.0	
		TV-4			97.0	

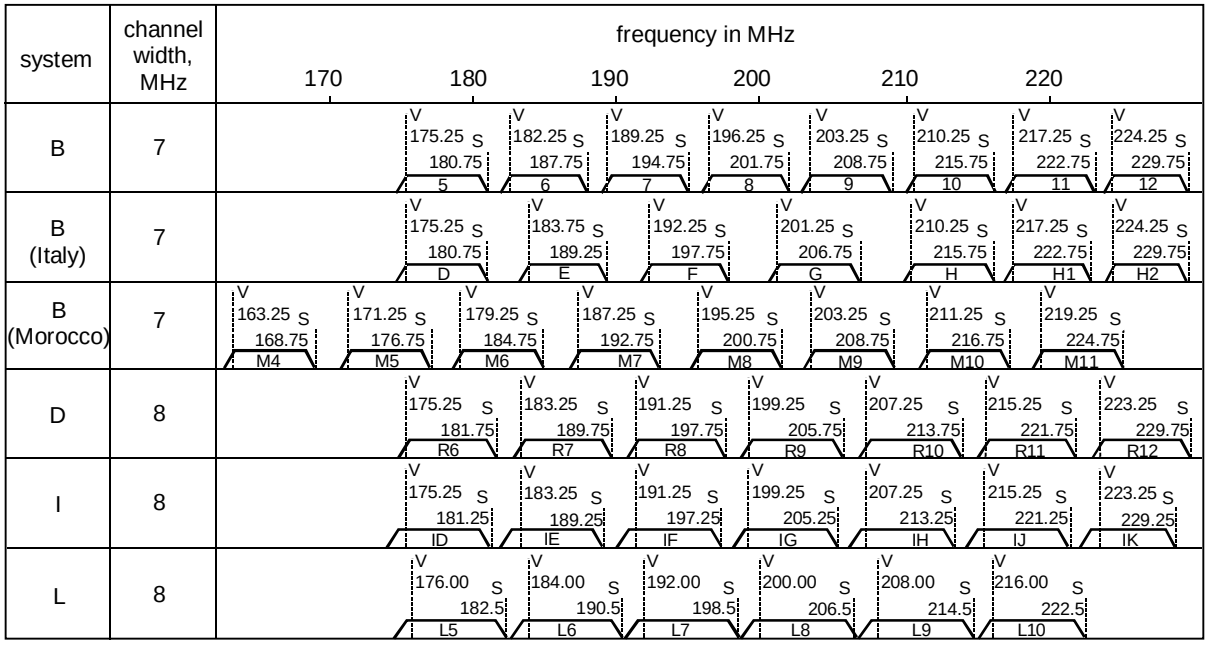
Code	Country or Territory	Service	Number of VHF Transmitters	Number of UHF Transmitters	Percentage Population Coverage	Number of receiver households (millions)
SVK	Slovak Republic	STV1	508	111	97	1.16
		STV2	1	298	90	(registered TV
		Markiza	0	15	54.5	sets)
		Private		5	10	
SVN	Slovenia	TV Slovenija 1	90	121	97%	1.0
		TV Slovenija 2	12	189	95%	
		POP TV	2	26	79%	
		KANAL A		8	75%	
		TV3	1	16	75%	
		GAJBA TV		3	52%	
		TV KOPER		33	41%	
		VTV		3	37%	
		Regional		2	20%	
TUR	Turkey					
UKR	Ukraine	UT-1				
		UT-2				
		OK-1				
AND	Andorra	No	information	available		

Annex D2.2 Television channel rasters



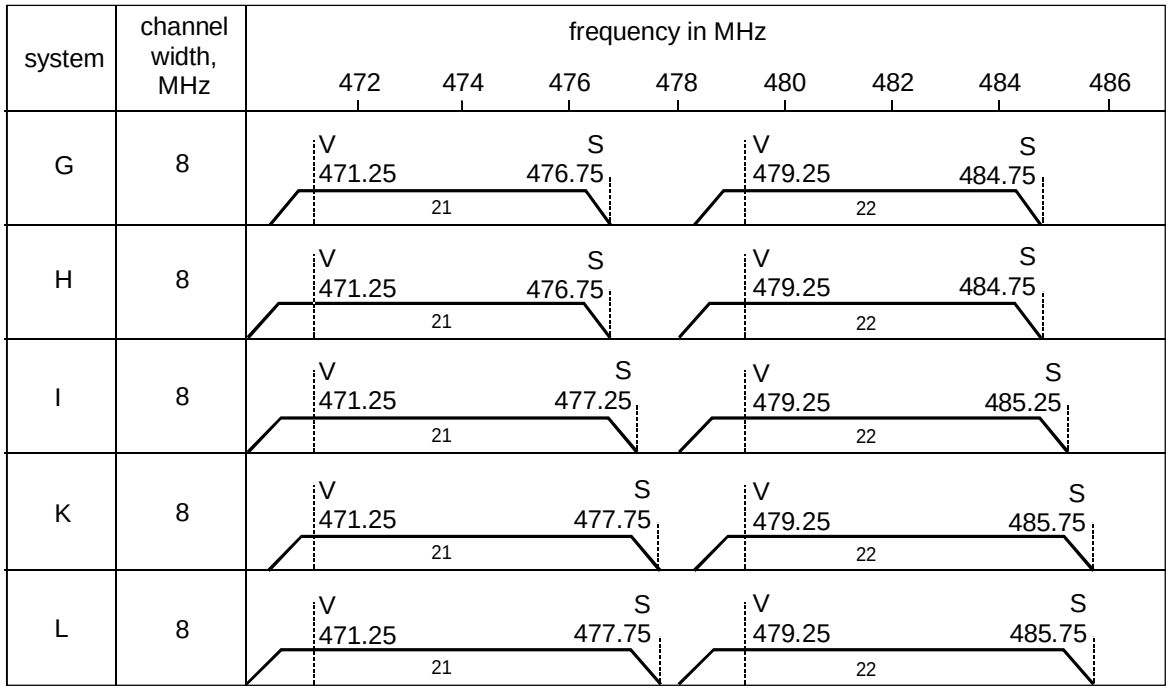
* Note that the sound carrier is 1 MHz lower in frequency for System B1

Channel positions in television Band I



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

Channel positions in television Band III



Channel positions in television Bands IV & V

Television systems in use in Europe

System	Number of lines	Channel width MHz	Vision bandwidth MHz	Vision/Sound separation MHz	Vestigial side-band MHz	Vision modulation	1st Sound modulation	2nd Sound system	Vision/2nd Sound sep. MHz
B	625	7	5	+5.5	0.75	C3F Negative	F3E (FM)	A2/NICAM	5.74/5.85
D	625	8	6	+6.5	0.75	C3F Negative	F3E (FM)	[NICAM]	[5.85]
G, B1	625	8	5	+5.5	0.75	C3F Negative	F3E (FM)	A2/NICAM	5.74/5.85
H	625	8	5	+5.5	1.25	C3F Negative	F3E (FM)	NICAM	5.85
I	525	8	5.5	+5.996	1.25	C3F Negative	F3E (FM)	NICAM	6.55
K	625	8	6	6.5	0.75	C3F Negative	F3E (FM)	[NICAM]	[5.85]
L	625	8	6	6.5	1.25	C3F Positive	A3E (AM)	NICAM	5.85

Annex D2.3: Frequencies used by television channels in Europe

VHF System B

Channel	Channel boundaries MHz		Vision carrier MHz	Sound carrier MHz	Dual FM Second Sound carrier MHz	NICAM carrier MHz
2	47	54	48.25	53.75	53.99	54.1
2*	48.25	55.5	49.75	55.25	-	-
3	54	61	55.25	60.75	60.99	61.1
4	61	68	62.25	67.75	67.99	68.1
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

VHF System B (Italy)

Channel	Channel boundaries MHz		Vision carrier MHz	Sound carrier MHz	Dual FM Second Sound carrier MHz
A	52.50	59.50	53.75	59.25	59.49
B	61.00	68.00	62.25	67.75	67.99
C	81.00	88.00	82.25	87.75	87.99
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

Annex D2.3

VHF System B (Morocco)

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

VHF System B1

Channel	Channel boundaries MHz		Vision Carrier MHz	Sound Carrier MHz	Dual FM Second Sound carrier MHz	NICAM Carrier MHz
R1	48.5	56.5	49.75	56.25	56.99	55.60
R2	58	66	59.25	65.75	65.99	65.10
R3	76	84	77.25	83.75	83.99	83.10
R4	84	92	85.25	91.75	91.99	91.10
R5	92	100	93.25	99.75	99.99	99.10
R6	174	182	175.25	181.75	181.99	181.10
R7	182	190	183.25	189.75	189.99	189.10
R8	190	198	191.25	197.75	197.99	197.10
R9	198	206	199.25	205.75	205.99	205.10
R10	206	214	207.25	213.75	213.99	213.10
R11	214	222	215.25	221.75	221.99	221.10
R12	222	230	223.25	229.75	229.99	229.10

VHF System D

Channel	Channel Boundaries MHz		Vision Carrier MHz	Sound Carrier MHz	NICAM carrier MHz
R1	48.5	56.5	49.75	56.25	55.60
R2	58	66	59.25	65.75	65.10
R3	76	84	77.25	83.75	83.10
R4	84	92	85.25	91.75	91.10
R5	92	100	93.25	99.75	99.10
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

Annex D2.3

VHF System I

Channel	Channel boundaries MHz		Vision carrier MHz	Sound carrier MHz	NICAM carrier MHz
IA	44.50	52.50	45.75	51.75	52.30
IB	52.50	60.50	53.75	59.75	60.30
IC	60.50	68.50	61.75	67.75	68.30
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

VHF System L

Channel	Channel boundaries MHz		Vision carrier MHz	Sound carrier MHz	NICAM carrier MHz
L2	49.00	57.00	55.75	49.25	-
L3	53.75	61.75	60.50	54.00	-
L4	57.00	63.75	63.75	57.25	-
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

Annex D2.3

UHF System G, H, I, K, L

Channel	Channel boundaries MHz		Vision carrier MHz	System G System H Sound carrier MHz	System G Dual FM Second Sound carrier MHz	System G System H System L (System K) NICAM carrier MHz	System I Sound carrier MHz	System K System L Sound carrier MHz	System I 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

Annex D2.4: Spectrum availability in a number of countries around Europe

Details about spectrum availability in a number of countries in and around Europe (as of 25-07-97)

Code	Country	Band I 47 - 68 MHz		Band II 76 - 100 MHz		Band III 174 - 230 MHz		Band IV - V 470 - 862 MHz		System VHF	System UHF
		Channels	Remarks	Channels	Remarks	Channels	Remarks	Channels	Remarks		
ALB	Albania									SECAM D	SECAM K
AUT	Austria	2 - 4	Shared with land mobile.		Unavailable.	5 - 12	Channel 12 foreseen for T-DAB.	21 - 60 61 - 69	TV and also used for SAB/SAP. Availability depends on neighbouring countries.	PAL B	PAL G
BEL	Belgium	2 - 4	Channel 2 (47 - 54 MHz) unavailable - reserved for land mobile services.		Unavailable.	5 - 12	Channel 11 & 12 (216 - 230 MHz): unavailable reserved for T-DAB.	21 - 67 68 - 69	Channel 38: unavailable - radio astronomy. Channel 68 & 69: unavailable - land mobile service primary.	PAL B	PAL G/H
BIH	Bosnia and Herzegovina									PAL B	PAL G
BUL	Bulgaria	No		R3 -R5	Shared with FM-BC	R6-R12	Ch 12 shared with T-DAB	21-69	Shared with Aeronautical Radio Navigation	SECAM D	SECAM K PAL K
CVA	Vatican City									PAL B	PAL G
CYP	Cyprus				87.5 - 100 MHz FM Sound Broadcasting - primary.	6	Only channel 6 used	21 - 69	All channels used for TV.	PAL B	PAL G
CZE	Czech Republic	R1 - R2	50-52 MHz Amateur service-secondary		87.5 - 100 MHz: FM Sound Broadcasting primary.	R6 - R12	Channel 12 foreseen for T-DAB	21 - 69 66 - 69	Channel 54: unavailable - other services (no time limit). Channel 55: low power TV only (no time limit). Channels 61, 62 & 63: not available for TV before 2003 Unavailable - other services	SECAM D PAL D	PAL K

Code	Country	Band I 47 - 68 MHz		Band II 76 - 100 MHz		Band III 174 - 230 MHz		Band IV - V 470 - 862 MHz		System VHF	System UHF
D	Germany	2 - 4	Shared with land mobile: not available for DVB-T.		Unavailable.	5 - 11 12	Available for analogue TV and T-DAB T-DAB	21 - 60 61 - 69	Channel 38: restrictions due to radioastronomy. Unavailable for TV: Fixed service primary. Three channels will become available for broadcasting services (DVB-T favoured) up to 1998.	PAL B	PAL G
DNK	Denmark	2 - 4	Channel 2 (47 - 54 MHz): unavailable. Channel 3 and 4 TV.		Unavailable.	5 - 11	223 - 225 MHz: unavailable, land mobile service primary Channel 11 and 225 - 230 MHz reserved for T-DAB	21 - 60 61 - 69	TV Channels 61 - 69: mobile service primary but not very much used. SFNs foreseen.	PAL B	PAL G
E	Spain	2 - 4	47-68MHz:TV analogue. 47-68MHz:land mobile services. Near 50 MHz : radioamateur service		87.6 - 106.9 MHz : FM 107- 107.9 MHz : FM low power	5 - 10 5 - 7 7 - 10 11 12	174 -216 MHz : TV analogue 174 - 195 MHz : SAB/SAP 195 - 216 MHz : T-DAB (envisaged local) 216 - 223 MHz : T-DAB (national and regional SFNs) 223 - 230 MHz : PMR Trunked System	21 - 65 21 - 60 66 - 69 21 - 60 61 - 65 66 - 69	470 - 830 MHz :TV(analogue) 470 - 790 MHz : SAP/SAB 830 - 862 MHZ : Mobile links,SAB/SAP and studio to transmitter links. 470 - 790 MHz : DVB-T (MFNs envisaged 2002) 790 - 830 MHz : DVB-T (MFNs envisaged 2000) 830 - 862 MHz : DVB-T (SFNs envisaged 1998)	PAL B	PAL G
EST	Estonia	R1 - R2	Shared with land-mobile service and radiometers.	R3 - R5	76 - 87.5 MHz: Mobile and fixed services primary. 87.5 - 100 MHz: FM Sound Broadcasting primary. Channels R3 - R5: All existing TV stations will cease operation as soon as possible and not later than Year 2005.	R6 - R12	TV	21- 60 61 -69	TV except for: Channel 21: unavailable - wireless microphones only. Channels 61 - 69: generally reserved for digital television.	SECAM D	SECAM K PAL G

Code	Country	Band I 47 - 68 MHz		Band II 76 - 100 MHz		Band III 174 - 230 MHz		Band IV - V 470 - 862 MHz		System VHF	System UHF
F	France	L2 - L4	Band used on a secondary basis by fixed and mobile links for broadcasting and by radioamateur service (50.2 - 51.2 MHz) and is claimed (near 50 MHz) by wind profiler radars.		Unavailable.	L5 - L10	174 - 223 MHz: shared on geographic basis with radiotelephone, sharing is accentuated on the axis Lille - Paris - Lyon - Marseille - Nice. 223 - 230 MHz: unavailable for broadcasting. 223 - 225 MHz: remote control applications. 225 - 230 MHz: land mobile service.	21 - 65 66 - 69	TV except for: Channel 36: restriction due to aeronautical services in UK. Channel 38: restriction due to radio astronomy in UK, Holland and Germany. Channels 61 - 65: restrictions due to mobile service in Germany. Unavailable: mobile service, no new assignments for broadcasting.	SECAM L	SECAM L
FIN	Finland	2 - 4	Broadcasting to be phased out.		Unavailable.	5 - 10 11 - 12	TV 217 - 230 MHz reserved for T-DAB.	21 - 60 61 - 69	TV except for: Channel 21 (470 - 478 MHz): shared with mobile service. Channel 23 (486 - 494 MHz): shared with mobile service. Unavailable: mobile service.	PAL B	PAL G
G	United Kingdom*	IA - IC	Unavailable.		Unavailable.	ID - IK	Unavailable. 217 - 230 MHz reserved for T-DAB.	21 - 68 69	TV and also used for SAB except for: Channel 36: unavailable, aeronautical service. Channel 38: unavailable, radio astronomy service. Unavailable, military use.	-	PAL I
GRC	Greece		Unavailable.		Unavailable.	5 - 11 12	Unavailable,analogue TV. Unavailable,T-DAB.	21-65 66 67 - 69	Unavailable,analogueTV DVB-T Unavailable, military use.	PAL- B	PAL- G

* Note: GIB (Gibralta) uses TV system PAL B at VHF and system PAL G at UHF

Code	Country	Band I 47 - 68 MHz		Band II 76 - 100 MHz		Band III 174 - 230 MHz		Band IV - V 470 - 862 MHz		System VHF	System UHF
HNG	Hungary	R1 - R2	Television	R3 - R5	Unavailable	R6 - R11 R12	TV TV until 2002. T-DAB after 2002.	21 - 69	TV except for: Channels 44, 45, 46, 52 and 54 unavailable, aeronautical radionavigation (at present). Channel 55 possibly available Channels 57 and 60: with limitations Channels 62, 63, 65 and 66 unavailable until Year 2005. Channels 61, 64, 67, 68 and 69: low power TV only.	PAL-D	PAL-K
HOL	Netherlands	2 - 3 4	47 - 61 MHz: unavailable, nationally allocated to fixed and mobile services, no TV transmitters exist on these channels. TV		Unavailable.	5 - 10 11 - 12	174 - 223 MHz: allocated to broadcasting and land mobile, this includes SAB. T- DAB.	21 - 60 63-67 61,62, 68,69	TV except for: Channels 21-37 and 39-60 also allocated to land mobile and used for SAB. Channel 38 unavailable: used for radio astronomy. TV Unavailable: used for fixed services on a primary basis.	PAL B	PAL G
HRV	Croatia	2 - 4			Unavailable.	5 - 12		21 - 69		PAL B	PAL G
I	Italy	A - C			Unavailable.	D - H1 D - H2	TV T-DAB and TV	21 - 69	TV except for: Channel 38: unavailable, radio astronomy service.	PAL B	PAL G
IRL	Ireland	B, C	Broadcasting to be phased out.		Unavailable.	ID - IK	174 - 222 MHz allocated to analogue TV broadcasting. 222 - 230 MHz allocated to T-DAB.	21 - 69	TV except for: Channel 36 and 38 unavailable.	PAL I	PAL I
ISL	Iceland									PAL B	PAL G
LIE	Liechtenstein	2 - 4	TV		Unavailable - 87.5 - 108 MHz used for FM Sound Broadcasting.	5 - 11 12	TV Reserved for T-DAB.	21 - 69	TV	PAL B	PAL G

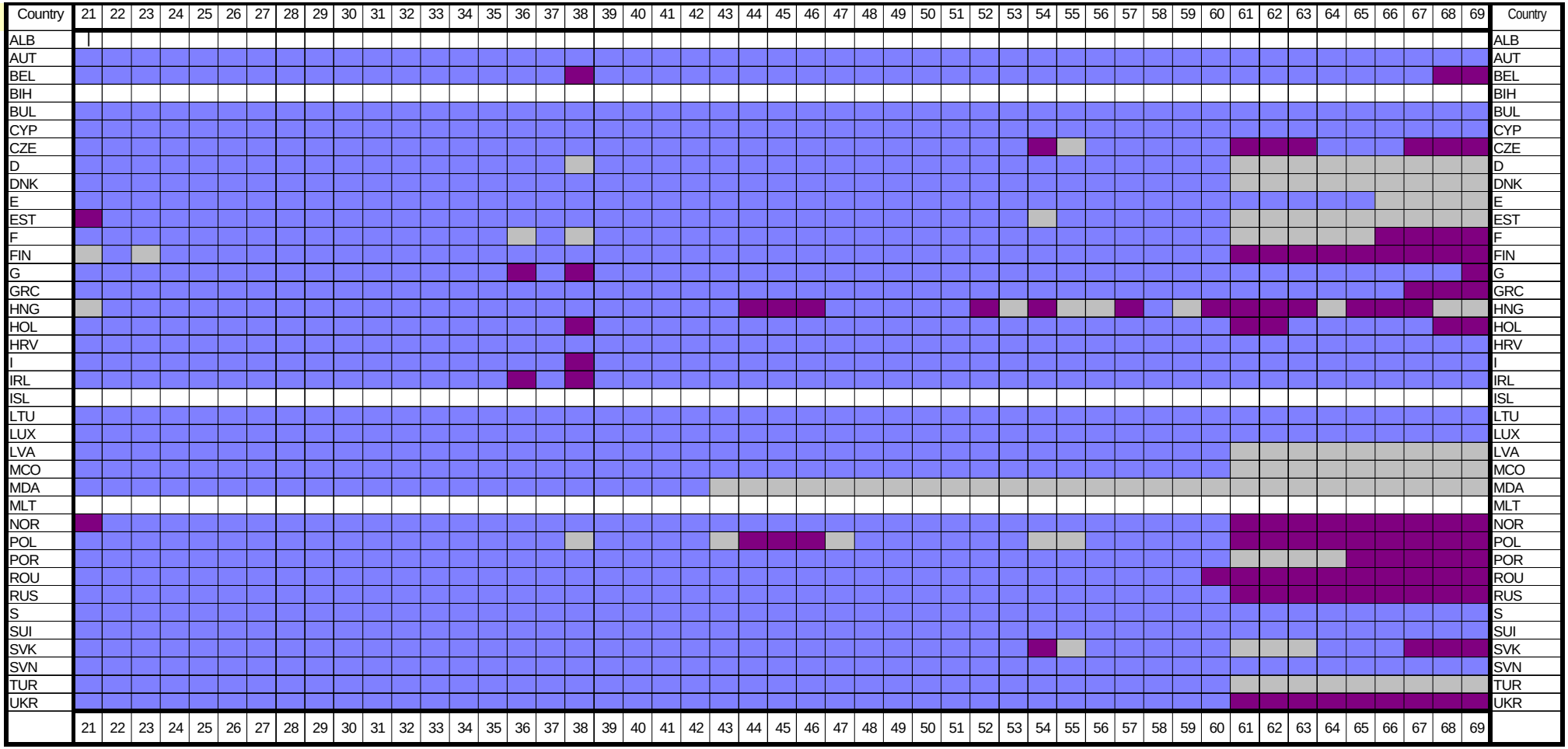
Code	Country	Band I 47 - 68 MHz		Band II 76 - 100 MHz		Band III 174 - 230 MHz		Band IV - V 470 - 862 MHz		System VHF	System UHF
LTU	Lithuania	R1 - R2		R3 - R5	R4 & R5 (87.5 - 100 MHz): to be used for FM Sound Broadcasting in near future.	R6 - R12		21 - 69	TV	SECAM D	SECAM K
LUX	Luxembourg	2 - 4				5 - 11		21 - 69	TV	PAL B	PAL G SECAM L
LVA	Latvia	R1 - R2		R3 - R5	Unavailable.	R6 - R12		21 - 60 61 - 69	TV Channels 61 - 69: not in use at present.	SECAM D	SECAM K
MCO	Monaco	L2 - L4 and 2 - 4			Unavailable.	L5 - L10	Shared with land mobile service	21 - 60 61 - 69	TV Channels 66 - 69: restrictions due to land mobile service in France.	SECAM L	PAL G SECAM L
MDA	Moldova	R1-R2	47 - 68 Mhz on primary basis shared with fix and land mobile services on secondary basis.	R3-R5	76 -100 Mhz Broadcasting	R6 - R12		21 - 42 42 - 69	470 - 645 MHz Broadcasting 645 - 862 MHz Broadcasting shared with aeronautical radionavigation on primary basis	SECAM D	SECAM K
MKD	The Former Yugoslav Republic of Macedonia									PAL B	PAL G
MLT	Malta									PAL B	
NOR	Norway	2 - 4			Unavailable.	5 - 12	223 - 230 MHz available to T-DAB from 1997.	21 - 60 61 - 69	TV except for: Channel 21 unavailable; allocated to SAB. Unavailable: allocated to fixed service.	PAL B	PAL G

Code	Country	Band I 47 - 68 MHz		Band II 76 - 100 MHz		Band III 174 - 230 MHz		Band IV - V 470 - 862 MHz		System VHF	System UHF
POL	Poland	R1 - R2	Mobile and Amateur Service	R3 - R5	Mobile Service 87.5 - 100 MHz : FM Broadcasting	R6 - R12	Television Service T - DAB	21 - 60 61 - 63 65 66 - 69	Television with restriction due to Radioastronomy in ch.38 and due to Aeronautical Radio Navigation in ch.43, 47, 54 and 55. Channels 44, 45, and 46 are unavailable due to Aeronautical RadioNavigation. Point-to-Multipoint Service. Aeronautical Radio Navigation	PAL D	PAL K
POR	Portugal	2 - 4			Unavailable.	5 - 11	Unavailable. Channels 11 - 12 may become available for T-DAB.	21 - 60 61 - 64 65-69	TV May become avaialble for DVB-T Unavailable.	PAL B	PAL G
ROU	Romania	R1 - R2		3 - 5	87.5 - 100 MHz also used for FM Sound Broadcasting.	R6 - R12	Channel R12 may become available for T-DAB.	21 - 59 60 - 69	TV Channels 60 - 69 unavailable.	PAL D	PAL G
RUS	Russian Federation	R1 - R2	TV in the following bands: 48.5 - 56.5 MHz 58.0 - 66.0 MHz	R3 - R5	TV is used.	R6 - R12	TV is used.	21 - 60 61 - 69	470 -790 MHz TV with limitation of use. . Aircraft Radio Navigation. Land Mobile (in some frequency bands)	SECAM D	SECAM K
S	Sweden	2 - 4			Unavailable.	5 - 11	Channel 12 (223 - 230 MHz) unavailable, reserved for T-DAB.	21 - 69	TV	PAL B	PAL G
SMR	San Marino									PAL B	PAL G
SUI	Switzerland	2 - 4	TV		Unavailable - 87.5 - 108 MHz used for FM Sound Broadcasting.	5 - 11 12	TV Reserved for T-DAB.	21 - 69	TV	PAL B	PAL G

Annex D2.4

Code	Country	Band I 47 - 68 MHz		Band II 76 - 100 MHz		Band III 174 - 230 MHz		Band IV - V 470 - 862 MHz		System VHF	System UHF
SVK	Slovak Republic	R1 - R2		R3 - R5	76.0 - 87.5 MHz: mobile and fixed services primarily. 87.5 - 100 MHz: FM sound broadcasting primarily.	R6 - R12		21 - 66 66 - 69	TV except for: Channel 54 unavailable, other services for the time being. Channel 55 low power TV only (at present). Channels 61- 63 available for TV after 1998. Unavailable (other services)	PAL B PAL D	PAL G PAL K
SVN	Slovenia	2 - 4	TV		Unavailable - 87.5 - 108 MHz used for FM Sound Broadcasting.	5 - 11 12	TV Reserved for T-DAB.	21 - 69	TV	PAL B	PAL G
TUR	Turkey	2 - 4	Allocated to Land Mobile Services. Not available for DVB		87.5 - 100 MHz used for FM sound broadcasting primary	5 - 11 12	174 - 223 MHz allocated to analogue TV Broadcasting. Also used for SAB/SAP 223 - 230 MHz allocated to T-DAB	21 - 69	UHF channels 61 - 69 available for DVB-T after 1999. Channel 21 - 60 available for TV Channel 61 - 65 used for SAB/SAP	PAL B	PAL G
UKR	Ukraine	R1 - R2	TV in the following bands : 48.5 MHz - 56.5MHz 58.0 MHz - 66.0 MHz	R3 - R5	TV is used.	R6 - R12	TV is used.	21 - 60 61 - 69	470 - 790 MHz with limitation of use. 790 - 862 MHz Aeronautical Radio Navigation	SECAM D	SECAM K

Summary of channel availability for television broadcasting in Bands IV and V (as of 25-07-97)



Key: Available | Possibly available | Unavailable | No information

Annex D2.5: Channel usage in Europe

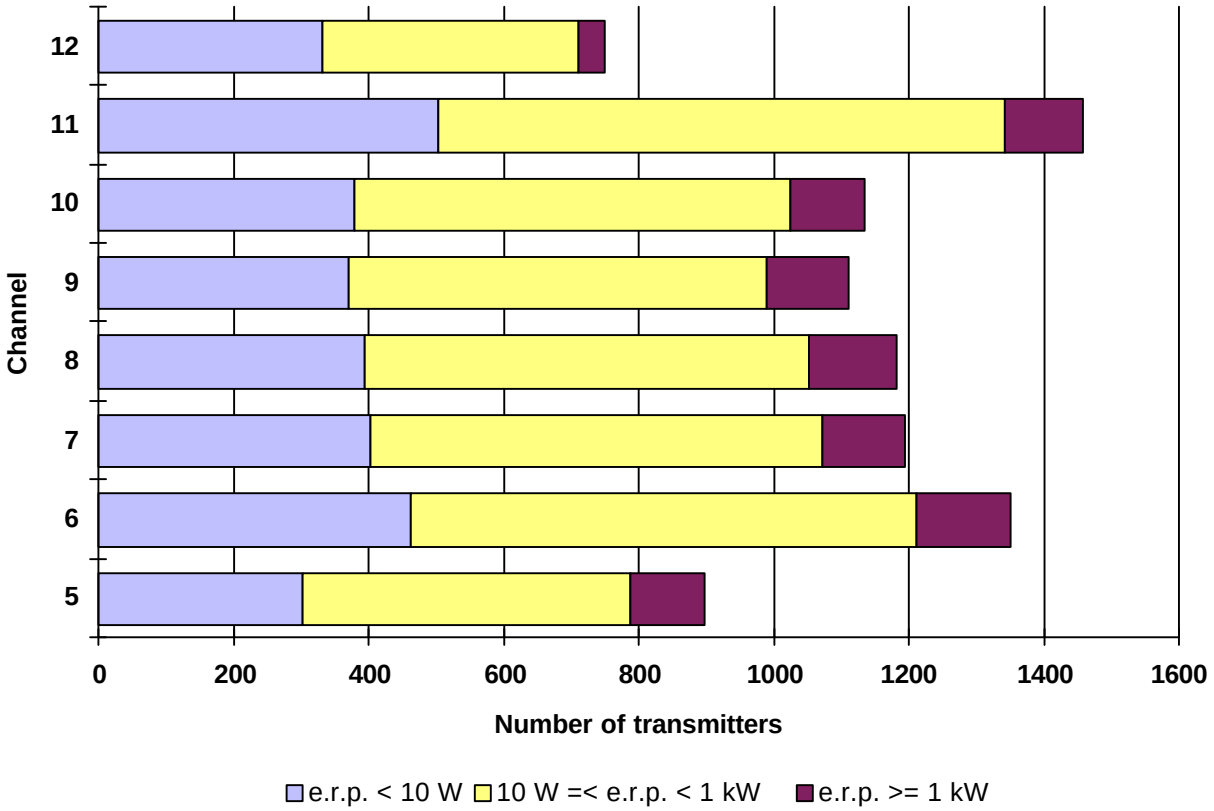


Figure Annex D2.5.1: Number of transmitters in use per channel in VHF Band III (5 to 12)

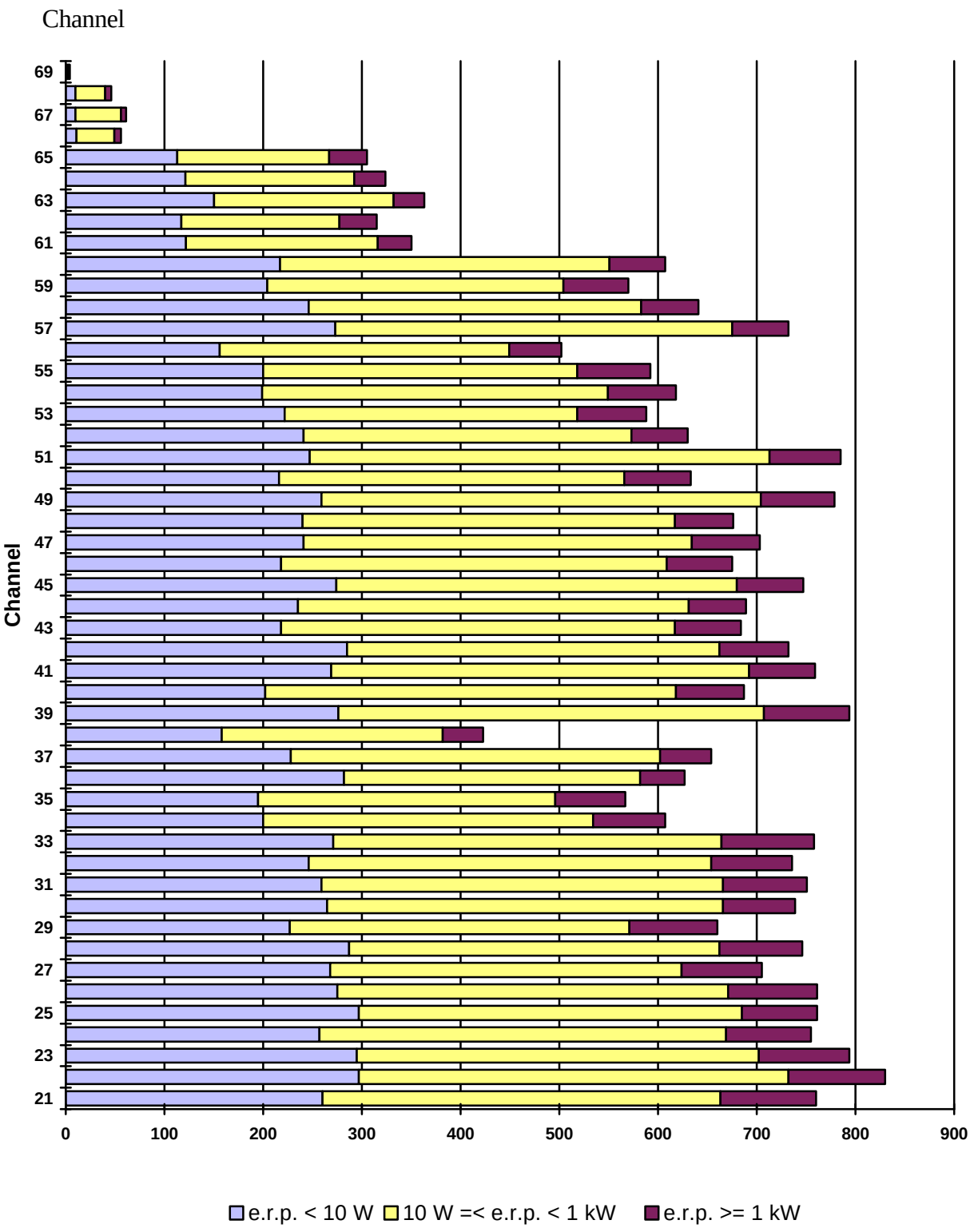


Figure Annex D2.4.2: Number of transmitters in use per UHF channel (21 to 69)

Annex D2.6 Direct to Home Satellite Broadcasting (DTH)

Present State

Direct Broadcasting by Satellite (DBS), or more correctly, the Broadcasting Satellite Service (BSS), is defined as "A radiocommunications service in which signals transmitted or re-transmitted by space stations are intended for direct reception by the general public".

Unlike terrestrial broadcasting which requires very many transmitters to provide a national coverage area, satellite broadcasting can achieve wide area coverage with just a single transmitter. Satellites can also provide smaller or larger coverage areas, within the limits of the spacecraft technology, power and the launcher's shroud capacity.

The high power DBS rationale is to enable the public to be able to receive high quality pictures on small dish antennas. Generally speaking, the higher the satellite power, the smaller the receiving antenna required on the ground.

A WARC was held in 1977 to agree a plan for satellite broadcasting. The 1977 DBS plan covered ITU Regions 1 and 3 and was modified at WRC97. Another regional conference developed a plan for Region 2 and the provisions for direct broadcasting by satellite have been embodied into Appendices 30 and 30A of the ITU Radio Regulations at WARC-88. For a broadcasting service, security of tenure that a Plan affords has been an important feature, bearing in mind the potentially very large public audience served and the ramifications for the public if such security is not possible. For the terrestrial services in the 12 GHz band the plan also facilitates long term planning and investments.

In the WARC77 plan, administrations in Europe were normally assigned 5 channels at an orbital slot 6° from an adjacent slot, either in the upper or lower half of the 11.7 to 12.5 GHz band. In this way, the terrestrial services were relatively free to use the alternative half of the band.

In 1986, the European Community (EC) adopted a Directive which related to the adoption of a common technical specification of the MAC (Multiplexed Analogue Components) Packet family of standards for direct satellite television broadcasting in the 12 GHz DBS band (Directive 86/529/EEC). A further EC Directive followed in 1989 concerning "Television without Frontiers" which aimed to co-ordinate national measures on television broadcasting, providing for the free transmission and reception of broadcasts from one Member State to another.

The advent in 1988 of the 16 channel Societé Européenne des Satellites (SES) ASTRA 1A and subsequently Astra 1B in February 1991, medium power satellite systems operating in the 11 GHz fixed service satellite band enabled direct reception in the home using much smaller dishes than hitherto possible with the lower power INTELSAT and EUTELSAT fixed service band satellites. A typical antenna diameter over much of Europe is 60 cm. During 1992 EUTELSAT also launched a second generation satellite with characteristics similar to ASTRA in an adjacent orbital position. A growing feature of such services is the inclusion of subcarrier audio channels (carrying separate radio programs) within television transmission channels. Digital Sound Radio (DSR) is another application of direct to home broadcasting.

The principal disadvantage in using the 11 GHz band for direct broadcasting to the public is that such reception using 60 cm paraboloids in most CEPT countries is not protected from interference arising from point to point radio relay links utilising the same frequency band. Within the co-ordination process it is possible to obtain protection from interference from other satellite systems utilising the same frequency band. Additionally, in formal terms the band is not allocated to the broadcasting satellite service in either the International Table of Frequency Allocations or in any National Table of CEPT countries. On the other hand, broadcasting in conformity with the ITU 12 GHz Appendix 30 plan is fully protected from such interference, in the case of national systems.

The 12.5 - 12.75 GHz band has also been used for direct reception from 1984, by the France Telecom I/2 systems, the German DFS Kopernikus system, the Spanish HISPASAT system and the Australian AUSSAT system - although their primary intent was distribution to cable heads.

Future prospects

On the international front, further utilisation of the 12 GHz band over and above that of the Appendix 30 DBS plan is being sought by a number of players. EUTELSAT is promoting the "Hot Bird Plus" project (13E) with a Europe-wide coverage, which will provide second generation DBS.

SES, supported by the administration of Luxembourg, has an ambitious programme utilising satellites in both the 10.7 - 11.7 GHz band (ASTRA 1A, 1B, 1C and 1D) and the 11.7 - 12.5 GHz band (ASTRA 1D, E, F) operating from the current ASTRA orbital position of 19.2 degrees east.

It is understood that there is some interest from other CEPT administrations in obtaining additional spectrum resources from the Appendix 30 and 30A plans in order to implement new systems.

At WARC 92 considerable interest was expressed in reviewing the Plans for Regions 1 and 3 at 12 (downlink) and 18 GHz (feeder links) and WRC-97 included this subject on its agenda. The CEPT agreement in preparation of this Conference should have the objective of ensuring that Europe achieves the satellite broadcasting it requires whilst other countries having assignments in the Appendix 30/30A Plans should not be significantly disadvantaged by European systems. It would also seem sensible to consider building additional flexibility into the 12 GHz band.

It has been also noted that any changes to the use of this band in Regions 1 and 3 should have minimal impact on the use of the band in Region 2. Studies of the way in which the band is used, taking account of current needs, may result in a conclusion that it might not to be necessary to revise the Plans but rather to adopt alternative procedures. This is reflected in both WRC 95 ("... to give initial consideration to proposals and views on the options to improve the effectiveness and efficiency of Appendices 30 and 30A of the Radio Regulations for Regions 1 and 3, with a view to WRC-97 undertaking further action") and WRC 97 ("... to review and revise as necessary Appendices 30 and 30A for Regions 1 and 3 ") agendas.

Turning specifically to the 11 GHz band, the use of this band for direct broadcasting has been established and will continue to increase.

However, the consensus, reflected by the ERC position, is that the fixed service allocations in the band 10.7 - 11.7 GHz cannot be removed or receive any reduced status. The ERC stated that the fixed satellite service provides a service to feed cable-head installations. If, as a side-effect DTH (Direct Television to Home) is possible in this band, then that is a benefit, but the DTH systems can not claim protection in the event of interference from other authorised radio emissions.

WARC 92 also decided that the band 21.4 - 22 GHz should be used for wide band high definition television in Regions 1 and 3 with feeder links located in the band 27.5 - 30 GHz (Teledesic permitting.) WARC92 also determined that the allocations would not be available until the year 2007 so consideration and planning of the systems are at an extremely early state. The opinion of both European broadcasters and CEPT administrations is that the allocations should be subject to a flexible planning approach, not a detailed planning as was the case for the 12 and 18 GHz bands.

Digital Satellite Television

There are a large number of satellite channels available for digital transmission and each of these channels would be technically capable of carrying, for example, one full quality HDTV with additional services or around eight services of PAL equivalent quality. Hundreds of additional programme services can be provided in a relatively straightforward way across most of Europe by using satellite digital technology. The recently approved DVB satellite specification (DVB-S, using QPSK modulation) provides a common European satellite transmission standard for operators to develop these new services. This combined with the complete set of DVB terrestrial and cable specifications will facilitate the development of digital receiving equipment for use in the home.

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D3. DVB-T IMPLEMENTATION SCENARIOS

D3.1 Introduction

Recent years have seen rapid progress in the development of digital terrestrial broadcasting technology. It is now likely that digital terrestrial television will become a reality in some parts of Europe. Therefore, it is of great importance to outline national and international strategies for the introduction of this service.

The introduction can be seen from a short-term or a long-term point of view. Objectives, constraints and possibilities differ in both cases, leading to several possible introduction scenarios, some in line with the short-term objectives and other better suited to the long-term. In addition, adequate transition methods from the short-term to the long-term scenarios have to be found. The three scenarios, short-term, transition phase and long-term are introduced below. Further details are given in §D3.4.

Spectrum usage differs in various countries. Some of the introductory strategies being adopted in Europe are given in §D3.5, and the outline of alternative strategies is given in §D3.3.

In spite of all of these differences, it seems that there are some common threads in the ways in which terrestrial digital television may be introduced, how it may develop and what its longer term uses may be. However, it has to be accepted that consideration of the long-term situation is rather speculative as there are so many variables involved. This section attempts to provide a general overview rather than concentrating on the detail in individual countries. In this overview, a distinction is made between short to medium term scenarios (indicated as S1, S2, in §D3.4 and long-term scenarios (indicated as L1, L2, in §D3.4).

D3.2 Implementation scenarios

D3.2.1 Short-term scenarios

Short-term scenarios deal with the introduction of DVB-T within the next few years. In this phase, digital television has to be accommodated in frequency bands, which are already extensively used by existing analogue broadcasts. Thus to fit into the current analogue spectrum, the new service has to cope with the major constraints of:

- being forced to adopt the existing channel structure, and
- protecting the existing analogue services.

In addition, it is necessary to reach the maximum achievable coverage for the digital service, at minimum expense for the viewer interested in the reception of such services and to provide an attractive development basis for the new technology.

For these reasons it seems reasonable to classify the various short-term scenarios according to the guideline of the different spectrum constraints that an introductory strategy encounters.

Current studies have been confined to the UHF band, because VHF Band III has various channel rasters in different countries and, in addition, might not be exclusively available for television broadcasting in future.

D3.2.2 Long-term scenarios

Long-term scenarios deal with the final implementation of digital television. At this stage, if the new technology has a successful market penetration, analogue services will have been phased out and digital transmission will be the only means of television broadcasting.

The scenarios can be classified according to the different objectives which are aimed at with digital services (e.g. service area, service mode, implementation, maintenance costs, etc.). The classification is done according to the size of intended digital service area (national or local) and variants of each class with respect to service modes, network modes and implementation costs are described.

The chosen subdivision along coverage areas must not be seen as exclusive, rather it is supplementary since, in general, countries will implement networks of at least two kinds, and possibly all three, in a layered structure.

In the long-term future a mixed analogue/digital environment is not envisaged, because it does not make the most efficient use of the spectrum. On the other hand, if terrestrial digital technology does not encounter the favour of the market, terrestrial broadcasting either remains analogue or is phased out. There would then be no portable reception and the coverage of local/regional programmes would be limited.

D3.2.3 Transition phase

Short-term and long-term scenarios differ in their objectives and, as a consequence, in their technical implementation features. Therefore, a third phase considering the transition of short into long-term implementations has to be analysed. It describes various ways to extend digital services in a mixed environment, where constraints on digital transmission should decrease and networks should be modified as appropriate, with frequency changes and site modifications. By decreasing constraints, implementation possibilities of digital terrestrial television will increase.

In addition, to facilitate the transition for the viewer, the receiving equipment should have some facilities such as automatic tuning of receiver, wide band receiving antenna systems, and so on. Until now only few studies have been carried out on this subject.

D3.3 Frequency management

D3.3.1 Spectrum requirements

The introduction of DVB is starting. However, DVB transmissions (with the exception of some DVB-T test transmissions) are currently limited to satellite and cable. Terrestrial DVB services are expected to start in 1998.

Partly because of the complex arrangement existing in Bands I and III, the studies concerning the possible introduction of DVB-T in Europe have mainly concentrated on the possibilities offered by the UHF band. On these channels, the new digital signals have to share the available spectrum with the analogue programmes.

It is possible that, in the long-term, a uniform channel bandwidth, together with a uniform alignment of channels for terrestrial digital television, could be adopted in the VHF band throughout Europe, although this is by no means certain.

D3.3.2 The DSI phase II investigation

The CEPT has carried out its second Detailed Spectrum Investigation (DSI), which covers the frequency range 29.7 to 960 MHz (therefore including the bands used for terrestrial television broadcasting). The final aim of the DSI is to establish a European Common Frequency Allocation Table (ECA) for all the CEPT countries. Such a process may lead to changes in spectrum allocation that could be implemented by about 2008.

The results of the DSI which affect the television situation in the VHF/UHF bands are given in **Table 2**.

TABLE D3.2
Final DSI 2 proposals

Frequency band MHz	Proposals
47 to 68	Proposal for television to be stopped
174 to 216	Shared with mobile services; possible reallocation after transition period
470 to 862	New channels mainly for digital television; after transition period digital television only

For some time, there has been strong pressure from mobile services for access to the broadcasting band below 900 MHz. Although recent projections made by the European Radiocommunication Office indicate a decreasing usage of frequencies below 900 MHz by the mobile services, the pressure for access remains.

On the other hand, many administrations and organisations are making alternative proposals to the CEPT regarding future use of this part of the spectrum. In particular, the EBU has proposed that the frequency ranges 174 to 216 MHz and 470 to 862 MHz should be available for terrestrial television on an exclusive basis, to permit development of the new market opportunities.

D3.3.3 Short-term period

As seen in the examples in §D2.5, the introduction phase of DVB-T will require the maximum spectrum availability, because of the current heavy usage of the VHF/UHF bands by analogue television services and the need for DVB-T to share with these services.

Thus, in the short-term phase, all of the spectrum dedicated to television in Bands III, IV and V will be needed for the successful introduction of DVB-T, including those channels which cannot be used for broadcasting at present.

D3.3.4 Long-term period

Digital technology provides enhanced spectrum efficiency. Thus, by today's criteria, in the long-term, less spectrum might be necessary for terrestrial broadcasting, and the present need of new channels expressed by European broadcasters could also be satisfied. In this hypothesis, part of the spectrum could be allocated to other services.

However, the following factors may lead to the complete utilisation of most, if not all of the spectrum currently available for television:

- it is likely that new market opportunities, based on additional services, will be developed thanks to the added flexibility which digital television can offer. Such market possibilities are restricted today by the limited capacity and versatility available within the existing analogue systems;

- the desirable future implementation of HDTV, when wide flat-screen displays become available on the market, at a reasonable price, will substantially increase the spectrum occupied by each programme;

- with the introduction of digital broadcasting services - which are more robust than the current analogue ones, a wider use of portable receivers is to be expected. To satisfy all the foreseen requirements for portable or mobile reception, a rugged system variant may be necessary and, as a consequence, more spectrum would be required for each programme.

In the future, all these possibilities might lead to the complete utilisation of all the spectrum currently available for television, considering Europe as a whole. However, it is very difficult, if not impossible, to estimate today the possible long-term future trend.

D3.3.5 Transition period

Because there are several hundred million television receivers in use in Europe, and because the minimum lifetime of a modern television set is at least seven years, it is essential that the transition period is sufficiently long to avoid any disruption of service.

For these reasons it is perhaps not unreasonable to assume that the transition period will last some 15 years from the introduction date of digital services. As the latter date will not be the same in all European countries and as it is unlikely to occur in any country before 1998, it is easy to see that the transition period will last for such a long time that any prediction about the post-transition era must be considered somewhat speculative.

Therefore, it is quite unrealistic to envisage a rapid phasing out of the existing analogue services. It is possible that, around the year 2015, DVB-T might be nearing the end of the implementation phase in some countries, while in others the penetration of digital television might only be partially completed.

D3.3.6 Some speculative considerations

If the digital terrestrial television is successfully introduced and replaces analogue television, it is possible to give some consideration to band usage.

D3.3.6.1 Band I

Measurements have shown that man made noise levels in Band I (47 to 68 MHz) are considerably higher than in other television bands (Bands III, IV and V). Moreover Band I suffers from sporadic E propagation which may cause abrupt failure for digital systems at low time percentages. Consequently, Band I is deemed to be less suitable for DVB-T than the other television Bands and can be considered for reallocation.

In a number of countries, analogue television transmissions in Band I (particularly in the lowest channels) could be closed in the short-term. Nevertheless, a too early closure of such services could lead to their transition to the UHF band, lessening the introduction of DVB-T.

It is therefore recognised that, for operational reasons, there may be the need to continue the operation of analogue television in Band I, in particular when the replacement of the transmitters in UHF is either not possible, or limits the introduction of DVB-T.

D3.3.6.2 Bands III, IV, V

To facilitate the introduction of terrestrial digital television, all of the spectrum in Bands III, IV and V, which is normally available for terrestrial analogue television, will be required for DVB-T services for at least 20 years. Indeed, these bands will continue to be the primary medium for many broadcasting services and will also form a key part in the strategies for the transition from analogue to digital.

In addition, taking into account the increasing pressures in the spectrum during the transition period (while analogue services are being supplemented and replaced by digital services), it could be very highly desirable for broadcasting to have access to some spectrum not currently available in some countries.

Concerning the frequency sharing between analogue and digital services, a CEPT indication proposed that any channel that may become available in the short and medium term should not be used for extending the analogue networks. This requirement is quite a delicate issue. Very distinct situations exist in the different European countries and different digital start up philosophies are predictable. Therefore, a limitation on the development of analogue television may be too severe for the time being. In a general way, analogue television should still be allowed to be introduced.

In the long-term, the market potential for terrestrial transmission, will probably develop new opportunities and services, that only terrestrial transmission has the ability to provide. Therefore, despite the enhanced spectrum efficiency, the traditional bands assigned to the television terrestrial transmission could continue to be required for these services. On the basis of future periodical review of the situation, the appropriate decisions have to be taken.

D3.3.7 Can spectrum be released for use by other services?

Summarising the aforementioned ideas, it is very difficult and premature to predict today either the spectrum requirements for digital television in the long-term, or the time scale for its penetration.

As already said, it is possible that, by today's criteria, less spectrum will be needed for DVB-T in the future, but is very speculative to estimate the required amount at this stage. During the transition period, which could last well into the second decade of the next century, the number of terrestrial digital television services, their nature and several other factors will become clearer as they evolve.

Therefore, it is not possible, at the moment, to assess if any spectrum might be transferred to other services. Further reviews of spectrum usage and requirements will be needed periodically in future years to establish what spectrum allocation should be undertaken.

D3.3.8 Conclusions

DVB-T will be introduced in the UHF bands by some countries in Europe by 1998. To facilitate this early start-up, short-term strategies have to be adopted by these countries. The spectrum will have to be shared between the terrestrial analogue and the new terrestrial digital television services.

As the number of receivers for DVB-T increases, it will be possible to gradually withdraw the analogue services by a phased closing down of analogue transposer and transmitter stations. This is the transition phase between the shared use of the spectrum by the analogue and digital services and the long-term aim of a wholly digital television scenario. During this phase, channels will be released by the closure of analogue transmitters and these channels can be used to increase terrestrial digital coverage.

Finally, in a long-term scenario, the overall coverage will be achieved by DVB-T networks in Bands III, IV and V. The analogue transmissions will have been phased out and the released spectrum used by digital services. The completion of the conversion in any particular country could take a period of about 10 to 20 years from the start of implementation.

D3.4 Some possible implementation scenarios

D3.4.1 Short-term period

The main constraint for the introduction of digital terrestrial television in the immediate future (for example in the next five years) is the protection of existing analogue services.

Countries in Europe can be considered in two broad categories:

- **Category 1**

  – Those countries which have access to assignments which are currently unused for television stations, or even networks, (at relatively high effective radiated power) which have been fully co-ordinated and are thus included in the updated Stockholm Plan. Such channels are referred to below as "free channels."

Countries which can obtain access to, for example, channels above 60, may also be considered to be in Category 1.

- **Category 2**

  – Those countries which do not have access to unused (relatively high power) television station assignments.

This separation is convenient because different implementation strategies are possible in the two cases. However, even countries in Category 1 will probably not have access to sufficient spectrum to satisfy all of their requirements and will thus come into Category 2 for some requirements.

Three types of introductory scenarios, denoted in the paper by S1 to S3, can be foreseen. They refer to the various kinds of spectrum usage introductory digital scenarios have to cope with.

- S1: use of existing or planned assignments;
- S2: re-use of existing (used) channel assignments;
- S3: use of "free channels".

The chosen separation into the various scenarios is not exclusive. Countries may take up some or all approaches simultaneously, depending on the spectrum situation they are faced with.

D3.4.1.1 Short-term scenario 1 (S1): Use of existing or planned (but unused) channel assignments

The first scenario is possible for those countries belonging to Category 1.

In this case, large coverage areas are achievable, since there are relatively few restrictions on the radiated power. Therefore, it can provide an excellent starting point for the introduction of DVB-T and may make the core of a future digital MFN or represent, in the case of an entire network, the backbone of an MFN-based long-term scenario.

In general, it can be assumed that the coverage of plan assignments will be similar for digital and analogue services. However, caution has to be taken in those cases where planning of analogue service has been performed with precision off-set, which significantly reduces the restrictions on the analogue transmitter, or where a non-rugged digital service with the requirement for a high protection is intended. These circumstances might reduce the digital coverage.

It is essential that the relevant protection ratios and e.r.p. values for the digital and analogue services are considered on a case-by-case basis to ensure that an existing assignment can be used to achieve the digital service required.

The concept of mini SFNs provides an adequate means to cope with such kind of restrictions. Indeed, the interference potential of a mini SFNs configuration is significantly lower compared to a single transmitter solution.

The concept of mini SFNs can also be used to improve coverage, in particular in the case of portable reception.

Implementation costs of scenario S1 will be relatively low for the broadcasters, since in almost all cases transmitter installations already exist, if a conventional single transmitter solution is chosen.

Where the digital channel is close to the analogue one, there is a particular cost advantage for the viewers, because they can use their existing receiving antenna system. This cost advantage for the consumer may be a decisive aspect for the assessment of a digital scenario in the introductory phase when the supply with digital services is not yet completed and, therefore, has not its full attractiveness.

Use of the dense network approach substantially increases implementation costs for both broadcasters and consumers, since additional transmitters have to be installed as well as new receiving antennas.

Co-ordination effort is likely to be negligible since already co-ordinated channel positions are used. The conversion process given in the Chester 97 Agreement will be applied.

D3.4.1.2 Short-term scenario 2 (S2): Re-use of existing channel assignments

Scenario (S2) applies to Category 2 countries without free assignments and to Category 1 countries having already used their free assignments for their first digital networks, looking for alternative channels.

Channels that are only of very limited use for analogue services may be available for DVB-T, because of its higher robustness and smaller interference potential. Therefore, even an highly saturated UHF spectrum might offer some resources for the introduction of digital television. Of course, this situation is not favourable for the realisation of large scale SFNs.

The implementation of re-used channel assignments necessitates co-ordination with neighbouring countries. However, the approach fits into the existing spectrum usage.

For fixed reception it is possible to consider two variants (described in the chapter):

- **scenario S2a** - using existing transmitter sites and, whenever possible, channels near the existing analogue ones for the start of digital transmission;

- **scenario S2b** - adding new broadcasting sites to existing analogue ones.

For portable reception this distinction is not relevant.

The feasibility of scenario S2 strongly depends on the density of the current analogue services and differs significantly from country to country. Once being started, it may serve as a basis for a long-term digital service in MFN mode. Until now, scenario S2 is the most investigated introductory approach.

The main features of Scenario 2 are:

a) Protection of existing or planned analogue services

Any new station, digital or analogue, causes some increase of interference to existing viewers and thus causes a coverage reduction. The constraints on the power of digital stations will be set by considerations of how much additional interference to analogue viewers is tolerable and for what percentage of the time. The size of the digital coverage areas will be determined by a combination of factors:

- the radiated power of the digital transmitter;
- the amount of interference from analogue or other digital transmitters;
- the required C/N ratio for the digital service.

The required protection of analogue services will lead to e.r.p. restrictions, therefore to limitations of the achievable coverage areas for digital television.

b) Fixed roof top reception and limited portable reception

Most studies have shown that, at least during the transition period when analogue and digital services will have to coexist, the coverages achievable for portable reception are likely to be rather limited. However, useful portable coverage could be achieved if a transmitter is close to a population centre.

The implementation scenario where existing transmitter sites are used, may therefore take reception with fixed roof top antenna as a basis. Portable reception is subject to very variable conditions compared to fixed roof top reception and depends on receiving height, building penetration loss and local signal variations. Depending on the situation (indoor or outdoor, high or moderate location probability, bit-rate requirement, network configuration), portable reception may be possible to a large proportion of the area for upper floor reception.

It must be noted that in countries with high cable and satellite penetration, portable reception is seen as the primary target for future terrestrial services.

c) Possible change of frequency for low power analogue stations

It is clear that it will not be possible, in general, to change the channels used by the higher power analogue transmissions because of the widespread disturbance to analogue reception which could be caused. However, some of the e.r.p. restrictions on digital stations may be caused by the need to protect low power (and low coverage) analogue stations. In such cases, analogue channel changes may be feasible and this could make a significant improvement to the digital coverage achievable. In this context, it has to be remembered that there are some 20,000 operating stations with less than 10 Watts e.r.p. in Europe in addition to the 20,000 stations above 10 Watts.

D3.4.1.3 Scenario S2a: use of existing transmitter sites

Most homes already have a domestic receiving antenna, which is both frequency selective and oriented with a particular direction and polarisation. In order to maximise the commercial

attraction of digital transmissions, it is desirable that they should be easily receivable, for example by the existing receiving antenna systems. Indeed, the added cost of installing a new antenna represents a significant disadvantage for most viewers, especially if there are no additional programmes to be received (simulcast of analogue service).

Therefore a good starting solution is the use for the digital programmes of the same sites already transmitting the analogue ones. In addition, the new channels should be close to those used for existing analogue services and the same polarisation should be used.

Because the services come from the same site and because the digital power would be lower than that of the analogue service (for protection purpose), there would be little risk of causing adjacent channel interference to the existing analogue viewers.

It should be noted that if a country wishes to prepare a long-term future with SFNs, the choice of adjacent channels to the analogue services may be incompatible.

D3.4.1.4 Scenario S2b: adding new transmitter sites

Scenario S2b is a variation of scenario S2a. It is mainly based on the same assumptions for most areas, but with the addition of new low power stations in those areas where the protection of existing analogue services prevents adequate digital coverage from existing sites.

In such configurations, the receiving antennas used by the viewers of the analogue services are unlikely to be suitable for reception of the digital services from the new relay stations, because of the different channel and direction.

On the other hand, they have the advantage of reducing the impact of interference from the digital network and thus the coverage areas may be increased in size. However, there is the risk of causing interference to existing analogue viewers in some marginal parts of the analogue coverage area. Indeed, there are likely to be viewers of the analogue transmissions from the main station who are situated close to the new digital relay station sites. Such viewers may experience interference from the digital transmissions, if these use channels adjacent to those of the analogue services, due to the high level digital signals in areas where the analogue signal is relatively weaker.

Concerning implementation costs, obviously, such networks are likely to be more expensive to install than conventional ones, because of the need for additional transmitter sites.

D3.4.1.5 Short-term scenario 3 (S3): Use of “free channels” on a national or regional scale

In some countries there exists the possibility that in the UHF band one or more channels will be released for the implementation of digital services on a nation-wide basis. These channels are either not currently allocated to television broadcasting, or they are allocated but not used by television services.

In some European countries, the UHF channels 61 to 69 are used by the military or by fixed services. There is a prospect, encouraged by CEPT considerations, that some or all of these channels can be made available for digital television broadcasting.

In Germany at least one channel will probably be cleared in the relatively near future.

A similar situation is found in the Netherlands. The existing services in these channels may (partly) be moved to higher bands.

D3.4.1.6 SFN implementation

This kind of situation offers a unique chance to implement an SFN-based digital service on a national or regional scale. It potentially represents the introduction of an attractive long-term scenario from the very beginning.

In general, the use of these channels will not be possible on an entire nation-wide basis because of neighbouring countries, which probably use these channels for analogue or other services. Co-ordination will be difficult in these cases, as long as the neighbours operate these channels on an MFN basis.

As compared to single transmitter or MFN introductory strategies, portable reception finds larger coverage because of the higher homogeneity of the field strength within an SFN. Additional increase of transmitter density, by means of low power stations, would offer the option for a national or regional coverage for portable reception from the very beginning. This would imply further, new transmitter sites which increase the implementation costs.

D3.4.1.7 Conventional planning

If the existing conditions do not permit the implementation of SFNs (e.g. when neighbours have already access to these channels, and the realisation on a single frequency basis becomes hard to co-ordinate) or, simply, if the SFN mode is not seen as the long-term scenario, the free channels can be utilised in the conventional mode.

D3.4.1.8 Implementation of SFNs

Some studies advocate extensive use of Single Frequency Network techniques at an early stage in order to prepare for a long-term future. SFNs offer the major advantage of requiring few channels to cover large areas. Indeed, in theory, only a single channel may be needed for a complete national network. Equally, regional SFNs may be possible in many countries preferring such coverage. In addition, SFN technique improves portable reception.

However, care should be taken not to put too much emphasis on this technique. Indeed, the heavy congestion in the UHF band with analogue systems will, in many instances, prevent or lessen the possibilities of using the SFN technique - for instance the use of channels near to the analogue ones. In some situations these considerations may lead to an easier introduction of digital television using conventional planning.

D3.4.2 Long-term period

Terrestrial digital television introduction requires not only good perspectives in the near future, but needs also to be examined from the long-term strategy point of view (15 to 20 years from start).

In this phase it is also possible to classify the potential scenarios into three categories. These include two different maximisation strategies:

- scenario L1: maximises the amount of coverage;
- scenario L2: maximises the number of programmes in limited areas;
- scenario L3: no digital terrestrial transmissions (put in only to provide further thought).

Compromises between these extremes are not considered here.

D3.4.2.1 Long-term scenario 1 (L1): Maximising size of coverage areas

Scenario L1 is based on Single Frequency Networks.

D3.4.2.1.1 Wide coverages

As already stated, SFNs offer the major advantage of requiring few channels to cover large areas. Indeed, in theory, only a single channel may be needed for a complete national network. MFN planning would require several channels.

With an SFN a national coverage can be achieved on the same channel. As neighbouring countries will claim an equitable share of the spectrum, not all channels can be used for national coverage. Experience in planning SFNs for T-DAB has shown that, at least in Western Europe, one fifth of the total band capacity is available for national coverage in a given country. Of course, channels from neighbouring countries can be re-used at a certain distance from the border.

For band IV/V, channels 21 to 60, there could be 8 channels available in each country for national coverage. In a digital mode with 4 programmes per channel this means 32 programmes. Re-use of other channels on a regional basis adds multiple of 32 programmes. Depending on the location viewers may have one hundred, or at certain places, even more programmes.

Therefore, even if part of the UHF spectrum were to be made available to other services, terrestrial broadcasting has good prospect for programme capacity in the long-term.

D3.4.2.1.2 Portable reception

As an alternative to large number of programmes, one can prefer portable reception over the wide area, the maximum bit rate in a channel being used with robustness instead of multiplying the number of programmes.

D3.4.2.1.3 Analogue networks closing

In most cases, finding a clear channel all over a wide area means closing of existing analogue stations working on this channel. Therefore, scenario L1 is a straight forward scenario, but it

implies the end of analogue transmissions at a given time and needs a strong will and a good management of the transition period (see Section 3.2.4).

D3.4.2.2 Long-term scenario 2 (L2): Maximising number of programmes in limited areas

Scenario L2 applies when wide coverages, as in scenario L1, are not the main objective. In this case more possibilities become available. Indeed, it may be reasonable to ask if full national coverage is a requirement for terrestrial digital television in the presence of alternative delivery media such as cable and satellite.

Therefore, the aim is to concentrate on coverage of urban areas which may limit the necessary investment costs. Elsewhere, people would receive the programme from satellite or by any other means.

The aim could then be to maximise the number of programmes available, especially for portable reception.

SFNs with wide areas (Scenario L1) require sharing of the available channels between neighbouring countries, thus dividing the total possibilities in the available frequency range, as indicated above.

In scenario L2, where services are concentrated over limited areas, possible interference between co-channel service areas are of less importance. All channels can be used in these limited areas.

For the band IV/V channels 21 to 60 this means that 40 channels are available for local coverage. In a digital mode with 4 programmes per channel this means 160 programmes.

Therefore, even if some part of the UHF spectrum were to be made available to other services, terrestrial broadcasting has good perspective of capacity in the long-term.

D3.4.2.3 Scenario long-term 3 (L3): No terrestrial broadcasting

In this scenario, DVB-T services would not start and the existing analogue services will eventually be phased out. Digital programmes are only delivered by satellite or cable. It now seems that this is an unlikely scenario.

D3.4.3 Transition period

During the transition period, analogue and digital services have to co-exist. While constraints on digital transmission should decrease, networks should be modified to extend digital service. The main uncertainty associated to this phase is the duration of the transition period.

Any spare capacity which can be found during the transition period will mainly be used for digital transmission. In those countries in which the number of available channels is insufficient, the coverage attainable by digital services will be limited. This constraint increases the problem of terminating the transition period.

This section outlines some ways to decrease the constraints on digital transmission. It should be noted, however, that an increase of interference to analogue stations may make the conversion of these stations to digital more difficult in the future.

D3.4.3.1 Reduction of analogue service protection

Generally, it can be assumed that the transition period will be characterised by decreasing importance of analogue coverage as the penetration with digital receivers grows. This gives the possibility to gradually reduce the protection of some or all analogue transmitters, allowing for an increase of digital coverage by higher transmitter powers and/or implementation of new digital transmitters. It is a means to expand MFN-based digital services on a national, regional or local scale.

The protection of the existing analogue transmission is controlled through three major parameters:

- level of impairment of the analogue service due to the digital transmission: the level of interference is measured through the increase of the 'usable field strength'. For example, an increase of 3 dB corresponds to an impairment of half a grade on the CCIR quality scale;

- percentage of time during which analogue transmission is protected: in principle, 99% of the time;

- percentage of locations where the analogue reception is protected in its service area: in principle, 50% (at the edge of the service area).

By modifying progressively the above parameters, the implementation possibilities of digital terrestrial television will increase. This could be measured in percentage increase of the covered population.

However, a study carried out by TDF for France indicates that benefits gained from a relaxation in the planning parameters may be relatively small. TDF investigated, for a national digital network, the increase in covered population if the threshold for allowed additional interference to analogue services is raised from 1 dB to 3 dB. For vertical polarisation the percentage increased from 63% to 66% and for horizontal polarisation from 53% to 58%. Since a reduction of protection by 3 dB already corresponds to a picture quality deterioration of 1/2 picture grade, further decrease of the analogue protection would result in an unacceptable impairment of the affected analogue service.

D3.4.3.2 Reduction of the number of protected analogue transmitters

Closure of analogue transmitters or change of their frequency are important possibilities for the improvement of digital coverage, by allowing either for a larger coverage of already existing digital transmitters, or for the installation of new digital transmitters at the sites of the closed analogue transmitters.

As shown by some studies, the digital implementation possibilities heavily vary according to the set of analogue transmitters to be protected. For example, a planning exercise for France set up a list of analogue transmitters with frequencies difficult, or very difficult to change, without a global re-planning of UHF bands. It included transmitters with high e.r.p., transmitters placed in elevated locations and transmitters with a population coverage of more than 30,000 inhabitants. This data base counted 1173 transmitters. For the neighbouring countries, it was assumed that frequencies of both transmitters and transposers would not be changed.

The planning exercise compared the coverage of digital networks obtainable assuring the protection of all analogue transmitters, on one hand, and of only the 1173 analogue transmitters, on the other. The study was based on fixed roof-top reception and 14 dB C/N conditions. The results were the following:

Table D3.1: Comparison of digital population coverage for protection of analogue services

Analogue Txs protected	Population coverage of digital services
All	15% for the one network possible
1173	60 to 70% for the four networks possible

From these numbers the extreme sensitivity to the level of protection appears. It is therefore important to reduce the number of analogue transmitters to be protected during the transition stage. However, not all analogue transmitters are likely to be removable without substitution, implying additional implementation costs for analogue installations which are to be phased out in the near future.

Another variant of this scenario arises if a country decides to move a national (or regional, if the region is large enough) analogue service from terrestrial to satellite service. In particular, this case may occur if the country intends to provide this service from satellite as a digital one. The free spectrum may then serve for the extension or implementation of one or more regional MFN-based digital services.

Implementation costs for the latter scenario are likely to be low, since transmission infrastructures and receiving antenna systems already exist.

Also co-ordination with neighbouring countries should be relatively easy - the new digital transmitters being in the place of already co-ordinated analogue transmitters.

D3.4.3.3 Completing SFNs

In a similar evolutionary way, the transformation of a short-term SFN into a long-term SFN can be accomplished. In this case, the installation of new transmitters may be necessary to increase the density of the network, allowing for a higher degree of portable reception.

This scenario does not imply additional co-ordination effort since the channel is already co-ordinated for the whole service area.

Implementation costs are the usual ones required for the installation of SFNs.

Also, the transition from a former short-term national SFN to a long-term regional SFN seems to pose no problems, as after the introductory phase, more channels are available for digital within the envisaged coverage areas.

D3.4.3.4 Transformation of MFNs into SFNs

A difficult transformation process is encountered, if a country introduces its digital services on an MFN basis but aims at the SFN mode in the long-term.

A network can only operate in the SFN mode under the condition that its channel is cleared for the entire service area. If there are still analogue services using this channel (and this is probable as long as there is any analogue service in operation) the affected analogue transmitters would have to be shifted in frequency.

Among these transmitters, there will certainly be main stations realising a considerable amount of population coverage. It is questionable whether it makes sense (because of the large cost efforts for broadcasters and consumers) to re-arrange an analogue service which will be soon phased out. However, there may be suitable channel configurations that make this transformation practicable.

If the envisaged SFN channels are thoroughly used by digital transmitters, on an MFN basis, the transition seems to be less problematic. Transmitters would have to be changed from their MFN channels to the SFN channel. This will result in some costs with respect to transmitter installations since, in general, MFN and SFN channels will not be situated close together, and possibly re-arrangements of the receiving digital antenna installations would be necessary.

With respect to national/regional SFN coverage, this scenario makes co-ordination with all neighbouring countries inevitable. Since SFN and MFN approaches are not compatible, at least on a large scale, neighbouring countries would have to agree on which to use. Therefore, a large co-ordination effort is expected to be required for this scenario and a lot of good will is necessary for it to succeed.

D3.5 Some European introductory strategies

D3.5.1 Introduction

It is common opinion that an early start is necessary if terrestrial transmission has to compete with what satellite or cable can offer by digital means.

The European panorama is quite various. In the Terrestrial Commercial Module (TCM) of the European DVB project, a number of organisations are identified to be developing plans for the introduction of DVB-T. The most promising plans for early introduction of DVB-T exist in the UK and Sweden, where a launch is foreseen in 1998. Other countries are not presently ready for the huge investments needed for the start of digital terrestrial television. Or simply, they don't have a set of frequencies suitable for the delivery of the digital service to a significant proportion of population.

As general characteristic, hierarchical modulation is not considered for the introduction phase as the number of programmes is more important (even due to the lack of spectrum). Whether hierarchical transmission will be used at a later stage remains to be seen.

In this section an insight into the different national introductory strategies concerning the introduction of digital terrestrial television is provided as of April 1997.

D3.5.2 United Kingdom

In August 1995 the UK Government became the first EU member state to bring forward proposals for the introduction of digital terrestrial television. The Broadcasting Bill was

introduced in the UK Houses of Parliament in January 1996 and has recently received Royal Ascent to become law. There will be 6 national channels or multiplexes providing around 24 new programmes.

The assumption in the proposal is that a single channel or multiplex will carry around 24 Mbits/s of digital capacity (this could be provided, for example, by an OFDM 64 QAM with rate 2/3 error coding). There is no definitive assumption on the bit rate capacity of a single television programme but, if 6 Mbits/s is assumed, then each multiplex can carry four services, and a total of 24 such services might therefore be available.

The existing terrestrial broadcasters (i.e. BBC1, BBC2, ITV, Channel 4 - with S4C in Wales - and soon to be introduced Channel 5) would be given guaranteed slots on these multiplexes. In return for their guaranteed places, public service broadcasters will be required to simulcast their existing analogue services on the digital network. New services (funded by advertising, by subscription or by pay-per view) may also be provided alongside simulcast.

The multiplex with the greatest geographical coverage (more than 90% of the population) will be allocated to **BBC**.

ITV will be offered half of the multiplex with the second greatest coverage.

Channel 4 will have the other half of this multiplex.

In Wales, **S4C** and **Channel 4** will have a quarter multiplex each.

Channel 5 will be offered half the space on the multiplex with the third highest coverage (more than 80%).

The UK is pressing ahead to make a start for DVB-T possible in the shortest feasible time frame. It is envisaged that services will start to 1998. One commonly held view is that unless digital terrestrial television starts on this type of time frame, it will loose its window of opportunity and will be overtaken in the market by digital satellite and cable.

The analogue switch off will depend on the success of digital television and, in particular, the take-up of Set Top Boxes or digital sets. The situation will be reviewed after 5 years into the first licence period or when 50% of homes have digital sets or STBs, whichever is the sooner.

D3.5.3 Sweden

In June 1995 the Swedish Government appointed a special commissioner to investigate the possibilities of introducing digital television in Sweden. The commissioner presented his report in February 1996. He proposed that development of the terrestrial networks for digital television should begin by 1997 at the latest, and the first stage, providing 8 nation-wide channels, should be concluded within two years.

The first stage should include simulcasting of the existing analogue programmes, namely SVT1, SVT2 and TV4, as well as 5 new programmes. In the second phase, the broadcasting network should be enhanced to be able to accommodate 24 programmes.

Current analogue terrestrial television should cease as soon as possible, however at the latest within ten years after digital terrestrial broadcasting has been started. In the long-term, the overall number of nation-wide programme possibilities was estimated to about 50.

The Swedish Government has instructed the National Post and Telecom Agency to make the necessary frequency co-ordination. Initially, frequencies for four national digital networks are to be co-ordinated. These networks shall be based on the existing infrastructure. At least one of them is to accommodate possibilities for regional transmissions.

The National Post and Telecom Agency shall also assess possibilities for the co-ordination of two additional digital networks.

A Government proposal for the introduction of DVB-T in Sweden was presented to Parliament in December 1996. It was proposed that terrestrial digital television broadcasting shall be introduced in stages. In the first stage, possibly beginning in the autumn of 1997, broadcasting will start in a limited number of areas in Sweden. These areas should be selected so that they complement each other in different ways. For instance, highly populated areas as well as rural areas should be represented. At least two transmission channels should be made available for each area. The introduction period will be prepared by a special co-ordinator, whose responsibilities include making suggestions for the service areas. Television broadcasting shall be the main service, but other services such as education and telecommunication services of various types can be included. Local and regional programmes should be given priority. The present terrestrial television broadcasters should be given the opportunity to participate.

D3.5.4 France

Analogue terrestrial broadcasting is still very important in France, as cable and satellite coverage is very low. That implies that the interest for digital terrestrial television could be potentially important in France, although nowadays the major interest is turned to analogue services.

Several works are on-going to improve the analogue terrestrial broadcasting. NICAM has been adapted to SECAM, and is currently being introduced for TF1, FR2, ARTE/La Cinquieme. Studies are going on with respect to additional data or audio services, 16:9 analogue broadcasting, etc.

Since analogue transmissions benefit from primary protection, the possible introduction of digital television should be characterised by a long transition period and start of transmissions in taboo channels.

D3.5.5 Germany

In the opinion of the German **public broadcasters**, the introduction of digital television is very difficult, if not impossible, due to the lack of frequency for new services. The existing analogue television services exploit the UHF and VHF frequency range extensively. In addition non-broadcasting services make use of spare capacity within these bands.

It is the position of German public broadcasters that existing analogue services have to be still maintained for a considerable period of time. For this reason, any degradation or restrictions by any new service to be established affecting these services are not acceptable. This statement also reflects the view of the German private broadcasters.

It is the expectation of **Deutsche Telekom** that introduction of DVB-T will begin on a local/regional basis. Therefore, first spectrum investigations are concentrated on the largest cities and on the centres of higher population density (in total 32 sites with around 25 million of inhabitants).

The objective is to have around 5 channels available from the beginning and the first investigations consider the frequency band 470 to 790 MHz (UHF channels 21 to 60). The insertion of DVB-T signals in this band means that the used analogue channels, which have to be protected, may be affected. Therefore, it can be expected that 5 channels cannot be found within that band. A solution could be the use of channels in the band 790 to 862 MHz, as far as they may be freed but not be used for SFN purposes.

It is the interest of some broadcasters and Deutsche Telekom to begin DVB-T pilot projects as soon as the equipment (transmitters and receivers) is available. The first tests with DVB-T compliant equipment have been carried out in the Cologne area showing excellent mobile performance what was originally not expected.

D3.5.6 Spain

There is an increased use of the UHF Bands due to different factors.

The first one is the introduction at the beginning of 1994 of a Plan to increase the coverage of the three private national broadcasters from 80% to 90%. A high number of very low power stations are being put into service, mainly in low populated areas using sites at the lowest possible altitude in order to maintain terrain shielding. Feeding of these stations is by satellite reception. This Plan is expected to have little impact on the frequency availability for the introduction of DVB-T.

In December 1995 local television has been regulated, with a maximum of two local television stations in each city. The law poses a temporal limit (5 years) to the initial authorisation of new local stations, the renewal of this authorisation being linked to the availability of cable distribution in the city. Frequencies could be changed at this stage. The provisions of the Law are expected not to hamper the reallocation of frequencies if properly applied.

Local television stations will affect the availability of frequencies in most of the highest populated areas. As a consequence , the introduction of DVB-T is becoming rather difficult. The Spanish Administration is sensitive to these restrictions, and is therefore exploring the feasibility of allocating new television channels (at present time unavailable for transmissions) for the only use of digital television.

In the other hand, a Plan has been approved for the introduction of experimental terrestrial digital transmissions in the Madrid area. First transmissions were planned for the end of 1996. The 8k option of the specification will be used.

D3.5.7 Italy

The Italian situation is quite difficult. Three national public networks (RAI), more than nine national private networks (Mediaset, TelepiùTMC and others) and about 600 local stations live in the overcrowded national spectrum. The traditional bands are not sufficient to assure the national coverage (99% of population) to all the national operators. Other additional services are not allowed by this lack of capacity.

In 1995 the Italian PTT Ministry hosted a meeting to which representatives of the main national and local broadcasting companies attended. The subject of that meeting was the introduction of digital technology in terrestrial broadcasting.

The private parties expressed a great interest in the new system that, thank to the enhanced potentialities, could represent a solution to their needs.

However some problems were envisaged in the operation: the high economical investment required (not all of the broadcasters can bear it), the diffusion of digital receiving equipment in the home of the viewers (that has to be sufficiently wide to make the system interesting from a market point of view) and, last but not least, the spectrum unavailability.

Indeed, it is easy to understand that, in a situation such the Italian one, frequency resources available for the introduction of DTTV are very limited, especially in most populated areas where major market potential exist. Therefore it will be extremely difficult to think to a possible strategy for the introduction of digital television, if radical decision are not taken at national level.

On the technical side, RAI and Mediaset have already begun to evaluate the possibility of DTTV introduction and some planning exercises have been drawn up.

D3.5.8 Netherlands

D3.5.8.1 The market situation in The Netherlands

In The Netherlands about 90% of all households have an individual subscription to a cable system. All in all some 95% of all households have access to cable television. There is a trend for cable operators to merge, resulting in cable networks covering increasingly larger areas. It is to be expected that in a number of years there will only be some 50 head ends left. The largest cable system is located in Amsterdam, covering about 600,000 households. In general cable networks transmit some 20 to 30 programmes, including the three public services, most of the eight Dutch-speaking commercial services and a number of foreign public and commercial services. Sometimes also local programmes are distributed.

At present there are three terrestrial analogue television networks having a near 100% coverage. It is likely that an analogue regional terrestrial television network is built up within 2 years from now.

Commercial television programmes are now distributed digitally via satellite and re-distributed (in PAL) in cable systems. Nethold recently launched a bouquet of Dutch-speaking programmes, including both pay-television and free programmes via digital satellite.

D3.5.8.2 Prospects for DVB-T

Recently Nozema published its plans for digital terrestrial television. The plans consist of transmitting a package of 12 to 20 programmes via terrestrial television transmitters for services to:

- the 620,000 households without a cable connection;
- second and third television sets in and near homes with a cable connection;
- television sets at camping and pick-nick places.

Terrestrial digital television networks will also provide a competitor for cable distribution systems.

One of the conditions for success is that DVB-T services can be received with simple antennas. This is one of the main features of DVB-T. By proper network design portable reception can be achieved in most of the urban areas.

D3.5.8.3 Marketing Research

To investigate the interest of the public in portable reception of digital television a telephone survey was held amongst 500 people. The respondents were told that in some years digital television sets equipped with rod-antennas will be available to the public.

The results of the survey are as follows. About 50 % of the respondents have an interest in digital television, for 12 % the interest is depending on the price. About one third is not interested and 4% has no opinion.

Compared to the price of a current television set, about 50% of the respondents with an interest in DVB-T is prepared to pay a premium of up to DFL 500 and about 17% is prepared to pay up to DFL 700 more for a digital television set.

The aspects that could be of importance in the decision to buy a digital television set are:

- number of services that can be received (73%)
- reception without cable connection (82%)
- price (82%)

The first results of a marketing research on digital terrestrial television support the views of Nozema that portable reception of DVB-T is very important, the price of DVB-T (transmission and receiver) should be competitive to other delivery systems and a sufficient number of programmes should be transmitted.

D3.5.8.4 Test transmissions

From 1 December 1997 to 1 December 1998 a DVB-T experiment is going on. The idea is to do technical experiments on DVB-T. For this project two transmitter sites will be used in

Lopik and Hilversum. Also a pilot project for market research is in preparation for the area around Utrecht. Most probably this will start in 1999. Nozema is involved in both projects.

D3.5.8.5 Regulatory situation

Governmental investigations are underway in order to establish a facilitating, regulatory framework for the introduction of DVB-T in The Netherlands. It is expected to become effective mid 1998.

The Netherlands Television Platform has a separate working group for the implementation of digital terrestrial television.

D3.5.9 Denmark

In Denmark there are two national public service broadcasters, each of them transmitting one programme. One of the programmes is split into regional programmes part of the day. Apart from the national broadcasters there is a number of small local broadcasters.

Approximately 50% of the households receive the terrestrial transmissions directly. A large part of them also receive terrestrial transmissions from Germany and Sweden. The other 50% of the households are cabled.

There are now plans to increase the number of national television programmes. Additionally there are intentions to broadcast in 16:9 format, and plans for the transition on the production side are in progress.

Frequencies for a possible third analogue network are, for the time being, available throughout most of the country.

At present there is a public debate on the future of broadcasting in general. This debate is initiated by a questionnaire issued by the Ministry of Cultural Affairs. It is not stated directly, that the available frequencies shall be used for a digital network, but the text indicates, that this should be the choice.

It is expected that the existing national programmes would be simulcast as digital programmes. Two new programmes, exclusively transmitted in digital, in addition to some of the existing programmes transmitted in 16:9 format, would be a strong incentive for consumers to purchase digital STBs. The local programmes will probably not be broadcast digitally from the early stages, both for financial reasons and lack of available frequencies.

D3.5.10 Belgium

Belgium is a federal state where cultural affairs, including broadcasting and the management of broadcasting frequencies, is in the hands the community government (based upon the language).

There are three communities in Belgium:

- the **Flemish Community**, based in the north of the country with Dutch as the official language;
- the **French Community**, in the south of the country with French as the official language;
- the **German Community**, in a small region close to the German border, with German as the official language.

Belgium has a very high cable penetration comprising more than 90% of viewers. The cable channels offer up to 25 programmes including those from other countries. Consequently both viewers with an individual antenna and/or satellite dish form a much lower proportion of the total number of television homes compared with other countries.

In the **Flemish Community** the two programmes of the public broadcasting company BRTN are radiated terrestrially and are received by both the cable head-end and by individual viewers. On the contrary, the three programmes of the commercial broadcasters, the two programmes of Filmnet and the 11 regional television stations are only distributed by cable.

It is expected that the public broadcaster will probably take the initiative to introduce digital terrestrial service in 1998 or 1999, this being driven by the requirements for portable reception.

In Flanders, each television-station has a planned (under the Stockholm Agreement) but unused frequency available. These would allow the introduction of DVB-T via a conventional network topology or mini SFNs.

In the **French Community**, the two programmes of RTBF and the pay-television programme of Canal Plus Belgium are radiated terrestrially and are received by both the cable head-end and by individual viewers. One programme of the commercial broadcaster RTL-TVI is also transmitted terrestrially, though from a transmitter in Luxembourg, the second one is radiated in encrypted form via satellite, both are distributed via cable. The local television stations are distributed via cable only. Here the possibilities of setting up a new digital network seem quite small. As a matter of fact, the Stockholm Conference allowed the French Community three groups of frequencies for each broadcasting site. Since three programmes are currently being broadcast there are now only a few frequencies available for additional services.

Summarising, the lack of frequencies in the **French Community** is a significant factor against the possibilities for introduction of digital television within the Community.