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

ECC REPORT 161

ADDITIONAL TECHNICAL CONSIDERATIONS RELATING TO THE L-BAND AND THE MA02REVCO07

Luxembourg, February 2011

0 EXECUTIVE SUMMARY

The Maastricht, 2002, Special Arrangement, as revised in Constanța, 2007 (MA02revCO07) governs the frequency band 1452 - 1479.5 MHz. It has been adopted by CEPT multilateral meeting on 04 July 2007 and has come into force on 01 September 2007. The Arrangement contains technical characteristics for T-DAB and multimedia systems to operate in the L-band.

Since the adoption of MA02revCO07, a number of systems have been identified as potential user of the L-band for which the characteristics may slightly differ from those given in the Arrangement. Therefore, this ECC Report provides additional technical characteristics relating to:

- Hand-held reception of TV, audio, datacast and multimedia services
- Programme Making and Special Events (PMSE).

It also indicates that new systems are under development such as Next Generation Handheld (NGH) which may need to be further considered at a later stage.

In addition, it provides additional guidance on the maximum allowable PFD levels of the satellite networks to protect T-DAB systems for coordination with S-DAB systems in the sub-band 1467 MHz to 1479.5 MHz.

Finally, the report provides guidance to administrations in the application of the envelop concept in the framework of the MA02revCO07 Arrangement.

Table of contents

LIST OF ABBREVIATIONS

Abbreviation	**Explanation**
AGL	Above Ground Level
BR IFICs	BR International Frequency Information Circular
CCI	Co-channel interference
CGC	Complementary Ground Component
CEPT	European Conference of Postal and Telecommunications Administrations
DVB-H	Digital Video Broadcasting - Handheld,
DVB-SH	Digital Video Broadcasting –SH (Satellite services to Handheld devices)
DVB-T	Digital Video Broadcasting – Terrestrial
FFT	Fast Fourier Transform
FLO™	Forward Link Only
GF	Galois Field
ITU-R	International Telecommunication Union Radiocommunication Sector
LoS	Line of sight
MA02revCO07	Maastricht, 2002, Special Arrangement, as revised in Constanța, 2007
MCM	Multi Carrier Modulation
MFER	MPE-FEC Frame Error Rate
MMN	Man-Made Noise
MPE-FEC	MultiProtocol Encapsulation Forward Error Correction
MRC	Maximum Ratio Combining
NGH	Next Generation Handheld
PCCC	Parallel Concatenated Convolutional Code
PCF	Propagation Correction Factor
PDF	Polarisation Discrimination Factor
PEDB	Pedestrian B
PER	Packet Error Rate
PFD	Power Flux Density
PMSE	Programme Making and Special Events
PDA	Personal Digital Assistant
PWMS	Professional Wireless Microphone Systems
OFDM	Orthogonal Frequency Division Multiplexing
QAM	Quadrature Amplitude Modulation
QEF	Quasi Error free
RRC-06	ITU Radiocommunications Regional Conference 2006
SFN	Single Frequency Network
T-DAB	Terrestrial Digital Audio Broadcasting
T-DMB	Terrestrial Digital Multimedia Broadcasting

Additional Considerations relating to the L-band and the MA02revCO07

1 INTRODUCTION

The Maastricht, 2002, Special Arrangement, as revised in Constanța, 2007 (MA02revCO07) [1] governs the frequency band 1452 - 1479.5 MHz. It has been adopted by CEPT multilateral meeting on 04 July 2007 and has come into force on 01 September 2007. The Arrangement contains technical characteristics for T-DAB and multimedia systems to operate in the L-band.

Since the adoption of MA02revCO07, a number of systems have been identified as potential user of the L-band for which the characteristics may slightly differ from those given in the Arrangement. Therefore, this ECC Report provides additional technical characteristics relating to:

- Hand-held reception of TV, audio, datacast[1] and multimedia services
- Programme Making and Special Events (PMSE).

In addition, some administrations indicated that guidance in the frequency co-ordinations process with satellite networks published in ITU-R BR IFICs in the sub-band 1467 MHz to 1479.5 MHz (see Resolution 528 Rev.WRC-03 [2] and ECC/DEC/(03)02 [3]) to protect T-DAB systems were needed. Therefore, this ECC Report provides additional guidance on the maximum allowable PFD levels of the satellite networks to protect T-DAB systems.

Finally the report provides guidance to administrations in the application of the envelop concept in the framework of the MA02revCO07 Arrangement.

2 HAND-HELD RECEPTION

Hand-held reception of TV, audio, datacast and multimedia services is a fairly new broadcasting application, in general. Hand-held receivers are defined as: *"Hand-held devices ('handhelds' for short) are personal wireless devices, normally of a very small size, similar to that of a mobile phone or PDA (Personal Digital Assistant), with the capability of receiving audiovisual streams and data services, often with facilities for bidirectional voice/data communication."* [4]

Two systems for hand-held reception have been derived from the digital terrestrial broadcasting systems T-DAB and DVB-T. These are T-DMB and DVB-H, respectively. Forward Link Only (FLO™) Air Interface has been designed explicitly for mobile TV. On the other hand DVB-SH system has been developed for reception of multimedia content (audio, video and data) under possible dual coverage: satellite and terrestrial, and which is derived from DVB-H with some specific enhancements and adaptations. DVB-SH can provide services to handheld and mobile terminals.

The hand-held reception requirements are different from those of fixed reception (using a roof top antenna) or portable and mobile reception, in terms of its use and with respect to planning. This means that higher field strengths are needed in order to compensate the low antenna gain, lower receiving antenna height and building penetration loss, real mobility, etc, associated with the use of hand-held devices. These restricting aspects can in part be compensated by improvements of the link layer. For example, in the case of DVB-H, forward error correction leads to an improvement in C/N performance, Doppler performance in mobile channels and an improved tolerance to impulse interference[2]; in addition, it is possible to employ the 4k mode for trading off mobility and SFN cell size.

DAB presently provides two variants for transmitting multimedia to mobile and hand-held terminals: DMB and DAB-IP. It can be assumed that the planning criteria for such DAB based systems are very similar. For this reason only T-DMB, as defined by ETSI TS 102 427 [5] and TS 102 428 [6], is covered in the present document.

Recent frequency planning for digital terrestrial broadcasting systems, as given in the RRC-06 frequency plan, is based on the characteristics of T-DAB and DVB-T in band III, and DVB-T in bands IV/V. Except for mobile reception, hand-held reception has not been taken into account in the RRC-06 planning process.

The harmonised broadcasting frequency bands are 174-230 MHz (band III) and 470-862 MHz (bands IV and V). There are no specific frequency (sub-) bands decided for mobile television planning. T-DMB using T-DAB channel raster is intended for implementation in band III or in the 1.5 GHz band. DVB-H is primarily targeting the bands IV and V, but band III and the 1.5 GHz band are also under consideration. FLO can be deployed in band III, IV, V or the 1.5 GHz band. DVB-SH can be deployed in all frequency bands below 3 GHz, which allow deployment in L band.

---

[1] datacast: broadcasting file delivery service

[2] MPE-FEC (Forward error correction for multi-protocol encapsulated data) is not mandatory for DVB-H

This document provides guidance for network planning aspects for hand-held reception using DVB-H, DVB-SH, FLO and T-DMB in the 1.5 GHz band. It provides in particular the planning parameters of these three systems.

2.1 Reception modes

2.1.1 Portable reception

In the context of this document, portable reception is defined as the reception at rest (stationary reception) or at very low speed (walking speed). Portable reception will, in practice, take place under a great variety of conditions (outdoor, indoor, ground floor and upper floors). In addition, the hand-held receiver will probably be moved (at walking speed) while being viewed. In this document, portable reception is classified into two classes:

Class A: hand-held portable outdoor reception
with external (for example telescopic or wired headsets) or integrated antenna
at no less than 1.5 m above ground level, at very low speed or at rest

Class B: hand-held portable indoor reception
with external (for example telescopic or wired headsets) or integrated antenna
at no less than 1.5 m above ground level, at very low speed or at rest
on the ground floor in a room with a window in an external wall.

It is assumed that the portable receiver is not moved during reception and large objects near the receiver are also not moved. This does not mean that the transmission channel is static, rather a slowly time-varying channel is assumed. It is also assumed that extreme cases, such as reception in completely shielded rooms, are disregarded.

For the hand-held reception mode, it is often possible to improve reception by moving the receiver position and/or by having an antenna with higher efficiency.

It is to be expected that there will be significant variation of reception conditions for indoor portable reception, also depending on the floor-level at which reception is required. There will also be considerable variation of building penetration loss from one building to another and considerable variation from one part of a room to another. Also, hand-held receivers could suffer from body-absorption/reflection loss in certain circumstances, e.g. file-downloading applications when the receiver is in a pocket. It is to be expected that "portable coverage" will be mainly aimed at urban and suburban areas.

2.1.2 Mobile reception

In the context of this document, mobile reception is comprised of two classes:

Class C: hand-held reception inside a moving vehicle (car, bus etc.)
with the receiver connected to the external antenna of the vehicle.
at no less than 1.5 m above ground level, at higher speed.
Class D: hand-held reception inside a moving vehicle (e.g. car, bus, etc.)
without connection of the receiver to the external antenna of the vehicle.
with external (for example telescopic or wired headsets) or integrated antenna.
at no less than 1.5 m above ground level, at higher speed.

It should be noted that body-absorption/reflection losses could also be of importance in Class D under certain circumstances, for example when the terminal is in a pocket and file downloading is underway. However, the present document does not consider this situation.

It is to be expected that there will be significant variation of reception conditions for mobile reception, depending on the environment of the receiver. There might also be considerable variation of entry loss caused by the varying construction of cars and vehicles.

In both cases, it is assumed that the mobile receiver and/or large objects near the receiver may move during the reception. It is also assumed that extreme cases, such as reception in completely shielded vehicles, are disregarded.

2.2 Systems aspects

2.2.1 DVB-H

2.2.1.1 Transmission Modes

In addition to the native DVB-T 2k and 8k FFT[3] sizes, DVB-H has an additional 4k FFT size mode. As the C/N performance is FFT size independent, the new 4k size will offer the same performance as the other two modes in Gaussian, Rice and Rayleigh channels.

The current DVB-T standard can provide satisfactory mobile performance with 2k modes, but with 8k modes the performance is not always satisfactory. On the network planning side, the short guard interval associated with the 2k mode effectively prevents its usage in the SFN type of planning, where rather large geographical areas are covered with one frequency. For these reasons, a compromise mode lying between the 2k mode and the 8k mode would allow acceptable mobile performance on the receiver side whilst allowing more flexible network architectures. This was the reason for introducing the new 4k mode.

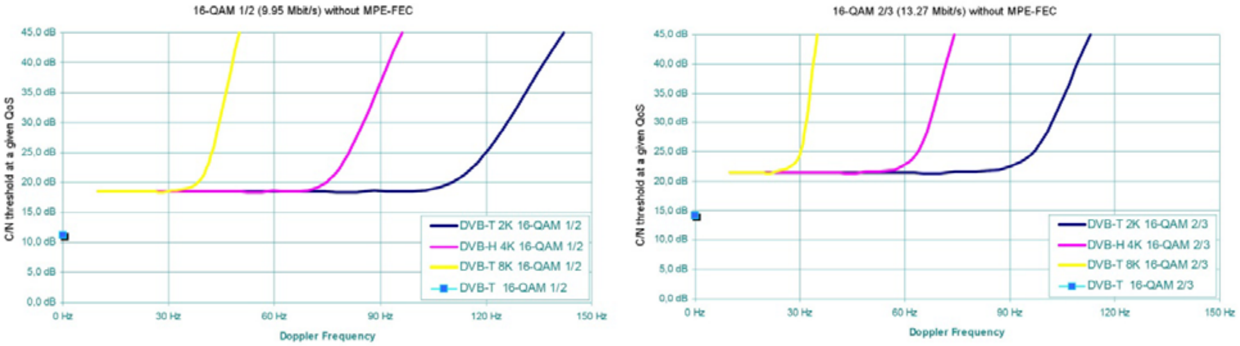


Figure 1: DVB-H 4k versus 2k and 8k

Note: The square mark (corresponding to a Doppler Frequency = 0 Hz) indicates the C/N values for a specific static transmission channel, taken as a reference in [5]. This value is not relevant for planning.

Note: As a rule of thumb, if the transmission channel is at 1500 MHz, a rough approximation of the corresponding speed in km/h may be obtained by multiplying the Doppler frequency, f_d [4] by a factor of 2/3.

The 4k mode will provide roughly 2 times better Doppler performance than the 8k mode. By using this rule and performing linear interpolation between the known 2k and 8k modes performance figures of the reference receiver developed in the Motivate project [7], Figure 1 of the predicted 4k mobile performance can be produced. It shows, for DVB-T-16-QAM-1/2 and -2/3 as examples, how the Doppler performance varies with the FFT size.

Theoretically, in the design of SFNs the acceptable inter-transmitter distance is proportional to the maximum echo delay acceptable by the transmission system, which depends on the guard interval value. For the 4k mode, this distance is 2 times larger than for the 2k mode and half that of the 8k mode.

Table 1 shows the guard interval lengths in time and how the guard interval values and therefore the size of SFN cells for the 4k mode fall between those of the 2k and 8k modes.

---

[3] FFT: fast Fourier Transform. The 2k, 4k and 8k variants refer to the number of OFDM subcarriers in the digital signal.

[4] The relation between Speed v and Doppler Frequency f_d is: $v = c\frac{f_d}{F_c}$ where c is the speed of light and F_c is the channel frequency (speeds in m/s and frequencies in Hz). This gives the following relation with more practical units: $v_{[km/h]} = 1080\frac{f_{d[Hz]}}{F_{c[MHz]}}$. It should be noted that this speed corresponds to the worst case of multipath reception in a Rayleigh channel. It always occurs when there is no dominant echo present or in the case of SFN reception.

	2k	4k	8k
1/4	56 µs	112 µs	224 µs
1/8	28 µs	56 µs	112 µs
1/16	14 µs	28 µs	56 µs
1/32	7 µs	14 µs	28 µs

Table 1: DVB-H guard interval lengths for all modes (8 MHz bandwidth)

The remaining impact of the new 4k mode on network planning is minimal, as the 4k mode has similar spectrum mask characteristics and protection ratios as current DVB-T.

The 4k mode used in conjunction with the in-depth interleaver (8k interleaver with 4k and 2k symbols) may have an impact on the impulse interference tolerance as in this case the bits of one symbol are spread over two 4k symbols providing a better time diversity.

2.2.1.2 DVB-H minimum C/N requirements

The following information for DVB-H is based on early simulations and measurements [8]. It should be considered as preliminary and may change, as more comprehensive information becomes available.

2.2.1.2.1 DVB-H degradation criterion

In DVB-H a suitable degradation criterion is the MPE-FEC frame error rate (MFER), referring to the error rate of the time sliced burst protected with the MPE-FEC (MultiProtocol Encapsulation Forward Error Correction). As an erroneous frame will destroy the service reception for the whole interval between the bursts, it is appropriate to fix the degradation point to the frequency of lost frames. Obviously the used burst and IP-parameters will affect the final service quality obtained with certain fixed MFER, but experience has shown that the behaviour is very steep and a very small change in C/N will result in a large change in MFER. MFER is the ratio of the number of erroneous frames (i.e. not recoverable) and total number of received frames.

$$\text{MFER}[\%] = \frac{\text{Number of Erroneous Frames x 100}}{\text{Total Number of Frames}}$$

Table 2: DVB-H MFER

It has been agreed that 5% MFER is used to mark the degradation point of the DVB-H service. Note that the service reception quality at the 5% MFER degradation point may not meet the QoS requirement in all cases. The criterion is nevertheless suitable for measurements, and a small 0.5 dB to 1 dB carrier power increase will improve the reception quality to less than 1% MFER.

2.2.1.2.2 General

In the ETSI Technical Report [7], the DVB-H C/N-values for Gaussian and static Rayleigh channels are based on theoretical simulated DVB-T values where the measured effect of the MPE-FEC and different degradation point (QEF (Quasi Error free) vs. MFER 5%) has been added. No implementation loss has been included. Therefore, these values are artificial in the context of the present document and may not be used for planning purposes. However, for completeness these figures are given in Table 3.

For the time-variant mobile transmission channel, the ETSI [7] distinguishes between a “typical” and a “possible” reference receiver. They differ by 1 dB in their C/N values. In the present document the “typical” reference receiver is taken as representative.

The performance is given for the following parameters:

DVB-H burst bit rate 4 Mbit/s
MPE-FEC code rate 3/4
Number of rows in MPE-FEC 1024[5]
DVB-T/H bandwidth 7.61 MHz

These parameters will result in approximately 0.5s duration for the time slicing bursts: Burst Duration = Burst size / (Burst bit rate*0.96). The degradation criterion has been set to 5% MFER.

2.2.1.2.3 C/N Performance in a Gaussian channel and in a static Rayleigh channel

The receiver should have the theoretical performance given in Table 3 when noise (N) is applied together with the wanted carrier (C) in a signal bandwidth of 7.61 MHz. The values are calculated using the theoretical C/N figures given in EN 300 744 [9] and the measured effect of the MPE-FEC. The difference between DVB-T QEF C/N and MFER 5% C/N is assumed to be 1.0 dB in a Gaussian Channel and 1.5 dB in a static Rayleigh channel. An ideal transmitter and receiver are assumed. For a practical receiver, an implementation margin of 2.5 dB should be added to these figures.
Figures for some modulation/code rates are not available for the time being.

Modulation	Code rate	C/N (dB) Gaussian MPE-FEC CR = 3/4	C/N (dB) Static Rayleigh MPE-FEC CR = 3/4
QPSK	1/2	2.5	3.9
QPSK	2/3	4.3	6.9
QPSK	3/4	n.a.	n.a.
16--QAM	1/2	8.3	9.7
16--QAM	2/3	10.4	12.7
16--QAM	3/4	n.a.	n.a.
64--QAM	1/2	n.a.	n.a.
64--QAM	2/3	n.a.	n.a.
64--QAM	3/4	n.a.	n.a.

Table 3: C/N (dB) in a Gaussian and in a static Rayleigh channel

2.2.1.2.4 C/N performance in Portable and Mobile Channels

The reference receiver model describes the DVB-H receiver performance in an idealized way using two figures, C/N_{min} and F_{d3dB}. C/N_{min} gives the minimum required C/N for MFER 5%. The C/N curve is flat up to high Doppler frequencies, but is not applicable to very low Doppler frequencies $F_d < 1$/burst duration.

F_{d3dB} gives the Doppler frequency where the C/N requirement has raised 3 dB from the C/N_{min} value. Note that F_{d3dB} is almost equal the F_{dmax}. The schematic behaviour of the reference receiver is shown in Figure 2. The C/N values are given in Table 4:. The implementation margin is already included in these figures.

---

[5] The burst size in case MPE-FEC is set directly by the number of rows. With MPE-FEC code rate ¾, 1024 Rows give a burst size of 2 048 kbit = 2 Mbit

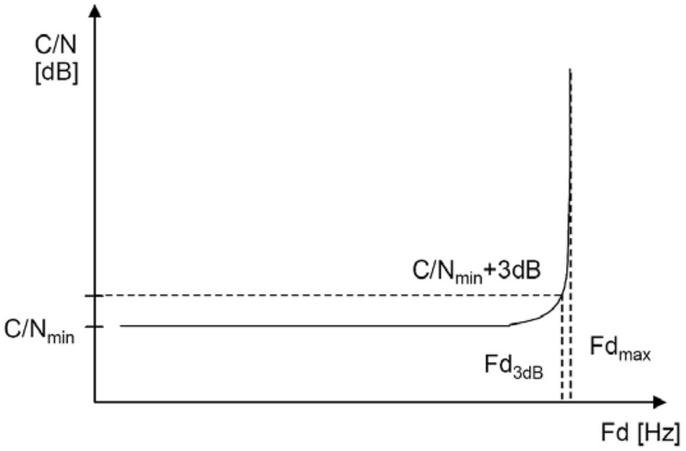


Figure 2: DVB-H reference receiver C/N behaviour in a Mobile Channel

Using the Typical Urban (TU6) channel model for DVB-H would generally increase the required C/N at lower speed (lower Doppler) corresponding to the portable reception case, compared to the mobile reception case. The reason for this is that the MPE-FEC (time interleaving) is not fully effective due to the low Doppler frequency (at pedestrian speed).

However, measurements within the Wing TV project show that the portable reception channel is less demanding than the TU6 channel model at low Doppler frequencies. Using the portable reception channel model might in fact result in lower C/N values for portable reception than for mobile reception.

Foreseen measurements within the B21C program, based on the portable channel profiles, might therefore call for a later revision of the C/N values currently proposed for portable reception. However since this is still an ongoing process, it has been decided to use the same C/N values for all four reception classes (A-D) for the time being.

For planning of **portable reception** (Class A and B) and **mobile reception** (Class C and D) it is proposed to use the C/N values in Table 4. The values are taken from ETSI implementation guideline TS 102 377 version 1.2.2 [8] for the “typical” reference receiver for mobile reception.

Modulation	**Code rate**	**C/N (dB)**	
		Portable (Class A and B)	**Mobile (Class C and D)**
QPSK	½	9.5	9.5
QPSK	2/3	12.5	12.5
16--QAM	½	15.5	15.5
16--QAM	2/3	18.5	18.5

Table 4: C/N for planning purposes, portable (A, B) and mobile (C, D) reception

2.2.1.2.5 Noise figure

The receiver performance is defined according to the reference model shown in Figure 3.

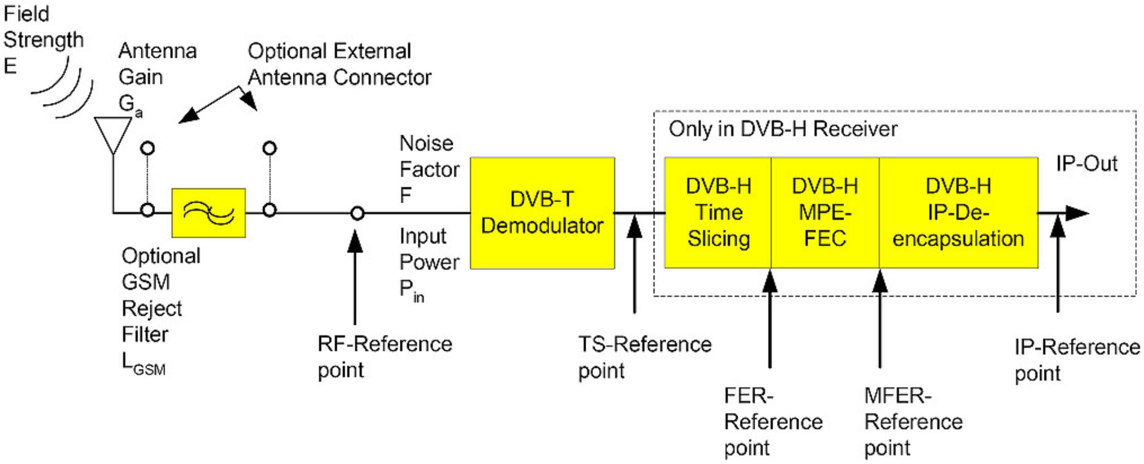


Figure 3: DVB-H receiver reference model (Extracted from ETSI TR 102 377 [8])

All the receiver performance figures are specified at the RF-reference point, which is the input of the receiver. The noise figure for planning purposes at 1.5 GHz is 6 dB.

2.2.2 DVB-SH terrestrial component [10],[11], [12]

2.2.2.1 Introduction

DVB-SH system has been initially designed to provide an efficient and flexible mean of carrying broadcast services over an hybrid satellite and terrestrial infrastructure operating at frequencies below 3 GHz to a variety of portable, mobile and fixed terminals having compact antennas with very limited or no directivity. Target terminals include handheld defined as light-weight and battery-powered apparatus (e.g. PDAs, mobile phones), vehicle-mounted, nomadic (e.g. laptops, palmtops, etc.) and stationary terminals.

The broadcast services encompass streaming services such as television, radio programs as well as download services enabling for example Personal Video Recorder services.

The DVB-SH Complementary Ground Component (CGC) can be implemented as a terrestrial standard (with or without satellite component) and can be implemented in the L-band (see ETSI references below).

2.2.2.2 Transmission Modes

Multi Carrier is based on the DVB-T physical layer defined in ETSI EN 300 744: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television". Three FFT modes are defined by DVB-T: 2k, 4k and 8k.

The standard allows the following bandwidth: 1.7 MHz, 5 MHz, 6 MHz, 7 MHz and 8 MHz. This bandwidth is most of the To cope with reduced signal bandwidth at a channelisation of 1.74 MHz in L-band, an additional 1k mode is defined. It is a strict downscaling of the existing DVB-T modes

The following tables give a synthesis of the different modes used in DVB-SH.

	5 MHz				6 MHz				7 MHz				8 MHz			
FFT	1k	2k	4k	8k	1k	2k	4k	8k	1k	2k	4k	8k	1k	2k	4k	8k
1/4	44.8	89.6	179.2	358.4	37.33	74.66	149.33	298.66	32	64	128	256	28	56	112	224
1/8	22.4	44.8	89.6	179.2	18.66	37.33	74.66	149.33	16	32	64	128	14	28	56	112
1/16	11.2	22.4	44.8	89.6	9.33	18.66	37.33	74.66	8	16	32	64	7	14	28	56
1/32	5.6	11.2	22.4	44.8	4.66	9.33	18.66	37.33	4	8	16	32	3.5	7	14	28

Table 5: DVB-SH guard interval lengths for all modes

	1k
1/4	140
1/8	70
1/16	35
1/32	17.5

Table 6: DVB-SH guard interval lengths for all modes (1.7 MHz bandwidth)

For 1.7 MHz, only 1k mode is considered.

2.2.2.3 DVB-SH Minimum C/N requirements

The different information provided in the different following tables are based on different measurements using real chipset, and TU6 channel emulator, as well as some simulation results.

The DVB-SH degradation criterion for terrestrial channel measurements is the FER (Frame Error Rate) defined as follows FER: Frame Error Rate, corresponding to the ratio of erroneous Frame including at least one erroneous bit to the total number of Frames in the observation period. A Frame is an MPE Frame, without any IFEC or MPE-FEC error correction being applied.

FER(x): Frame Error Rate of x %. The retained threshold is 5 %; The minimum C/N is defined as the minimum C/N required to obtain the FER of 5 %. It is also called the C/N @ FER 5%.

2.2.2.3.1 General

The different measurements are presented on the Implementation Guidelines. Different channels have been considered:

- Gaussian Channel (AWGN)
- Static Rayleigh channel
- Portable and mobile channels

The minimum C/N requirements have been measured for all the different bandwidth, and there is no difference between the results when comparing the same modulation coding scheme. So the presented results are valid for all bandwidths. In all the different configurations, a short physical interleaving scheme has been implemented

2.2.2.3.2 C/N performances in. a Gaussian Channel and static Rayleigh channel

The results are based on laboratory measurements

Modulation	Code rate	C/N (dB) Gaussian	C/N (dB) Static Rayleigh
QPSK	1/5	-3.6	-2.3
QPSK	2/9	-2.8	-1.8
QPSK	1/4	-2.1	-1
QPSK	2/7	-1.5	-0.3
QPSK	1/3	-0.7	0.8
QPSK	2/5	0.5	2.5

QPSK	1/2	1.9	4
QPSK	2/3	4.6	8.3
16-QAM	1/5	1.5	2.8
16-QAM	2/9	2.5	3.5
16-QAM	1/4	2.9	4.3
16-QAM	2/7	-1.5	5
16-QAM	1/3	4.6	6.1
16-QAM	2/5	6.3	8
16-QAM	1/2	8.1	10.3
16-QAM	2/3	11.8	15.2

Table 7: C/N (dB) in a Gaussian channel and in a static Rayleigh channel

2.2.2.3.3 C/N performance in Portable and Mobile Channels

Different measurements have been made with all the different modulation/coding cases, and at different speeds up to the maximum sustainable Doppler spread. The results in Table 7 represent an example of the variation of required C/N versus the applied maximum Doppler frequency corresponding to a certain speed, depending on the used central frequency. Different *C/N* values are represented in the following plots:

a) Required C/N for portable channels at low speed on the left of the curve

b) F_{dmax}, corresponding to the vertical part of the curves, and maximum Doppler frequency;

c) Required *C/N* at $F_{dmax}/2$, corresponding to half of the maximum speed. One can notice that the required C/N value is quasi constant from 100 Hz to $F_{dmax}/2$;

d) Required *C/N* at $F_{dmax}/2$ + 3 dB corresponding at the previous C/N plus 3 dB and with a corresponding speed.

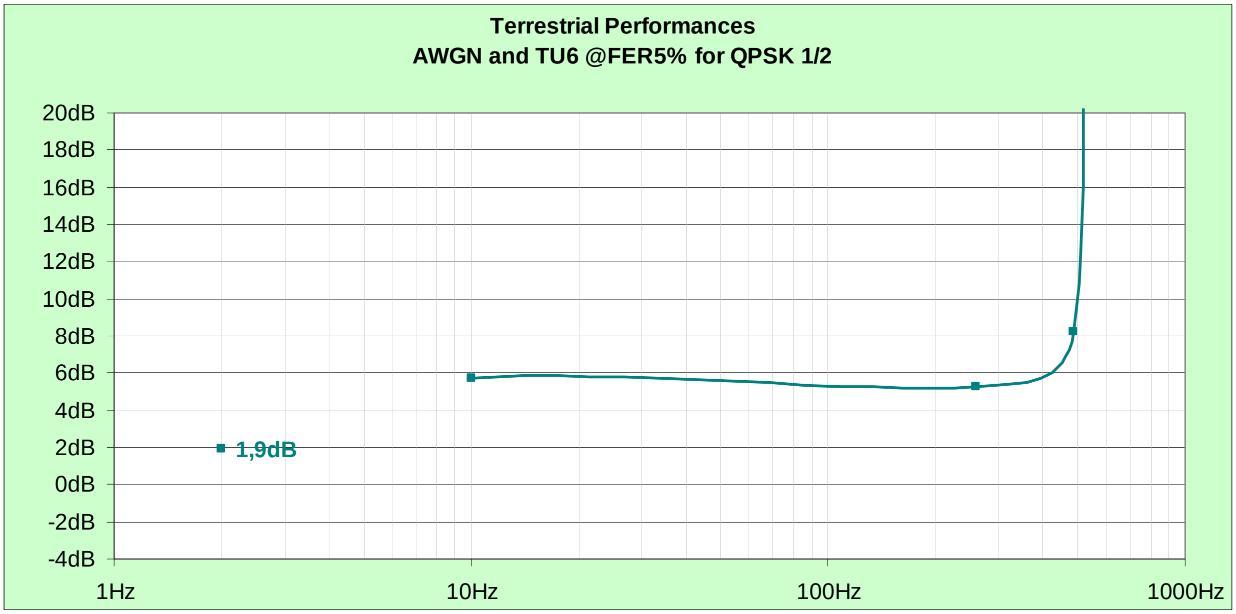


Figure 4: Impact of Speed on the required C/N

Note: in fact Doppler shift is represented in frequency shift, allowing for translation in any band.
Translated at 1.5 GHz

- In portable channel at low speed (around 7 km/h at 1.5 GHz) , required C/N is 5.8 dB
- The maximum Doppler speed is corresponding to 519 Hz, so 380 km/h,
- The required C/N at half maximum speed is 5.3 dB
- The speed at C/N + 3 dB is corresponding to 489 Hz, so 358 km/h

For planning of **portable reception** (Class A and B) and **mobile reception** (Class C and D) it is proposed to use the C/N values in next table. The values are taken from ETSI implementation guideline TS 102 584 version 1.2.2 [10] for possible receiver. These values are also in line with the measured values in the frame of B21C project.
The following values are valid for all frequency bands: 5, 6, 7 and 8 MHz, and for FFT mode: 2k, 4k, and 8k.

Mod	Code Rate	**C/N (dB) In Portable (Class A and B)**	**C/N (dB) In Mobile (Class C and D)**
QPSK	1/5	0.5	0.0
	2/9	0.8	0.3
	1/4	1.3	0.8
	2/7	2.0	1.3
	1/3	2.8	2.0
	2/5	4.3	3.5
	1/2	5.8	5.3
	2/3	9.5	9.3
16QAM	1/5	5.9	3.8
	2/9	6.3	4.4
	1/4	7.2	5.0
	2/7	7.8	5.9
	1/3	9.1	7.2
	2/5	10.9	9.1
	1/2	12.8	11.3
	2/3	17.5	16.3

Table 8: DVB-SH C/N for planning purposes, portable (A, B) and mobile (C, D) reception in 5, 6, 7 and 8 MHz

Following table gives some examples of measured C/N minimum requirements at 1.7 MHz.

Mod	Code Rate	**C/N (dB) In Portable (Class A and B)**	**C/N (dB) In Mobile (Class C and D)**
QPSK	1/3	3.5	2.3
	1/2	6.4	5.3
16QAM	1/3	9.1	8.3
	1/2	12.8	11.9

Table 9: DVB-SH C/N for planning purposes, portable (A, B) and mobile (C, D) reception at 1.7 MHz

2.2.2.4 Minimum signal input levels for planning and Noise figures

2.2.2.4.1 Noise floor for vehicular receiver

The receiver should have a noise figure better than 2 dB at the reference point, at sensitivity level of each DVB-SH mode. This corresponds to the following noise floor power levels:

- Pn = -103.2 dBm [for 8 MHz OFDM channels, BW = 7.61 MHz];
- Pn = -103.7 dBm [for 7 MHz OFDM channels, BW = 6.66 MHz];
- Pn = -104.4 dBm [for 6 MHz OFDM channels, BW = 5.71 MHz];
- Pn = -105.2 dBm [for 5 MHz OFDM channels, BW = 4.76 MHz];
- Pn = -110.2 dBm [for 1.7 MHz OFDM channels, BW = 1.52 MHz].

2.2.2.4.2 Noise floor for handheld receiver

The receiver should have a noise figure better than 4.5 dB at the reference point, at sensitivity level of each DVB-SH mode. This corresponds to the following noise floor power levels:

- Pn = -100.7 dBm [for 8 MHz OFDM channels, BW = 7.61 MHz];
- Pn = -101.2 dBm [for 7 MHz OFDM channels, BW = 6.66 MHz];
- Pn = -101.9 dBm [for 6 MHz OFDM channels, BW = 5.71 MHz];
- Pn = -102.7 dBm [for 5 MHz OFDM channels, BW = 4.76 MHz];
- Pn = -107.7 dBm [for 1.7 MHz channels, BW = 1.52 MHz].

2.2.2.4.3 Minimum input levels: Sensitivity for vehicular receiver

At RF-reference point, the receiver should observe reference criterion for a wanted signal level greater than Pn.

- Pn = -103.2 dBm + C/N [for OFDM 8 MHz];
- Pn = -103.7 dBm + C/N [for OFDM 7 MHz];
- Pn = -104.4 dBm + C/N [for OFDM 6 MHz];
- Pn = -105.2 dBm + C/N [for OFDM 5 MHz];
- Pn = -110.2 dBm + C/N [for OFDM 1.7 MHz].

where C/N is specified above and is depending on the channel conditions and DVB-SH modes.

2.2.2.4.4 Minimum input levels: Sensitivity for handheld receiver

At RF-reference point, the receiver should observe reference criterion for a wanted signal level greater than Pn.

- Pn = -100.7 dBm + C/N [for OFDM 8 MHz];
- Pn = -101.2 dBm + C/N [for OFDM 7 MHz];
- Pn = -101.9 dBm + C/N [for OFDM 6 MHz];
- Pn = -102.7 dBm + C/N [for OFDM 5 MHz];
- Pn = -107.7 dBm + C/N [for OFDM 1.7 MHz].

where C/N is specified above and is depending on the channel conditions and DVB-SH modes.

2.2.3 FLO

2.2.3.1 Transmission Modes (from ETSI TS 102 589 [13])

The Forward Link Only Physical layer provides the channel structure, frequency, power output, modulation and encoding specification for Forward Link Only radio networks. The Forward Link Only Physical layer uses Orthogonal Frequency Division Multiplexing (OFDM) as the modulation technique. In addition, it incorporates forward error correction techniques involving the concatenation of a parallel concatenated convolutional code (PCCC), i.e. turbo code and a Reed-Solomon erasure correcting code.

In the Forward Link Only Physical layer, transmission and reception are based on using 4 096 (4 K) subcarriers. The QAM modulation symbols are chosen from a QPSK or 16-QAM alphabet. The Forward Link Only Physical layer transmission parameters are outlined in Table 10.

	Parameters	**Values**
1	Channel bandwidths (see note 1)	a. 5 MHz b. 6 MHz c. 7 MHz d. 8 MHz
2	Used bandwidth	a. *4.52 MHz (see note 2)* b. *5.42 MHz* c. *6.32 MHz* d. *7.23 MHz*
3	Number of subcarriers or segments	4 000 (out of 4 096) - 4 K
4	Subcarrier spacing	a. *1.1292 kHz* b. *1.355 kHz* c. *1.5808 kHz* d. *1.8066 kHz*
5	Active Symbol or segment duration	a. *885.6216 μs* b. *738.018 μs* c. *632.587 μs* d. *553.5135 μs*
6	Guard interval or Cyclic Prefix duration - 1/8th of useful OFDM symbol	a. *110.7027 μs* b. *92.2523 μs* c. *79.0734 μs* d. *69.1892 μs* (see note 3)
7	Transmission unit (frame) duration - Superframe - exactly 1 second in duration. Values in OFDM symbols - each superframe consists of 4 frames of equal duration (approx 1/4 second in duration)	a. 1 000 b. 1 200 c. 1 400 d. 1 600
8	Time/frequency synchronization	Time-division multiplex (TDM) and frequency division multiplex (FDM) pilot channels
9	Modulation methods	QPSK, 16-QAM, layered modulation
10	Coding and error correction methods	Inner code: Parallel concatenated convolutional code (PCCC), rates 1/3, 1/2 and 2/3 for data and 1/5 for overhead information Outer code: RS with rates 1/2, 3/4, 7/8 and 1.
11	Net data rates (see note 4)	a. *2.3 Mbps to 9.3 Mbps* b. *2.8 Mbps to 11.2 Mbps* c. *3.2 Mbps to 13 Mbps* d. *3.7 Mbps to 14.9 Mbps*

NOTE 1: All parameters that may vary depending on selected channel bandwidth are listed in the order of corresponding channel bandwidths as shown in row 1 using sub-references a, b, c and d, as applicable.
NOTE 2: Values in italics are approximate values.
NOTE 3: The placement of the pilot sub-carriers in consecutive Forward Link Only OFDM symbols enables estimation of channels with delay spread up to two times the guard interval duration.
NOTE 4: Data rates do not include the overhead due to use of RS coding.

Table 10: Forward Link Only Transmission Parameters

2.2.3.2 Minimum C/N requirements

Following data is extracted from the FLO field test public document [14].

2.2.3.2.1 FLO degradation criterion

The FLO system is used to deliver video and audio to wireless users and the resulting quality is closely linked to the fraction of packets in error at the receiver. Hence, the performance is characterized by measuring the Packet Error Rate (PER) at the receiver and the target PER (based on studies of audio/video quality) is defined to be 1%. Note that the packet error rate is measured after RS decoding at the receiver.

2.2.3.2.2 FLO modes tested and laboratory performance

The modes of the FLO air interface evaluated in this report are listed in Table 11. The capacities of 5, 6, 7, and 8 MHz RF allocations are the product of the bandwidth of operation and the bps/Hz per mode. Modes of operation are distinguished based on the turbo code rate, the modulation scheme, outer code rate, and whether the modulation is layered.

Mode	**Modulation**	**Inner Code Rate**	**Outer Code**	**Bps/Hz**	**Reference C/N PEDB 3 km/h (dB)**
1	QPSK	1/2	RS(16.12)	0.525	6.8
2	16-QAM	1/3	RS(16.12)	0.7	8.7
3	16-QAM	1/2	RS(16.12)	1.05	12.3
7	QPSK (Layered, 4:1)	1/2	RS(16.12)	1.05	9.8 (B), 14.1 (E)

Table 11: FLO modes Evaluated

The bps/Hz capacity listed in Table 11 accounts for the overhead introduced by the RS coding across the turbo packets. Specifically, the RS code is over Galois Field (GF) (256), the block length is 16, and the information lengths of 8, 12, 14, and 16 are supported (16 corresponds to no RS coding). In this case, MAC layer packets (each of size 122 octets1) are divided into blocks of 12 and RS coding is performed across the packets to generate 4 parity packets. The 16 packets together form an RS code block and are split equally across the four frames in a super frame, so that there are 4 packets in each frame. The data rate of an MLC can be varied by changing the number of code blocks.

Mode 7 corresponds to the FLO air interface supported use of layered modulation, where the data stream is divided into a base layer and an enhancement layer. Each layer is independently encoded using a packet size of 1000 bits, and the final coded bits are mapped into a 16 point constellation. Layered modulation provides a finer trade-off between coverage and data rate, since the base layer is more robust and extends the edge of coverage while the enhancement layer increases the data rate inside the coverage area.

Finally, the reference values for Carrier-to-Noise ratio (C/N) in Table 11 are derived from lab measurements on a form-factor accurate phone and a channel emulator using a modified Pedestrian B (PEDB) profile. The basic PEDB profile, recommended in [15], is modified by including an additional cluster 40 micro-seconds away and 5 dB below the main cluster, as a model for a typical two transmitter SFN. For the layered modes, references are provided for the base and enhancement layers separately.

The scenarios considered in the following are listed in Table 12.

Test environment	**Typical speeds (km/hr)**	**Location**	**Number of transmitters**	**Modes of operation**	**Bandwidth**
Pedestrian (Walk)	0 to 6	Indoor	One and two	1, 2 and 7	Single bandwidth
Suburban (Drive)	0 to 60	Outdoor	One and two	1, 2 and 7	Single bandwidth
Highways (Drive)	90 to 110	Outdoor	One and two	1, 2 and 7	Single bandwidth
Combined (Drive)	0 to 110	Outdoor	One to three	1, 2, 3 and 7	Multi-bandwidth

Table 12: FLO Test Environment Scenarios

Single bandwidth corresponds to 6 MHz operation while multi-bandwidth examines 5, 6, 7, and 8 MHz operation.

Test Environment	**C/N (dB) for 1% PER**			
	Mode 1	Mode 2	Mode 7 Base	Mode 7 Enhancement
Pedestrian (Walk)	5.5	7.2	10.1	15.1
Suburban (Drive)	6.8	8.6	9.6	14.2
Highways (Drive)	6.5	8.7	9.5	14.9
Average Field Result	6.3	8.2	9.7	14.7
Reference Value 3km/hr	6.8	8.7	9.8	14.1

Table 13: FLO Two-transmitter SFN Test Results Summary, Single bandwidth

Test Environment	C/N (dB) for 1% PER			
	Mode 1	Mode 2	Mode 7 Base	Mode 7 Enhancement
Pedestrian (Walk)	6.2	8	9.3	13.6
Suburban (Drive)	6.8	8.6	9.8	14.2
Highways (Drive)	7.3	9	9.8	14.4
Average Field Result	6.8	8.5	9.6	14.1
Reference Value 3km/hr	6.8	8.7	9.8	14.1

Table 14: FLO Single-transmitter SFN Test Results Summary, Single bandwidth

C/N Required for 1% PER						
Bandwidth	Mode 1	Mode 2	Mode 3	Mode 7B	Mode 7E	Units
5 MHz	6.2	9.0	11.8	9.3	13.6	dB
6 MHz	6.0	8.8	11.6	9.0	14.0	dB
7 MHz	6.0	8.7	12.0	9.0	14.0	dB
8 MHz	5.7	8.8	11.7	9.1	13.8	dB
Average	6.0	8.8	11.8	9.1	13.8	dB
Reference Value 3km/h	6.8	9.9	12.3	9.8	14.1	dB

Table 15: FLO Result Summary SFN, Multi-bandwidth, Combined Drives

C/N Required for 1% PER						
Bandwidth	Mode 1	Mode 2	Mode 3	Mode 7B	Mode 7E	Units
5 MHz	6.4	10.0	12.1	9.3	14.1	dB
6 MHz	6.0	9.7	12.0	9.2	14.2	dB
7 MHz	6.6	10.1	12.2	9.5	13.9	dB
8 MHz	6.1	10.0	12.2	9.3	13.9	dB
Average	6.3	9.9	12.1	9.3	14.0	dB
Reference Value 3km/h	6.8	9.9	12.3	9.8	14.1	dB

Table 16: FLO Result Summary Single Transmitter, Multi-bandwidth, Combined Drives

2.2.3.2.3 Summary of FLO C/N performance

It is recommended that the dual PEDB 3 km/hr results be utilized for network planning purposes, as low speed performance has been shown to be the limiting case for network performance over the range of speeds of practical interest.

Mode	**Modulation**	**Code rate**	**C/N (dB)**	
			Portable (Class A and B)	**Mobile (Class C and D)**
1	QPSK	1/2	6.8	6.8
2	16-QAM	1/3	8.7	8.7
3	16-QAM	1/2	12.3	12.3
7B	QPSK (Layered, 4:1)	1/2	9.8	9.8
7E	QPSK (Layered, 4:1)	1/2	14.1	14.1

Table 17: FLO C/N for planning purposes, portable (A, B) and mobile (C, D) reception

2.2.3.3 FLO Noise Figure

The value of noise figure assumed for FLO in the 1.5 GHz band is 6 dB.

2.2.4 T-DMB

2.2.4.1 Transmission Modes

The transmission modes, in terms of number of carriers, guard interval and symbol duration are identical to those of the T-DAB system.

The system provides four transmission mode options that allow for portable and mobile reception in both band III and the 1.5 GHz band. These transmission modes have been designed to cope with Doppler spread and delay spread, for mobile reception in the presence of multi-path echoes.

The transmission modes in the band 1.5 GHz are shown in Table 18 below.

System Parameter	**Transmission Mode**	
	II	**IV**
Guard interval duration	~62 µs	~123 µs
Useful symbol duration ts	250 µs	500 µs
Total symbol duration Ts	~312 µs	~623 µs
No. radiated carriers, N	384	768
Nominal maximum transmitter separation for SFN	24 km	48 km

Table 18: Characteristics of the transmission modes (T-DAB based) in the 1.5 GHz band

Mode II will be used for medium-scale SFNs in the 1.5 GHz band. Larger transmitter spacing can be accommodated by inserting artificial time delays at the transmitters and by using directive transmitting antennas. Mode IV is also used in the 1.5 GHz band and allows large transmitter spacing in SFNs. However, it is less resistant to degradation at higher vehicle speeds.

2.2.4.2 Minimum C/N requirements

Since T-DAB uses only one level of error protection (together with deep time interleaving) both in stream mode (SM) and in packet mode (PM), it needs an additional level of error protection for video or data transmission using the MPEG-2 transport stream (TS) or the Internet protocol (IP). This has been implemented in T-DAB by means of the Enhanced Stream Mode and the Enhanced Packet Mode. T-DMB also uses the Enhanced Stream Mode, which, for the same transmission parameters provides coverage for MPEG-2 TS that is about the same as for T-DAB radio services. In view of this, only C/N measurements made for T-DAB are referred to in the following text.

Measurements of the required C/N for T-DAB have been made for both mobile and portable reception using a Typical Urban (TU12) channel model. The required C/N for mobile reception was measured to be 13.5 dB [16].

For portable reception, i.e. Classes A and B, slow variation of field strength is a major problem and this requires the use of an approximately 3 dB higher minimum C/N value.

Nevertheless, as explained for DVB-H, the portable reception channel is expected to be less demanding than the Typical Urban channel model at low Doppler frequencies. For this reason, it has been decided to use the same C/N values for all reception classes (A-D) for the time being.

Based on the preceding considerations, for planning of **portable reception** (Class A and B) and **mobile reception** (Class C and D) it is proposed to use the C/N values in Table 19.

		Minimum C/N
D-QPSK 1/2	Class A, B	13.5 dB
	Class C, D	13.5 dB

Table 19: Minimum C/N requirements for T-DMB in the 1.5 GHz band

2.2.4.3 Noise Figure

The value of noise figure assumed for T-DMB in the 1.5 GHz band is 7 dB.

2.2.5 Diversity receivers

A significant reduction in terms of the required C/N ratio for portable or mobile reception is achieved when using diversity receivers, for T-DMB, FLO and DVB-H. In these receivers, output signals obtained from several antennas are linearly combined using adjustable complex weight factors (MRC, Maximum Ratio Combining), before being decoded using the standard decoding algorithm. This leads to lower minimum field strength values, which allow for the reduction of transmitter powers, or for improvement of the indoor reception for a given transmitter power.

However, the small size of the hand-held receivers does not allow implementing this technique in general. It is more suitable for reception with antennas integrated in a car.

In this document, it is assumed that the planning is made for receivers without diversity reception. However, figures of minimum median equivalent field strength required for diversity receivers could easily be derived from the calculated figures by applying a diversity gain equal to the difference between the C/N without diversity and the C/N with diversity.

2.2.6 Service planning parameters

2.2.6.1 Coverage definitions

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

Receiving location

The smallest unit is a receiving location with dimensions of about 0.5 m × 0.5 m. In the case of portable antenna reception, it is assumed that optimal receiving conditions will be found by moving the antenna or by moving the hand-held terminal up to 0.5 m in any direction.

Such a location is regarded as covered if the required carrier-to-noise and carrier-to-interference values are achieved for 99% of the time.

Small area coverage

The second level is a "small area" (typically 100 m × 100 m).

In this small area the percentage of covered location is indicated.

The coverage of a small area is classified as:

‘Good’, if at least 95% of receiving locations within the area are covered for portable reception and 99% of receiving locations within it are covered for mobile reception.

‘Acceptable’, if at least 70% of receiving locations within the area are covered for portable reception and 90% of receiving locations within it are covered for mobile reception.

Coverage area

The third level is the 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 class of coverage is achieved.

2.2.6.2 Minimum receiver signal input levels

To illustrate how the C/N ratio influences the minimum signal input level to the receiver, the latter has been calculated for representative C/N ratios. For other values simple linear interpolation can be applied.

The receiver noise figure is given in Sections 2.2.7 for DVB-H, FLO and T-DMB respectively. The noise figure is given for all the frequency bands and thus the minimum receiver input signal level is independent of the transmitter frequency. If other noise figures are used in practice, the minimum receiver input signal level will change correspondingly by the same amount.

The minimum receiver input signal levels calculated here are used in Section 2.2.6.3 to derive the minimum power flux densities and corresponding minimum median equivalent field strength values for various frequency bands.

Definitions:

B : Receiver noise bandwidth [Hz]
C/N : RF signal to noise ratio required by the system [dB]
F : Receiver noise figure [dB]
P_n : Receiver noise input power [dBW]
$P_{s\ min}$: Minimum receiver signal input power [dBW]
$U_{s\ min}$: Minimum equivalent receiver input voltage into Z_i [dBμV]
Z_i : Receiver input impedance (75 Ω)

Constants:

K : Boltzmann's Constant = $1.38\text{x}10^{-23}$ Ws/K
T_0 : Absolute temperature = 290 K

Formulas used:

P_n(in dBW) $= F + 10 \log (K\text{x}T_0\text{x}B)$
$P_{s\ min}$ (in dBW) $= P_n + C/N$
$U_{s\ min}$ (in dBμV) $= P_{s\ min} + 120 + 10 \log (Z_i)$

2.2.6.3 *Signal levels for planning*

In Section 2.2.6.2 the minimum signal levels to overcome noise are given as the minimum receiver input power and the corresponding minimum equivalent receiver input voltage. No account is taken of any propagation effects. However, it is necessary to consider these effects when considering reception in a practical environment, especially in a mobile/portable environment.

In defining coverage, 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" portable reception. For mobile reception the percentages defined were 99 and 90, respectively.

The minimum median power flux densities and equivalent field strengths are calculated for:

a) Four different conditions for portable and mobile reception:

1) Hand-held portable outdoor reception = Class A.
2) Hand-held portable indoor reception at ground floor = Class B.
3) Mobile vehicular reception = Class C.
4) Hand-held mobile reception (i.e. terminals are used within a moving vehicle) = Class D.

b) The frequency representing band 1.500 GHz

c) Representative C/N ratios:

Representative C/N values are used for these examples, as explained in Section 2.2.6.2. Results for other system variants may be obtained by applying the difference of C/N to the minimum median power flux density and the minimum median equivalent field strength, provided that the same channel bandwidth and the same frequency are used.

d) Combinations System/Channel bandwidth/Frequency band

Calculations are made for the following two combinations:
DVB-H / 5 MHz / band 1.5 GHz
FLO / 5 MHz / band 1.5 GHz

T-DMB / 1.712 MHz / band 1.5 GHz

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

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:

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

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

$\phi_{med} = \phi_{min} + P_{mmn} + C_l + L_h$ (For Classes A and C)

$\phi_{med} = \phi_{min} + P_{mmn} + C_l + L_h + L_b$ (For Class B)

$\phi_{med} = \phi_{min} + P_{mmn} + C_l + L_h + L_v$ (For Class D)

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

where:

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_h : Height loss (10 m a.g.l. - above ground level - to 1.5 m a.g.l.) [dB]
L_b : Building penetration loss [dB]
L_v : Vehicle entry 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] [$A_a = G_{iso} + 10\log_{10}(\lambda^2/4\pi)$]. G_{iso} is the antenna gain relative to an isotropic antenna.
$P_{s\,min}$: Minimum receiver input power [dBW]

For calculating the location correction factor C_l a log-normal distribution of the received signal is assumed.

$C_l = \mu \times \sigma$

where:

μ : distribution factor, being 0.52 for 70%, 1.28 for 90%, 1.64 for 95% and 2.33 for 99%;
σ : the standard deviation taken as 5.5 dB for outdoor reception. See section 2.2.6 for σ values appropriate for indoor reception.

While the matters dealt with in this section are generally applicable, additional special considerations are needed in the case of SFNs where there is more than one wanted signal contribution.

2.2.6.4 Antenna gains

The same figures of antenna gains apply for Class A, B and D reception, as all relate to antenna in a small hand-held terminal. In Class C reception a vehicular built-in antenna is used with a greater gain than for hand-held terminals. The practical standard antenna for vehicle reception is λ/4 monopole which uses the metallic roof as ground plane. The antenna gain for conventional incident wave angles depends on the position of the antenna on the roof. The figures used for planning relate to passive antenna systems.

Generally, no polarisation discrimination can be expected from this type of portable or mobile reception antenna and the radiation pattern in the horizontal plane is omni-directional.

Achievable antenna gains at 1.5 GHz are around -4 dBd (max gain) for an integrated antenna, with an external antenna typically -1 dBd.

For an adapted antenna, the figure used is 0 dBd, taken from BPN 003 [17].

For planning purposes the values shown in Table 20 will be used for the different bands and environment classes.

	Antenna gain	Classes
Integrated antenna	-4 dBd	A, B, D
External antenna)(*)	-1 dBd	A, B, D
Adapted antenna	0 dBd	C

(*) Telescopic or wired headsets

Table 20: Antenna gain in dBd for the different reception classes in the 1.5 GHz band

2.2.6.5 Man-Made Noise (MMM)

For planning purposes, the figures in Table 21 are used for man-made noise (MMN).

Urban / Rural	**Allowance for man-made noise**	**Classes**
Relevant value for integrated antenna	0 dB	A, B, D
Relevant value for external antenna (*)	0 dB	A, B, D
Relevant value for adapted antenna	0 dB	C

(*) Telescopic or wired headsets

Table 21: Allowance for man-made noise in the 1.5 GHz band used in the calculation for urban and rural areas

2.2.6.6 Height Loss

For portable reception, the antenna height of 10 m above ground level, generally used for planning purposes, is not representative 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 1.5 m above ground level (outdoor) or above floor level (indoor) has been assumed.

The propagation prediction method of ITU-R Recommendation P.1546 [18] uses a receiving height that corresponds to the height of the surrounding clutter (buildings etc.). To correct the predicted values for a receiving height of 1.5 m above ground level a factor called "height loss" has been introduced.

However, the height loss can also be specified for different types of receiving environments. ECC Report 049 [19] provides the height loss values for some type of environments.

For planning purposes the values in Table 22 could be used for the different environment classes.

	Receiving antenna height loss (dB)
Urban	27
Suburban	21
Rural	19

Table 22: Height loss in the 1.5 GHz band for the different environment classes

The height loss values are based on the ITU-R Rec. P.1546 [18].

The height loss may also depend on the distance between the transmitter and the receiver, which makes it variable with the size of the coverage area. Therefore, in this document the figures of minimum median equivalent field strength are calculated at 1.5 m AGL. The values of height loss given in this section could be used to derive the minimum median equivalent field strength corresponding to the height of the surrounding clutter (buildings etc.). Further investigations about the height loss are, however, needed.

2.2.6.7 Penetration Loss

Portable reception will take place at outdoor and indoor locations but also within moving objects such as cars or other vehicles. The field strength at indoor locations will be attenuated significantly by an amount depending on the materials and the construction of the building. A large spread of building penetration losses and entry losses for moving objects is to be expected.

For planning purposes, the present document assumes the values shown in

Class B	
Median value	**Standard deviation**
11 dB	6 dB

Table 23: For Class B (portable indoor)

Class B	
Median value	**Standard deviation**
11 dB	6 dB

Table 24: Building penetration loss in the 1.5 GHz band

For the 1.5 GHz band the same values as for bands IV/V are taken i.e. the values are taken from the ETSI DVB-H implementation guidelines [8], (where further information on building penetration loss can be found).

For Class D (mobile inside), the values shown in Table 25 are used in the calculations.

Class D	
Median value	**Standard deviation**
8 dB	2 dB

Table 25: Vehicle (car) penetration loss in the 1.5 GHz band

These values come from a study presented in [20] which shows in-car penetration losses of 8 dB with an associated standard deviation of 2 – 3 dB, based on measurements at 800 MHz. Due to the lack of investigations concerning the car entry loss and its variation with the frequency, the same value is taken at 1.5 GHz. Further studies are needed on this subject.

Furthermore, it is expected that the value of 8 dB will not be sufficient for estimating penetration loss into trains.

2.2.6.8 Body absorption/reflection loss

Another issue is the influence of the user on the radiation characteristic of the antenna. Depending on the relative position of the user to the hand-held terminal, the human body could act as an absorber or a reflector. This could cause additional loss to the signal. However, due to lack of information on this subject, no account of this loss is taken in the planning parameters.

2.2.6.9 Location percentage

(a) Signal level variations

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, reflection and scattering. The micro-scale variations relate to areas with dimensions in the order of a wavelength and are mainly caused by multi-path reflections from nearby objects. The effect of micro-scale fading is normally taken into account by an appropriate C/N value for the transmission channel under consideration. Moreover, as it may be assumed that for portable reception the position of the antenna can be optimized within the order of a wavelength, micro-scale variations will not be too significant for planning purposes.

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 TV signals. Therefore an extra correction is required to the value derived from a field strength prediction that applies to 50% of locations.

(b) Location percentage requirements at outdoor locations (Class A)

ITU-R Recommendation P.1546 [18] gives a standard deviation for wide band signals of 5.5 dB. This value is used here for determining the location correction factor for outdoor locations.

Class A	
Coverage target	Location correction factor (dB)
> 70%	3
> 95%	9

Table 26: Macro-scale variation for portable outdoor reception: Coverage targets and location correction factors

(c) Location percentage requirements at indoor locations (Class B)

The location correction 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. As a consequence, the location variation of the field strength is increased for indoor reception.

At 1.5 GHz, where the macro-scale standard deviations are 5.5 dB and 6 dB (Section 2.2.6.7), respectively, the combined value is 8.1 dB.

The resultant location correction factors at indoor locations are given in Table 27.

Class B	
Coverage target	Location correction factor (dB)
> 70%	4
> 95%	13

Table 27: Macro-scale variation for portable indoor reception: Coverage targets and location correction factors

(d) Location percentage requirements for mobile vehicular reception (Class C)

The value of standard deviation given in (b) is used here for determining the location variation at outdoor locations for mobile vehicular reception. To cope with a mobile environment, larger values of location correction factors than for portable reception are used.

These location correction factors for Classes C and D are given in Table 28.

Class C	
Coverage target	Location correction factor
> 90%	7 dB
> 99%	13 dB

Table 28: Macro-scale variation for mobile vehicular reception: Coverage targets and location correction factors

(e) Location percentage requirements for hand-held reception in a moving vehicle (Class D)

The location correction factor for hand-held reception in a moving vehicle is the combined result of the outdoor variation and the variation factor due to vehicle penetration loss. These distributions are expected to be uncorrelated. The standard deviation of the field strength distribution for hand-held reception in a moving vehicle can therefore be calculated by taking the root of the sum of the squares of the individual standard deviations.

At 1.5 GHz, the standard deviation of the macro-scale variation is assumed to be 5.5 dB and the standard deviation for the penetration loss is assumed to be 2 dB (Section 2.2.6.7); the combined value is 5.9 dB.

The resultant location correction factors for hand-held reception in a moving vehicle (Class D) are given in Table 29.

Class D	
Coverage target	Location correction factor
> 90%	7.6 dB
> 99%	13.7 dB

Table 29: Macro-scale variation for hand-held reception in moving vehicle (Class D): Coverage targets and location correction factors

2.2.7 Examples of Signal levels for planning

The following sections give the details of calculation for the cases listed in Sections 2.2.1 to 2.2.4.

			DVB-H	**DVB-H**	**DVB-H**	**DVB-H**
			Class A	**Class B**	**Class C**	**Class D**
Frequency	Freq	MHz	1500	1500	1500	1500
Minimum C/N required by system	C/N	dB	9.5	9.5	9.5	9.5
System variant			QPSK, 1/4 GI, 1/2 CR, MPE-FEC ¾			
Bit rate		Mbit/s	2.33	2.33	2.33	2.33
Receiver Noise figure	F	dB	6	6	6	6
Equivalent noise band width	B	MHz	4.758	4.758	4.758	4.758
Receiver noise input power	Pn	dBW	-131.2	-131.2	-131.2	-131.2
Min. receiver signal input power	Ps min	dBW	-121.7	-121.7	-121.7	-121.7
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	17	17	17	17
Antenna gain relative to half dipole	Gd	dB	-4	-4	0	-4
Effective antenna aperture	Aa	dBm^2	-26.8	-26.8	-22.8	-26.8
Min Power flux density at receiving location	Φmin	dB(W)/m^2	-94.9	-94.9	-98.9	-94.9
Min equivalent field strength at receiving location	Emin	dBμV/m	51	51	47	51
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB		11		8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	dB(W)/m^2	-92.0	-79.6	-91.8	-79.3
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	53.8	66.2	54.0	66.5
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	dB(W)/m^2	-85.8	-70.6	-86.1	-73.2
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	60.0	75.2	59.7	72.6

Table 30: Examples of Signal levels for planning - DVB-H in the 1.5 GHz band

			DVB-H	DVB-H	DVB-H	DVB-H
			Class A	**Class B**	**Class C**	**Class D**
Frequency	Freq	MHz	1500	1500	1500	1500
Minimum C/N required by system	C/N	dB	15.5	15.5	15.5	15.5
System variant			16-QAM, 1/4 GI, 1/2 CR, MPE-FEC 3/4			
Bit rate		Mbit/s	4.66	4.66	4.66	4.66
Receiver Noise figure	F	dB	6	6	6	6
Equivalent noise band width	B	MHz	4.758	4.758	4.758	4.758
Receiver noise input power	Pn	dBW	-131.2	-131.2	-131.2	-131.2
Min. receiver signal input power	Ps min	dBW	-115.7	-115.7	-115.7	-115.7
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	23	23	23	23
Antenna gain relative to half dipole	Gd	dB	-4	-4	0	-4
Effective antenna aperture	Aa	dBm^2	-26.8	-26.8	-22.8	-26.8
Min Power flux density at receiving location	Φmin	dB(W)/m^2	-88.9	-88.9	-92.9	-88.9
Min equivalent field strength at receiving location	Emin	dBμV/m	57	57	53	57
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB		11		8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	dB(W)/m^2	-86.0	-73.6	-85.8	-73.3
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	59.8	72.2	60.0	72.5
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	dB(W)/m^2	-79.8	-64.6	-80.1	-67.2
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	66.0	81.2	65.7	78.6

Table 31: Examples of Signal levels for planning - DVB-H in the 1.5 GHz band

			DVB-SH	DVB-SH	DVB-SH	DVB-SH
			Class A	**Class B**	**Class C**	**Class D**
Frequency	Freq	MHz	1500	1500	1500	1500
Minimum C/N required by system	C/N	dB	9.1	9.1	8.3	8.3
System variant			16 QAM 1.3			
Bit rate		Mbit/s	1.68	1.68	1.68	1.68
Receiver Noise figure	F	dB	4.5	4.5	2	4.5
Equivalent noise band width	B	MHz	1.52	1.52	1.52	1.52
Receiver noise input power	Pn	dBW	-137.66	-137.66	-140.16	-137.66
Min. receiver signal input power	Ps min	dBW	-128.56	-128.56	-131.86	-129.36
Min. equivalent receiver input voltage, 50 ohm	Umin	dBµV	8.4	8.4	5.1	7.6
Antenna gain relative to half dipole	Gd	dB	-4	-4	0	-4
Effective antenna aperture	Aa	dBm^2	-26.82	-26.82	-22.82	-26.82
Min Power flux density at receiving location	Φmin	$dB(W)/m^2$	-101.74	-101.74	-109.04	-102.54
Min equivalent field strength at receiving location	Emin	dBµV/m	44.06	44.06	36.76	43.26
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB	0	11	0	8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	3.5	5.5	3.5	3.5
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-102.34	-92.04	-105.54	-90.44
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBµV/m	43.46	53.76	40.26	55.36
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-96.24	-82.94	-99.74	-84.34
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBµV/m	49.56	62.86	46.06	61.46

Table 32: Examples of Signal levels for planning - DVB-SH (1.7 MHz) in the 1.5 GHz band

			DVB-SH	DVB-SH	DVB-SH	DVB-SH
			Class A	**Class B**	**Class C**	**Class D**
Frequency	Freq	MHz	1500	1500	1500	1500
Minimum C/N required by system	C/N	dB	9.1	9.1	7.2	7.2
System variant			16 QAM 1.3			
Bit rate		Mbit/s	4.94	4.94	4.94	4.94
Receiver Noise figure	F	dB	4.5	4.5	2	4.5
Equivalent noise band width	B	MHz	4.76	4.76	4.76	4.76
Receiver noise input power	Pn	dBW	-132.70	-132.70	-135.20	-132.70
Min. receiver signal input power	Ps min	dBW	-123.60	-123.60	-128.00	-125.50
Min. equivalent receiver input voltage, 50 ohm	Umin	dBμV	13.4	13.4	9.0	11.5
Antenna gain relative to half dipole	Gd	dB	-4	-4	0	4
Effective antenna aperture	Aa	dBm^2	-26.82	-26.82	-22.82	-26.82
Min Power flux density at receiving location	Φmin	dB(W)/m^2	-96.78	-96.78	-105.18	-98.68
Min equivalent field strength at receiving location	Emin	dBμV/m	49.02	49.02	40.62	47.12
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB	0	11	0	8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	3.5	5.5	3.5	3.5
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	dB(W)/m^2	-97.38	-87.08	-101.68	-86.58
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	48.42	58.72	44.12	59.22
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	dB(W)/m^2	-91.28	-77.98	-95.88	-80.48
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	54.52	67.82	49.92	65.32

Table 33: Examples of Signal levels for planning - DVB-SH (5 MHz) in the 1.5 GHz band

			DVB-SH	DVB-SH	DVB-SH	DVB-SH
			Class A	**Class B**	**Class C**	**Class D**
Frequency	Freq	MHz	1500	1500	1500	1500
Minimum C/N required by system	C/N	dB	9.1	9.1	7.2	7.2
System variant			16 QAM 1.3			
Bit rate		Mbit/s	6.91	6.91	6.91	6.91
Receiver Noise figure	F	dB	4.5	4.5	2	4.5
Equivalent noise band width	B	MHz	6.66	6.66	6.66	6.66
Receiver noise input power	Pn	dBW	-131.24	-131.24	-133.74	-131.24
Min. receiver signal input power	Ps min	dBW	-122.14	-122.14	-126.54	-124.04
Min. equivalent receiver input voltage, 50 ohm	Umin	dBμV	14.8	14.8	10.4	12.9
Antenna gain relative to half dipole	Gd	dB	-4	-4	0	-4
Effective antenna aperture	Aa	dBm^2	-26.82	-26.82	-22.82	-26.82
Min Power flux density at receiving location	Φmin	$dB(W)/m^2$	-95.32	-95.32	-103.72	-97.22
Min equivalent field strength at receiving location	Emin	dBμV/m	50.48	50.48	42.08	48.58
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB	0	11	0	8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	3.5	5.5	3.5	3.5
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-95.92	-85.62	-100.22	-85.12
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	49.88	60.18	45.58	60.68
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-89.82	-76.52	-94.42	-79.02
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	55.98	69.28	51.38	66.78

Table 34: Examples of Signal levels for planning - DVB-SH (7 MHz) in the 1.5 GHz band

			FLO Class A	FLO Class B	FLO Class C	FLO Class D
Frequency	Freq	MHz	1500	1500	1500	1500
Minimum C/N required by system	C/N	dB	6.8	6.8	6.8	6.8
System variant			Mode 1, QPSK1/2			
Bit rate		Mbit/s	2.373	2.373	2.373	2.373
Receiver Noise figure	F	dB	6	6	6	6
Equivalent noise band width	B	MHz	4.52	4.52	4.52	4.52
Receiver noise input power	Pn	dBW	-131.4	-131.4	-131.4	-131.4
Min. receiver signal input power	Ps min	dBW	-124.6	-124.6	-124.6	-124.6
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	14.1	14.1	14.1	14.1
Antenna gain relative to half dipole	Gd	dB	-4	-4	0	-4
Effective antenna aperture	Aa	dBm^2	-26.8	-26.8	-22.8	-26.8
Min Power flux density at receiving location	Φmin	dB(W)/m^2	-97.8	-97.8	-101.8	-97.8
Min equivalent field strength at receiving location	Emin	dBμV/m	48.0	48.0	44.0	48.0
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB		11		8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	dB(W)/m^2	-94.9	-82.6	-94.8	-82.2
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	50.9	63.2	51.0	63.6
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	dB(W)/m^2	-88.8	-73.5	-89.0	-76.1
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	57.0	72.3	56.8	69.7

Table 35: Examples of Signal levels for planning – FLO in the 1.5 GHz band

			FLO	FLO	FLO	FLO
			Class A	**Class B**	**Class C**	**Class D**
Frequency	Freq	MHz	1500	1500	1500	1500
Minimum C/N required by system	C/N	dB	12.3	12.3	12.3	12.3
System variant			Mode 3, 16-QAM 1/2			
Bit rate		Mbit/s	4.746	4.746	4.746	4.746
Receiver Noise figure	F	dB	6	6	6	6
Equivalent noise band width	B	MHz	4.52	4.52	4.52	4.52
Receiver noise input power	Pn	dBW	-131.4	-131.4	-131.4	-131.4
Min. receiver signal input power	Ps min	dBW	-119.1	-119.1	-119.1	-119.1
Min. equivalent receiver input voltage, 75 ohm	Umin	dBµV	19.6	19.6	19.6	19.6
Antenna gain relative to half dipole	Gd	dB	-4	-4	0	-4
Effective antenna aperture	Aa	dBm^2	-26.8	-26.8	-22.8	-26.8
Min Power flux density at receiving location	Φmin	dB(W)/m^2	-92.3	-92.3	-96.3	-92.3
Min equivalent field strength at receiving location	Emin	dBµV/m	53.5	53.5	49.5	53.5
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB		11		8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	dB(W)/m^2	-89.4	-77.1	-89.3	-76.7
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBµV/m	56.4	68.7	56.5	69.1
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	dB(W)/m^2	-83.3	-68.0	-83.5	-70.6

Table 36: Examples of Signal levels for planning – FLO in the 1.5 GHz band

			T-DMB Class A	T-DMB Class B	T-DMB Class C	T-DMB Class D
Frequency	Freq	MHz	1500	1500	1500	1500
Minimum C/N required by system	C/N	dB	13.5	13.5	13.5	13.5
System variant			D-QPSK, 1/4 GI, 1/2 CR			
Bit rate		Mbit/s	1.06	1.06	1.06	1.06
Receiver Noise figure	F	dB	7	7	7	7
Equivalent noise band width	B	MHz	1.536	1.536	1.536	1.536
Receiver noise input power	Pn	dBW	-135.1	-135.1	-135.1	-135.1
Min. receiver signal input power	Ps min	dBW	-121.6	-121.6	-121.6	-121.6
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	17	17	17	17
Antenna gain relative to half dipole	Gd	dB	-4	-4	0	-4
Effective antenna aperture	Aa	dBm^2	-26.8	-26.8	-22.8	-26.8
Min Power flux density at receiving location	Φmin	dB(W)/m^2	-94.8	-94.8	-98.8	-94.8
Min equivalent field strength at receiving location	Emin	dBμV/m	51	51	47	51
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB		11		8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	dB(W)/m^2	-91.9	-79.5	-91.7	-79.2
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	53.9	66.3	54.1	66.6
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	dB(W)/m^2	-85.7	-70.5	-86.0	-73.1
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	60.1	75.3	59.8	72.7

Table 37: Examples of Signal levels for planning – T-DMB in the 1.5 GHz band

2.2.8 Frequency planning parameters

The frequency planning parameters for DVB-H, FLO and T-DMB include:

The protection ratios related to all possible combinations (co-channel, overlapping and adjacent channels/blocks) between the concerned systems (DVB-H, FLO and T-DMB) and the other broadcasting systems that may use the same frequency band.

The spectrum masks of DVB-H, FLO and T-DMB emissions, as these patterns have an influence on the impact of a given emission on the adjacent channels used in the same area.

General Remark:
The values of protection ratios given in the following sections are derived from values related to DVB-T or T-DAB by applying, when relevant, corrections to take into consideration the differences in C/N. However, these derived values need ultimately to be confirmed by laboratory or field measurements. They are made available here in order to give guidance to broadcasters and network operators making their network planning.

2.2.8.1 Protection Ratios for DVB-H

2.2.8.1.1 DVB-H interfered with by other broadcasting systems

The following cases are considered:

Wanted signal	**Unwanted signal**	**Table**
DVB-H	Co-channel DVB-H	Table 39
DVB-H	Adjacent channel DVB-H	Table 40
DVB-H	Co-channel T-DAB or T-DMB	Table 41
DVB-H	Adjacent channel T-DAB or T-DMB	Table 42

Table 38: References to Protection Ratios for DVB-H

2.2.8.1.2 Co-channel protection ratios for DVB-H interfered with by DVB-H

Modulation	Code rate	Protection ratio [dB]	
		Portable (Class A and B)	Mobile (Class C and D)
QPSK	1/2	9.5	9.5
QPSK	2/3	12.5	12.5
16--QAM	1/2	15.5	15.5
16--QAM	2/3	18.5	18.5

Table 39: Co-channel protection ratios (dB) for a DVB-H signal interfered with by a DVB-H signal for different variants of the wanted DVB-H signal (for the case of portable reception (Class A and B) and mobile reception (Class C and D)

The same protection ratios should be applied for DVB-H systems with 5. 7 and 8 MHz.

2.2.8.1.3 Overlapping and adjacent channels protection ratios for DVB-H interfered with by DVB-H

For overlapping channels, in the absence of measurement information, and if the overlapping bandwidth between the wanted and unwanted signals is less than 1 MHz, the protection ratio, PR, should be extrapolated from the co-channel ratio figure as follows:

$PR = CCI + 10 \log_{10}(BO/BW)$, where:
CCI : co-channel protection ratio
BO : bandwidth (MHz) in which the two signals are overlapping
BW : bandwidth (MHz) of the wanted signal

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

For an overlap greater than 1 MHz the CCI protection ratio should be used.
However, further studies are needed on this subject.
For adjacent channel, the figures of Table 40 below apply.

Channel	$N-1$	$N+1$
PR	–30 dB	–30 dB

Table 40: Protection ratios (dB) for a DVB-H signal interfered with by a DVB-H signal in the lower (N – 1) and upper (N + 1) adjacent channels

2.2.8.1.4 Co-channel protection ratios for DVB-H interfered with by T-DAB or T-DMB signals

Modulation	**Code rate**	**Protection ratio [dB]**	
		Portable (Class A and B)	Mobile (Class C and D)
QPSK	1/2	14.5	14.5
QPSK	2/3	17.5	17.5
16-QAM	1/2	20.5	20.5
16-QAM	2/3	23.5	23.5

Table 41: Co-channel protection ratios (dB) for a DVB-H 7 MHz and 8 MHz signal interfered with by a T-DAB or a T-DMB signal

Remark:
GE06 gives PRs for DVB-T interfered with by T-DAB that are around 5 dB higher than the PRs for DVB-T interfered with by DVB-T (the same difference is applied to the different reception modes but it varies with the system variant). As preliminary figures, subject to further studies, a 5 dB increase to the figures of DVB-H versus DVB-H (Table 39) has been applied to derive the figures of Table 42.

2.2.8.1.5 Adjacent channel protection ratios for DVB-H interfered with by T-DAB or T-DMB signals

Channel	$N-1$	$N+1$
PR	–30 dB	–30 dB

Table 42: Protection ratios (dB) for a DVB-H 7 MHz and 8 MHz signal interfered with by a T-DAB or T-DMB signal in the lower (N – 1) or upper (N + 1) adjacent channels

2.2.8.1.6 Other broadcasting systems (except T-DMB) interfered with by DVB-H

It is assumed here that DVB-H, as the unwanted signal, has the same effect as the DVB-T unwanted signal due to the noise-like characteristic of both signals and assuming identical spectrum patterns for both. Therefore, the protection ratios for the cases listed below can be taken from the tables contained in the GE06 Final Acts [21]. The relevant table is indicated for each case.

Wanted signal	Unwanted signal	GE06 Final Acts Table
T-DAB	DVB-H (8 MHz)	A.3.3-13
T-DAB	DVB-H (7 MHz)	A.3.3-14

Table 43: References to protection ratios of T-DAB interfered with by DVB-H

2.2.8.2 Protection Ratios for FLO

2.2.8.2.1 FLO interfered with by other broadcasting systems

The following cases are considered:

Wanted signal	Unwanted signal	Table
FLO	Co-channel FLO	Table 45
FLO	Adjacent channel FLO	Table 46
FLO	Co-channel T-DAB or T-DMB	Table 47
FLO	Adjacent channel T-DAB or T-DMB	Table 48

Table 44: References to Protection Ratios for FLO

The Protection Ratio is mainly independent of the FLO system bandwidth. The System bandwidth will mainly affect the wanted signal level (and therefore the maximum acceptable level of the interfering signal) but will not modify the Protection Ratio itself. As such, a single protection ratio is provided in the following for FLO with system bandwidth of 5, 6, 7 or 8 MHz.

2.2.8.2.2 Co-channel protection ratios for FLO interfered with by FLO

Mode	Modulation	Code rate	C/N (dB)	
			Portable (Class A and B)	Mobile (Class C and D)
1	QPSK	1/2	6.8	6.8
2	16-QAM	1/3	8.7	8.7
3	16-QAM	1/2	12.3	12.3
7B	QPSK (Layered, 4:1)	1/2	9.8	9.8
7E	QPSK (Layered, 4:1)	1/2	14.1	14.1

Table 45: Co-channel protection ratios (dB) for a FLO signal interfered with by a FLO signal for different variants of the wanted FLO signal (for the case of portable reception (Class A and B) and mobile reception (Class C and D)

The same protection ratios should be applied for FLO systems with 5, 6, 7 and 8 MHz.

2.2.8.2.3 Overlapping and adjacent channels protection ratios for FLO interfered with by FLO

In the absence of measurement information, adjacent channel protection ratio can be derived from [14], assuming FLO protection ratios are comparable to DVB-T protection ratios.

For overlapping channels, in the absence of measurement information, and if the overlapping bandwidth between the wanted and unwanted signals is less than 1 MHz, the protection ratio, PR, should be extrapolated from the co-channel ratio figure as follows:

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

where:

CCI : co-channel protection ratio
BO : bandwidth (MHz) in which the two signals are overlapping
BW : bandwidth (MHz) of the wanted signal

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

For an overlap greater than 1 MHz the CCI protection ratio should be used.

However, further studies are needed on this subject.

For adjacent channel, the figures of Table 46 below apply.

Channel	$N-1$	$N+1$
PR	–30 dB	–30 dB

Table 46: Protection ratios (dB) for a FLO signal interfered with by a FLO 5 MHz, 6 MHz, 7 MHz or 8 MHz signal in the lower (N – 1) and upper (N + 1) adjacent channels

The values given apply to the case where wanted and unwanted FLO signals have the same channel width. Other combinations of channel width need further studies. It is known from measurements of existing receivers that they permit lower protection ratios. But for planning purposes it is an advantage to have this value.

2.2.8.2.4 Co-channel protection ratios for FLO interfered with by T-DAB or T-DMB signals

Mode	**Modulation**	**Code rate**	**C/N (dB)**	
			Portable (Class A and B)	**Mobile (Class C and D)**
1	QPSK	1/2	11.8	11.8
2	16-QAM	1/3	13.7	13.7
3	16-QAM	1/2	17.3	17.3
7B	QPSK (Layered, 4:1)	1/2	14.8	14.8
7E	QPSK (Layered, 4:1)	1/2	19.1	19.1

Table 47: Co-channel protection ratios (dB) for a FLO 5 MHz, 6 MHz, 7 MHz or 8 MHz signal interfered with by a T-DAB or a T-DMB signal

Remark: GE06 gives PRs for DVB-T interfered with by T-DAB that are around 5 dB higher than the PRs for DVB-T interfered with by DVB-T (the same difference is applied to the different reception modes but it varies with the system variant). As preliminary figures, subject to further studies, a 5 dB increase to the figures of FLO versus FLO (Table 45) has been applied to derive the figures of Table 47.

2.2.8.2.5 Adjacent channel protection ratios for FLO interfered with by T-DAB or T-DMB signals

In the absence of measurement information, adjacent channel protection ratio can be derived from [16], assuming FLO protection ratios are comparable to DVB-T protection ratios.

Channel	$N-1$	$N+1$
PR	–30 dB	–30 dB

Table 48: Protection ratios (dB) for a FLO 5 MHz, 6 MHz, 7 MHz and 8 MHz signal interfered with by a T-DAB or T-DMB signal in the lower (N – 1) or upper (N + 1) adjacent channels

2.2.8.2.6 Other broadcasting systems (except T-DMB) interfered with by FLO

It is assumed here that FLO, as the unwanted signal, has the same effect as the DVB-T unwanted signal due to the noise-like characteristic of both signals and assuming identical spectrum patterns for both. Such an assumption is supported by [23] where FLO unwanted signal has been reported as having the same effect as DVB-T unwanted signal on DVB-T receivers. Therefore, the protection ratios for the cases listed below can be taken from the tables contained in the GE06 Final Acts [21]. The relevant table is indicated for each case.

Wanted signal	Unwanted signal	GE06 Final Acts Table
T-DAB	FLO (8 MHz)	A.3.3-13
T-DAB	FLO (7 MHz)	A.3.3-14

Table 49: References to protection ratios of T-DAB interfered with by FLO

For FLO 5MHz and FLO 6MHz, taking into account the noise-like characteristic of both signals and the tighter spectrum pattern for lower bandwidth, the Protection Ratio can be over-estimated as the protection ratio from FLO (7 MHz), with adequate adaptation of the separation frequency.

For FLO 7MHz, the signal expands to 6.32/2=3.16MHz from the carrier-frequency.
For FLO 6MHz, the signal expands to 5.42/2=2.71MHz from the carrier-frequency. Equivalent PR ratio as FLO 7 MHz are expected with Δf reduced by 3.16-2.71=0.45MHz, rounded to 0.4 for additional protection.
For FLO 5MHz, the signal expands to 4.52/2=2.26 MHz from the carrier-frequency. Equivalent PR ratio as FLO 7 MHz are expected with Δf reduced by 3.16-2.29=0.9MHz.

The resulting PR tables are provided in Table 50 and Table 51.

Δf*(MHz)	**−4.1**	**−3.3**	**−3.1**	**−2.1**	**0**	**2.1**	**3.1**	**3.3**	**4.1**
PR (dB) mobile and portable reception	−42	7	8	9	9	9	8	7	−42
PR (dB) Gaussian channel	−49	0	1	2	2	2	1	0	−49

** Δf: Centre frequency of the FLO signal minus centre frequency of the T-DAB signal*

Table 50: Protection ratios for T-DAB interfered with by a FLO 6 MHz system

Δf*(MHz)	**−3.6**	**−2.8**	**−2.6**	**−1.6**	**0**	**1.6**	**2.6**	**2.8**	**3.6**
PR (dB) mobile and portable reception	−42	7	8	9	9	9	8	7	−42
PR (dB) Gaussian channel	−49	0	1	2	2	2	1	0	−49

** Δf: Centre frequency of the FLO signal minus centre frequency of the T-DAB signal*

Table 51: Protection ratios for T-DAB interfered with by a FLO 5 MHz system

2.2.8.3 Protection Ratios for T-DMB

2.2.8.3.1 T-DMB interfered with by other broadcasting systems

The following cases are considered:

Wanted signal	Unwanted signal	Table
T-DMB	Co-channel T-DAB or T-DMB	Table 53
T-DMB	Adjacent block T-DAB or T-DMB	Table 54
T-DMB	DVB-H (8 MHz)	Table 55
T-DMB	DVB-H (7 MHz)	Table 56

Table 52: References to Protection Ratios for T-DMB

2.2.8.3.2 Co-channel protection ratios for T-DMB interfered with by T-DAB or T-DMB

Co-channel	**Protection ratio [dB]**	
	Portable (Class A and B)	Mobile (Class C and D)
T-DMB wanted / T-DAB or T-DMB unwanted	13.5	13.5

Table 53: Co-channel protection ratios (dB) for a T-DMB signal interfered with by a T-DAB or a T-DMB

2.2.8.3.3 Adjacent block protection ratios for T-DMB interfered with by T-DAB or T-DMB

No information is available on the adjacent block measured protection ratios for T-DMB. In the absence of measured figures, a unique value of -35 dB could be applied.

Block	*N* – 1	*N* + 1
PR	-35 dB	-35 dB

Table 54: Protection ratios (dB) for a T-DMB signal interfered with by a T-DAB or a T-DMB signal in the lower (*N* – 1) and upper (*N* + 1) adjacent blocks

2.2.8.3.4 Protection ratios for T-DMB interfered with by DVB-H

The values given in the Table 55 and Table 56 below are based on the values given in GE06 technical annexes for T-DAB/DVB-T by applying a correction equal to the difference between the corresponding C/N figures of T-DAB and T-DMB.

Δf* (MHz)	−5	−4.2	−4	−3	0	3	4	4.2	5
PR (dB) portable (Class A and B)	-41.6	7.6	8.6	9.6	9.6	9.6	8.6	7.6	-41.6
PR (dB) mobile (Class C and D)	−43	6	7	8	8	8	7	6	−43

* *Δf: Centre frequency of the DVB-H signal minus centre frequency of the T-DMB signal.*

Table 55: Protection ratios (dB) for a T-DMB signal interfered with by a DVB-H 8 MHz signal

Δf* (MHz)	−4.5	−3.7	−3.5	−2.5	0	2.5	3.5	3.7	4.5
PR (dB) portable (Class A and B)	-40.4	8.6	9.6	10.6	10.6	10.6	9.6	8.6	-40.4
PR (dB) mobile (Class C and D)	−42	7	8	9	9	9	8	7	−42

* *Δf: Centre frequency of the DVB-H signal minus centre frequency of the T-DMB signal.*

Table 56: Protection ratios (dB) for a T-DMB signal interfered with by a DVB-H 7 MHz signal

2.2.8.3.5 Other broadcasting systems (except DVB-H) interfered with by T-DMB

It is assumed here that T-DMB, as unwanted signal, has the same effect as the T-DAB unwanted signal due to the noise like characteristic of both signals and assuming identical spectrum patterns for both. Therefore, the protection ratios for the cases listed below can be taken from the tables contained in the GE06 Final Acts [21], the ITU-R Rec. BT.1368-5 [22] or the ITU-R Rec. BT.655-7 [23]. The relevant source is indicated for each case.

Wanted signal	Unwanted signal	Table
T-DAB	Co-channel T-DMB	GE06 Final Acts Table A.3.3-13
T-DAB	Adjacent channel T-DMB	GE06 Final Acts Table A.3.3-14

Table 57: References to protection ratios of T-DAB interfered with by T-DMB

2.2.9 Spectrum mask

2.2.9.1 Spectrum mask for DVB-H/FLO emission

Taking into account that DVB-H/FLO would in general share frequency bands used by DVB-T, it is proposed to apply the same spectrum pattern (or mask) as it is specified for DVB-T in the GE06 Agreement [21]. Two spectrum masks are specified in Figure 5 and in Table 58**.** The upper curve defines the spectrum mask for the non-critical cases and the lower curve defines the spectrum mask for the sensitive cases.

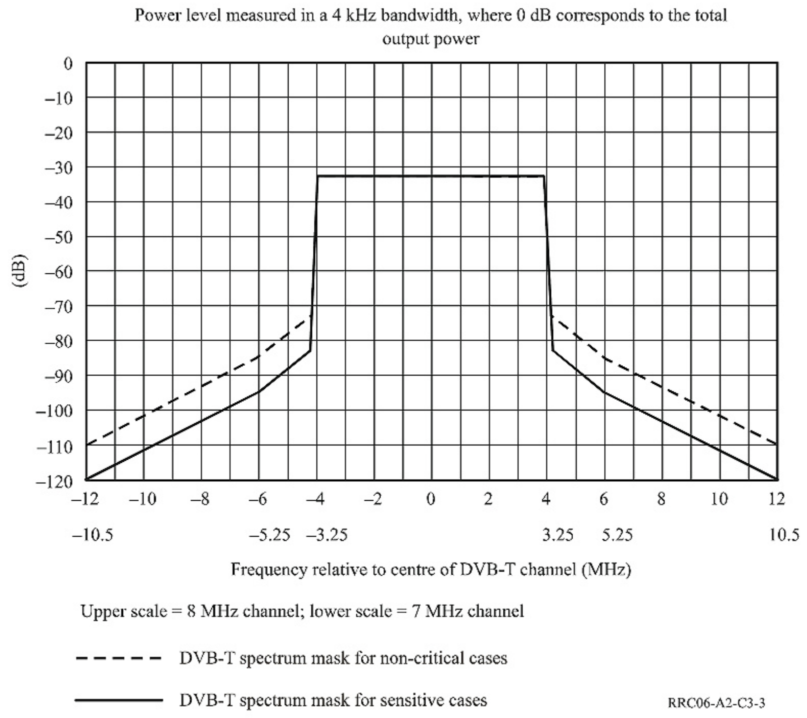


Figure 5: DVB-T/DVB-H/FLO symmetrical spectrum masks for non-critical and sensitive cases

Breakpoints					
8 MHz channels			**7 MHz channels**		
Relative frequency (MHz)	Non-critical cases	Sensitive cases	Relative freq.(MHz)	Non-critical cases	Sensitive cases
	Relative level (dB)	Relative level (dB)		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	–3.35	–32.8	–32.8
+3.9	–32.8	–32.8	+3.35	–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 58: DVB-T/DVB-H/FLO symmetrical spectrum masks' table for non-critical and sensitive cases

2.2.9.2 Spectrum mask for T-DMB emission

Taking into account that T-DMB would share frequency bands used by T-DAB, it is proposed to apply the same spectrum patterns (or masks) as are provided for T-DAB in the GE06 Agreement [21].

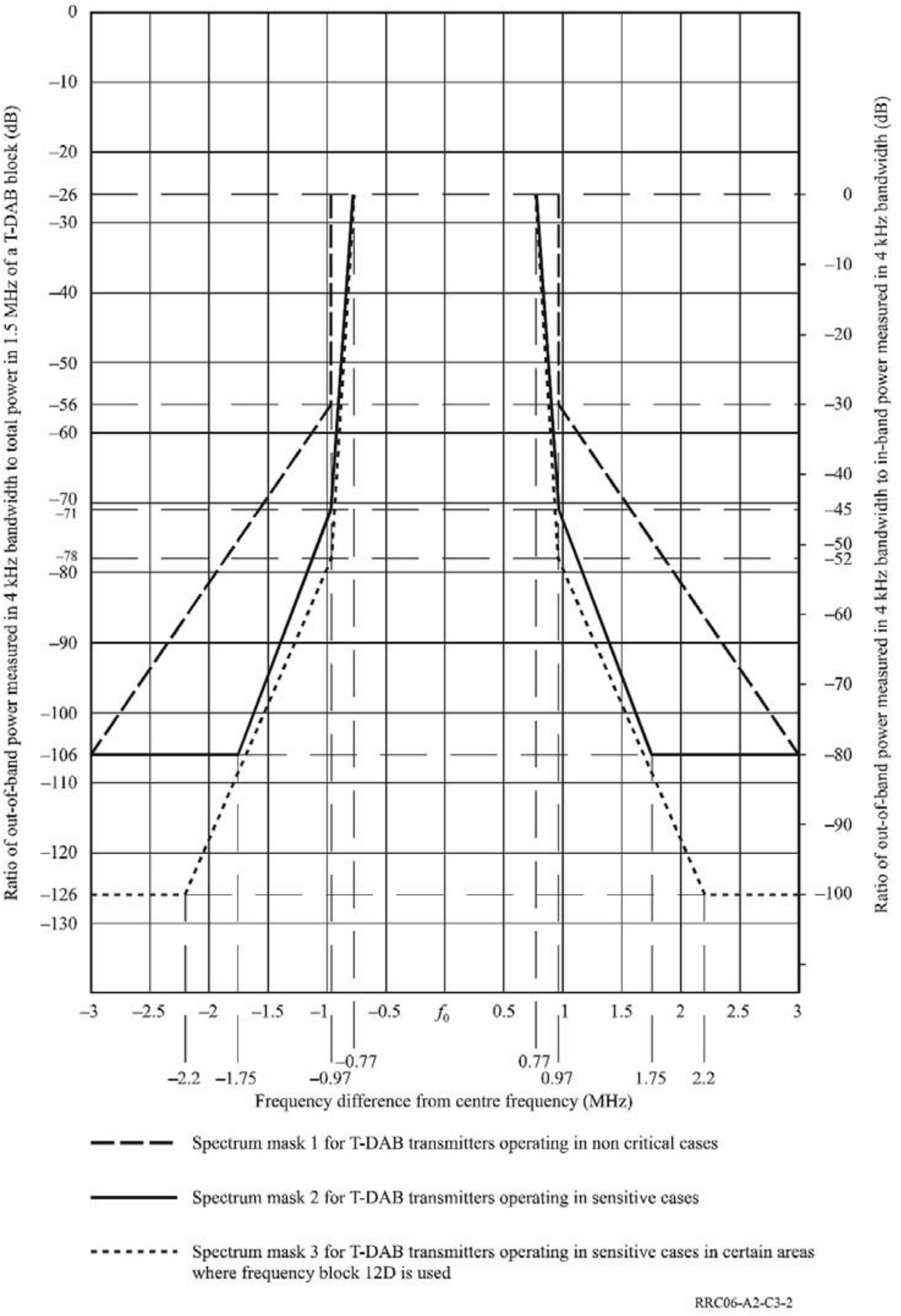


Figure 6: Out-of-band spectrum masks for a T-DAB/T-DMB transmission signal

Three spectrum masks are specified in Figure 6 and in Table 59. The upper curve defines the spectrum mask for the non-critical cases and the two lower curves define the spectrum mask for the sensitive cases. The additional dotted line (spectrum mask 3) corresponds to special cases in band III which do not apply to the 1.5 GHz band.

	Frequency relative to the centre of the 1.54 MHz channel (MHz)	Relative level (dB)
Spectrum mask for T-DAB or T-DMB transmitters operating in non-critical cases	± 0.97	–26
	± 0.97	–56
	± 3.0	–106
Spectrum mask for T-DAB or T-DMB transmitters operating in sensitive cases	± 0.77	–26
	± 0.97	–71
	± 1.75	–106
	± 3.0	–106
Spectrum mask for T-DAB or T-DMB transmitters operating in sensitive cases in certain areas where frequency block 12D is used	± 0.77	–26
	± 0.97	–78
	± 2.2	–126
	± 3.0	–126

Table 59: Out-of-band spectrum masks' table for a T-DAB/T-DMB transmission signal

2.3 Additional consideration

Looking to the future the DVB Project is expecting that by the 2015, Rich Media content consumption will increase several-fold and the content will be consumed using a variety of devices. To facilitate this Rich media content consumption, an efficient, flexible and robust Next Generation Handheld (NGH) system [24] is to be developed as part of the evolution of DVB family of standards, with superior performance, robustness and better indoor coverage than DVB-H.‘NGH’ is expected to complement Telecom networks such as 3G and LTE. The publication of the related ETSI standard(s) is expected in 2011.

Within the DVB-NGH Commercial Requirements document [25] for DVB-NGH it is stated that:

“

- the specification shall be designed to operate at least in the frequency bands III, IV and V, L-band and S-band.
- DVB-NGH shall be designed to operate in RF channel bandwidths of 1.7, 5, 6, 7, 8, 10, 15 and 20 MHz.
- DVB-NGH shall meet interference levels and spectrum mask requirements as defined by GE06 (and hence not cause more interference than DVB-T or T-DAB would do).

“

3 PMSE

CEPT has developed two ECC Reports dealing with compatibility between PMSE and other systems in the L-band (see ECC Report 121 [26] and ECC Report 147 [27]).

The compatibility of the introduction of PWMS in the band 1452-1479.5MHz with broadcasting services under the MA02revCO07 Special Agreement was considered in the ECC Report 121 [26] by highlighting that:

- PWMS applications of all types co-exist in an acceptable manner with T-DAB services in UHF,
- it is also possible that some administrations may elect not to deploy L-band T-DAB services, leaving this band very suitable for geographic sharing, noting that separation distances and required guard bands for T-DAB were not derived in ECC Report 121 [26].

Furthermore, sharing studies with the mobile multimedia systems studied in this report were not conducted. Section 2 of ECC Report 121 [26] provides characteristics of PMSE based on ETSI TR 102 546 [28]. It has to be noted that this TR is under revision within ETSI at the time of writing the present report to further describe the different applications under the PMSE family name. In addition, the European Standard ETSI EN 300 422 [29] addresses the Electromagnetic compatibility and Radio spectrum Matters (ERM) for Wireless microphones in the 25 MHz to 3 GHz frequency range.

In addition, within ETSI, a Special Task Force (STF 386) has been established to study different methods and test procedures for cognitive interference mitigation techniques for use by PMSE devices (Programme Making and Special Events). Review of existing studies and/or additional compatibility studies may be required if this task force identifies any potential and innovative new mitigation techniques.

4 COORDINATION BETWEEN T-DAB VERSUS S-DAB IN THE SUB-BAND 1467 MHz TO 1479.5 MHz

4.1 Introduction

Some administrations indicated that guidance in the frequency co-ordinations process with satellite networks published in ITU-R BR IFICs in the sub-band 1467 to 1479.5 MHz (see Resolution 528 Rev.WRC-03 [2] and ECC/DEC/(03)02 [3]) to protect T-DAB systems were needed. Therefore, this section provides additional guidance to define a coordination framework for the proper T-DAB reception conditions, which may comprise compatibility requirements, reception modes, minimum wanted field strength to be protected, compatibility scenarios and maximum allowable power flux density.

4.2 Coordination framework

4.2.1 Compatibility requirements

The sub-band 1467-1479.5 MHz is,

- on the one hand, the upper 12.5 MHz of the 1452-1479.5 MHz band designated for T-DAB use in MA02revCO07, as well as,
- on the other hand, it corresponds to the lower part of the 1467-1492 MHz band allocated to Satellite Broadcasting and designated for S-DAB use at ITU (see ITU-R Resolution 528 (Rev.WRC-03)).

In the sub-band 1467-1479.5 MHz, there may be compatibility sharing issues which may need to be considered. The issue will arise between T-DAB within CEPT and S-DAB operating from outside Europe. Figure 7 [26] provides information on the current segmentation of the band and spectrum allocation within Europe. Within Europe, the sub-band 1467-1479.5 MHz is divided into 7 frequency blocks LJ-LP, which are overlapped with S-DAB designated band at ITU level where the protection of T-DAB[6] shall be guaranteed from S-DAB interference.

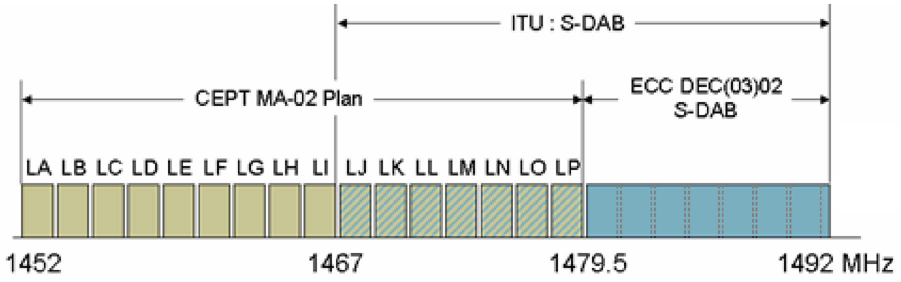


Figure 7: International and European BS and BSS allocations in 1452-1492 MHz

Appendix 1 to Annex 1 provides some background information on the WorldSpace system, since it seems to be related to the only operating satellite digital sound broadcasting system ("S-DAB") in L-band with impact in Europe, which needs to be taken into account in T-DAB/S-DAB coordination.

4.2.2 Reception modes

The appropriate reception mode for coordination should correspond to the most conservative conditions which are normally related to the most restrictive interfering limits. In fact, these limits become thresholds, and since they are not exceeded, protection can be assured in all cases.

---

[6] T-DAB is a terrestrial DAB system, with a carrier bandwidth of 1.536 MHz, as well as a corresponding channel bandwidth of 1.712 MHz.

The worst situation corresponds to a reception near to ground level, where the field strengths are lower which imply in lower interfering limits. Therefore, the fixed reception, where there is a roof-top antenna and higher field strengths, should be disregarded as a possible option.

The next step is the choice between outdoor and indoor reception, and the lowest limits clearly correspond to outdoor reception, since the indoor reception has to take into account penetration losses (building or vehicle) and therefore it shall be disregarded as well.

The final step shall be the choice between two outdoors reception modes, portable outdoor (Class A) and mobile (Class C) [30], and in principle the worst case seems to be the mobile reception mode in urban environment, or somehow an envisaged and appropriate combined reception mode.

4.2.3 Minimum wanted field strength to be protected

The minimum wanted field strength to be protected shall be defined for the reception modes identified in § 4.2.2, namely, portable outdoor and mobile reception modes.

Appendix 2 to Annex 1 provides considerations about planning field strengths and Table 63 presents calculations for five cases of examples, corresponding to the CEPT case (MA02revCO07 [1]) and three EBU guided cases (Annex B of EBU Tech 3317 [30]), while the fifth case stands for a case study.

The case study presented in Table 63 seems to correspond to a combined reception mode, somehow an intermediate step between mobile and portable in urban environment, as well as, similarly, between mobile in urban environment and mobile in rural environment.

The minimum wanted field strength to be protected (the so-called minimum median field strength, “E_{med}”) is derived from the minimum value of signal level to overcome receiver noise (also known as the minimum field strength “E_{min}” at the receiving place), to which are added, where relevant, appropriate correction factors to take account of any propagation effects, since T-DAB reception has to be considered in a practical environment.

Concerning the identified reception modes applied to digital systems, it can happen a very rapid transition from near perfect to no reception at all, and due to this propagation effect, E_{min} has to be achieved at a high percentage of covered locations, taken here as 99%L for good reception in both T-DAB portable outdoor and mobile modes.

The calculated value of E_{med} in the case study is 60 dBμV/m at the receiving height of 1.5 m AGL for 50% of location and 50% of the time, which is needed to ensure that E_{min} of 47 dBμV/m can be achieved at 99% of locations. The difference of 13 dB between both field strengths is calculated by the product “$\mu.\sigma$“, where μ stands for the log-normal distribution factor corresponding to 99% (2.33) and σ is the standard deviation of 5.5 dB, valid for outdoor reception of a wideband digital signal as T-DAB signal (see Rec. ITU-R P.1546 [18]).

With regard to the representative receiving antenna height to be considered for T-DAB mobile and portable reception, assumed as an outdoor receiving antenna near ground level at no less than 1.5 m AGL, it was agreed that the antenna height of 10 m AGL, generally used for planning, should be considered as well. In order to consider this, a correction factor needs to be introduced based on a receiving antenna height of 1.5 m AGL, which is termed the receiving antenna height gain correction (also known as “height loss correction factor”).

For coordination between two Contracting Administrations of MA02revCO07, the height loss correction factor of 10 dB (from 10 m AGL to 1.5 m AGL) given in MA02revCO07 should be used, but when one of the administrations is not a Contracting Administration, the Rec. ITU-R P.1546 [18] should be applied.

In this context, the required values for the height loss correction factor may be those indicated in the column of 1.5 GHz band in Table 1.3.7 (§ 1.3.3.4) of EBU document Tech 3317 [30] as given below:

Environment	Height loss correction factor	Receiving antenna height value
Rural environment	19 dB	10 m AGL
Suburban environment	21 dB	10 m AGL
urban environment	27 dB	20 m AGL

Table 60: height loss correction factor

4.2.4 Compatibility scenarios

Concerning sharing scenarios, it is possible to identify two extreme scenarios, a first one with the satellite in line of sight ("LoS") of the victim as the dominant contribution, and a second one where LoS may be missing at all as it can happen in a dense urban area.

In the case of a scenario with the satellite in LoS of the victim, no additional correction should be considered with regard to the propagation correction factor (see Appendix 3 to Annex 1).

However, there is scope for an alternative scenario, the so-called hybrid scenario which may arise at ITU level, where the satellite may not be in line of sight of the victim (e.g. in urban zones); in this scenario, the S-DAB signal might have two components, satellite and terrestrial, where the latter could be comparable to a T-DAB signal (see Appendix 1 in Annex 1). For this alternative scenario, an aggregated interfering field strength should be determined taking account for both contributions, the LoS satellite delivery as well as the terrestrial delivery components.

4.2.5 Maximum allowable power flux density

In respect of a satellite service as S-DAB, it is usual to coordinate in terms of the maximum allowable power flux density (φ_{maxi}) of the interfering signal, which is derived from the corresponding maximum allowable field strength (E_{maxi}) of the interfering signal, and calculated at 4 kHz bandwidth (by adding a conversion factor defined as "$10\log_{10}(4/1536)$"), as follows:

$$\varphi_{maxi} = E_{maxi} - 145.8 - 25.8 \text{ (dB(W/m}^2\text{/4kHz))} \quad \Leftrightarrow \quad \varphi_{maxi} = E_{maxi} - 171.6 \text{ (dB(W/m}^2\text{/4kHz))}.$$

The coordination criterion is based on MA02revCO07 [1], § 4.2.1, which states that the maximum allowable field strength of an interfering signal (E_{maxi}), to protect the minimum wanted field strength used for planning of a T-DAB signal (E_{med}), is calculated as follows:

$$E_{maxi} = E_{med} - PR - PCF \text{ (+ PDF) (dB}\mu\text{V/m)},$$

where PR is the T-DAB protection ratio against the interfering S-DAB signal, which is proposed to be of 15 dB, if S-DAB and T-DAB signals have the same structure (see Appendix 1 to Annex 1) and provided the S-DAB signal complies with the T-DAB spectrum mask as given in MA02revCO07.

Appendix 3 in Annex 1 provides considerations on the propagation correction factor (PCF) and the discrimination polarisation factor (PDF). In respect of PDF, it must be said that in MA02revCO07, §4.2.1, there is no note to consider, where relevant, receiving antenna directivity or polarisation discrimination (therefore the "PDF" in brackets in the above formula).

4.2.6 Results

Several examples of scenarios are presented in the Table 61 below, between a wanted T-DAB signal and an interfering S-DAB signal at several receiving antenna heights (≥1.5 m AGL), and valid for any one of the 7 T-DAB frequency blocks (LJ-LP) within the sub-band 1467-1479.5 MHz.

	CEPT (note 1)	ITU						
Scenarios (h ≥ 1.5 m AGL)	**----- (10 m)**	**LoS (1.5 m)**	**LoS (10 m)**	**LoS (10 m)**	**Hybrid (10 m)**	**Hybrid (1.5 m)**	**Hybrid (10 m)**	**Hybrid (≥20m)**
Scenario Id.	1	2	3	4	5	6	7	8
Typical environment	-----	Rural	rural	suburb	rural	suburb/urban	suburb	urban
L_h (dB)	10	0	19	21	19	0	21	27
$E_{med\ 1.5m\ agl}$ (dBµV/m)	59	60 (note 2)	60	60	60	60	60	60
$E_{med} = E_{med\_1.5m\ agl} + L_h$ (dBµV/m)	69	60	79	81	79	60	81	87
$PR_{co\text{-}block}$ (dB)	10	15 (note 3)	15	15	15	15	15	15
PCF (dB)	18	13	13	13	18	18	18	18
PDF (dB)	0	2 (note 4)	2	2	0	0	0	0
E_{maxi} (dBµV/m)	41	34	53	55	46	27	48	54
$\varphi_{maxi} = E_{maxi} - 171.6$ (dB(W/m^2/4kHz))	-130.6	-137.6	-118.6	-116.6	-125.6	-144.6	-123.6	-117.6

Table 61: Calculation of the maximum allowable power flux density at 4 kHz bandwidth

Note 1: see § 4.1 of MA02revCO07 [1]
Note 2: See case study in Table 63 in Appendix 2 to Annex 1.
Note 3: The 15 dB value is the co-block PR value for T-DAB vs. T-DAB in accordance with GE06 (§ 3.4), and it is used for the present situation, provided that the S-DAB signal complies with the T-DAB spectrum mask as given in MA02revCO07.
Note 4: A PDF of 2 dB is assumed in the LoS scenario, corresponding to an axial ratio of ≈2 dB (see Appendix 3 in Annex 1).

4.2.7 Conclusions

The results in Table 61 for the maximum allowable power flux density at 4 kHz bandwidth are frequency independent in the sub-band 1467-1479.5 MHz. In fact, being the E_{med} the term dependent of the frequency (see Appendix 2 to Annex 1), and since there are no important changes with the frequency variation, the results in Table 61 remain similar for all the 7 T-DAB frequency blocks (LJ-LP) in the sub-band 1467-1479.5 MHz.

The results presented in Table 61 stand for co-block values since they are the most significant in terms of coordination process. However, instead of the co-block T-DAB protection ratio ($PR_{co\text{-}block}$), it can also be used the adjacent block T-DAB protection ratio of “-30 dB” (see § 4.1 of MA02revCO07 [1]) in order to derive the corresponding E_{maxi} and φ_{maxi} values.

From observation of the scenarios indicated for ITU in Table 61, it seems to be advisable to consider the most appropriate scenario, for instance, as one of the four most conservatives, namely scenarios 2, 5, 6 and 7, for which correspond the most restrictive interference limits, as follows in Table 62 below.

ITU Scenarios (h ≥ 1.5 m AGL)	**LoS (1.5 m)**	**Hybrid (10 m)**	**Hybrid (1.5 m)**	**Hybrid (10 m)**
Scenario Id.	2	5	6	7
Typical environment	rural	rural	suburban/urban	suburban
L_h (dB)	0	19	0	21
$E_{med\ \ 1.5m\ agl}$ (dBµV/m)	60	60	60	60
$E_{med} = E_{med\_1.5m\ agl} + L_h$ (dBµV/m)	60	79	60	81
$PR_{co\text{-}block}$ (dB)	15	15	15	15
PCF (dB)	13	18	18	18
PDF (dB)	2	0	0	0
E_{maxi} (dBµV/m)	34	46	27	48
$\varphi_{maxi} = E_{maxi} - 171.6$ (dB(W/m^2/4kHz))	-137.6	-125.6	-144.6	-123.6

Table 62: Maximum allowable power flux density at 4 kHz bandwidth, for the four most conservative ITU scenarios of Table 61

In order to make an appropriate choice among these four most conservative scenarios, it could be added the following reasoning:

1) Scenario 2 (LoS, at 1.5 m AGL in rural area) seems to be realist, however it does not belong to the set of worst scenarios since it takes place in a rural environment where it is not expected so many occurrences when compared to a suburban or urban areas; this scenario corresponds to the second most restrictive scenario (φ_{maxi} = -137.6 dB(W/m^2/4kHz));
2) Scenario 5 (Hybrid, at 10 m AGL in rural area) seems to be not a realistic one, therefore it should be disregarded;
3) Scenario 6 (Hybrid, at 1.5 m AGL in suburban/urban areas) seems to be very realist, in fact corresponding to the most conservative scenario (φ_{maxi} = -144.6 dB(W/m^2/4kHz));
4) Scenario 7 (Hybrid, at 10 m AGL in suburban area) seems to be also realist, however it corresponds to the least restrictive scenario from these four ITU scenarios considered in Table 62 (φ_{maxi} = -123.6 dB(W/m^2/4kHz)).

Finally, a conclusion may be drawn from the above considerations. Scenario 2, since it does not fit to a worst scenario, should not be considered. Scenario 6, as the most conservative one, should be considered the appropriate choice in order to have a guarantee to cover all envisaged sharing situations. Scenario 7, since it is related to scenario 6 through the height loss correction factor of 21 dB, should not be disregarded.

So, the appropriate solution which may be adopted for the co-block T-DAB/S-DAB coordination in L-band, namely for the protection of the 7 T-DAB frequency blocks (LJ-LP) within the sharing sub-band 1467-1479.5 MHz, is proposed to be as follows:

$$\varphi_{maxi} = -144.6 \text{ dB(W/m}^2\text{/4kHz) at 1.5 m AGL}$$

or

$$\varphi_{maxi} = -123.6 \text{ dB(W/m}^2\text{/4kHz)}^{(7)} \text{ at 10 m AGL.}$$

4.2.8 Practical considerations

One administration reported that measurements were made concerning the supposed compatibility problem between T-DAB and satellite services (AFRIBSS, 21º E, AD beam (G_{max}=29 dBi; 1469 MHz$_{(block\ LJ)}$; B=3 MHz; e.i.r.p.$_{max\ peak}$=52.8 dBW)), within the -8 dB contour (see similar AD2 beam in Fig. 8 in Appendix 1 to Annex 1), whose final result was as follows:

PFD$_{(earth)}$ = -141.3 dB(W/m^2/4kHz) (where PFD stands for power flux density).

It shall be added that it is not mentioned the value of the receiving antenna height, just saying that the measurement was performed by the Leeheim Monitoring Earth Station. Assuming 10 m AGL, as it might be the case (since the corresponding interfering field strength was calculated and directly compared to the maximum allowable value), then it might be concluded, comparing to the above proposed limits, that T-DAB should be feasible without restrictions in Europe.

Furthermore, on the theoretical basis of ITU notices, it is foreseen in the -8 dB contour of AD beam a PFD$_{max}$ of -117.51 dBW/m^2 or -146.3 dB(W/m^2/4kHz) (related to -109.51 dBW/m^2 in the boresight, and taking account of the term 10log$_{10}$(4/3000)=-28.75). Compared to the above result of measurements, the theoretical value of -8 dB contour is exceeded by 5 dB.

However, a new satellite AfriStar-2 with SD1R beam (see Appendix 1 in Annex 1) seems to configure a worst case, since the boresight is in Europe with a PFD$_{max}$ of -130.9 dB(W/m^2/4kHz) (taking account of the term 10log$_{10}$(4/2600)=-28.13), and therefore new measurements seem to be needed.

5 ENVELOPE CONCEPT

Article 2.4 of MA02revCO07 indicated that The T-DAB Plan entries may be used for terrestrial mobile multimedia services with characteristics that may be different from those appearing in the Plan but within the envelope of their T-DAB Plan entry or aggregate entries under the provisions of the Special Arrangement, and that their administrations agree that any such use will be afforded protection to the levels defined by the interfering field strengths as arising from their Plan

---

[7] This value is higher by 0.5 dB than the limit of -124.1 dB(W/m^2/4kHz), which was proposed for coordination through two requests sent to the Portuguese Administration, by ANFR (France) in 9-Aug-2006 (used criterion: “69-6.5-18-171.6+3=-124.1”) and by FCC (USA) in 29-May-2008 (used criterion: “69-10-13-171.6+1.5=-124.1”).

entries, taking into account any relevant bilateral agreements. Systems with a bandwidth greater than one single T-DAB frequency block may be brought into operation by aggregating contiguous T-DAB frequency blocks which appear in the Plan under the conditions given in Annex 2 of the Agreement. Services brought into use under the terms of paragraph 2.4 shall not cause more interference nor claim more protection than the relevant T-DAB allotments in the Plan. Therefore, administrations shall consider the characteristics of the entry as given in Annex 2 of the Agreement. In order not to cause more interference than the corresponding entry, the procedure in Annex 4 of the Agreement shall be applied.

6 CONCLUSIONS

This ECC Report provides additional technical characteristics compared to those given in MA02revCO07 Agreement relating to:

- Hand-held reception of TV, audio, datacast and multimedia services
- Programme Making and Special Events (PMSE).

It also indicates that new systems are under development such as Next Generation Handheld (NGH) which may need to be further considered at a later stage.

In addition, it provides additional guidance on the maximum allowable PFD levels of the satellite networks to protect T-DAB systems for coordination with S-DAB systems in the sub-band 1467 MHz to 1479.5 MHz.

Finally, the report provides guidance to administrations in the application of the envelop concept in the framework of the MA02revCO07 Arrangement.

ANNEX 1: BACKGROUND FOR THE S-DAB/T-DAB COORDINATION

This section provides background material relating to the coordination between S-DAB and T-DAB with regard to:

- WorldSpace system (Appendix 1)
- Planning Field Strengths (Appendix 2)
- Propagation Correction and Polarisation Discrimination Factors (Appendix 3)

Appendix 1: WorldSpace System

In Rec. ITU-R BO.1130-4 [31], the WorldSpace system is considered under two types of digital systems in a total of five agreed digital systems. In Digital System D_s, the WorldSpace system is primarily designed to provide satellite digital audio and data broadcasting for fixed and portable reception. In Digital System D_H, also known as the hybrid satellite/terrestrial WorldSpace system, the system is also designed to provide satellite digital audio and data broadcasting for vehicular reception, besides fixed and portable reception.

The satellite delivery component of D_H is based on the same broadcast transport channel used in D_s (which is QPSK modulated onto a downlink TDM carrier), but with several significant enhancements designed to improve LoS reception in areas partially shadowed by trees.

The terrestrial delivery component of D_H is based on MCM (Multi Carrier Modulation), which is a multipath-resistant OFDM technique. The MCM terrestrial extension improves upon the techniques which are common in systems such as Digital System A, also known as the Eureka 147 DAB (Digital Audio Broadcasting) system.

Since WorldSpace systems D_s and D_H are considered as S-DAB systems, it may be useful to add some practical information on the relevant footprints intended to cover Europe, as those showed in figure 8 resulting of GSO AfriStar satellites at 21º East Longitude (E.L.) orbital location (which belong to the AFRIBSS Satellite Network of WorldSpace operator).

Each set of footprints showed in Figure 8 corresponds to one beam of AFRIBSS, either the SD1R on the left or the AD2 on the right. In each set of footprints, the service area boundary is represented by the “-8 dB” line (in bold), while the central cross represents the boresight of the corresponding satellite beam.

Particularising for the SD1R beam, corresponding to the AfriStar-2 satellite at 21º E.L. orbital location (authorized by FCC to be launched and operated since Jan-2006) some characteristics (taken from the respective ITU notice and FCC doc. DA 06-4) are added, as follows:

- Date of bringing into use of the SD1R beam: 01.02.2008;
- BSS (sound) service with two TDM carriers, each having a e.i.r.p.$_{\text{max peak}}$ of 59.8 dBW and circular polarisation (one on right-hand circular and the other on left-hand circular);
- Each TDM carrier has an assigned center frequency of 1479.5 MHz;
- Each TDM carrier has an allocated bandwidth of 2.6 MHz;
- PFD_{max} = -102.75 dBW/m^2, in the boresight ($\Leftrightarrow$ e.i.r.p.$_{\text{max peak}}$ of 59.8 dBW).

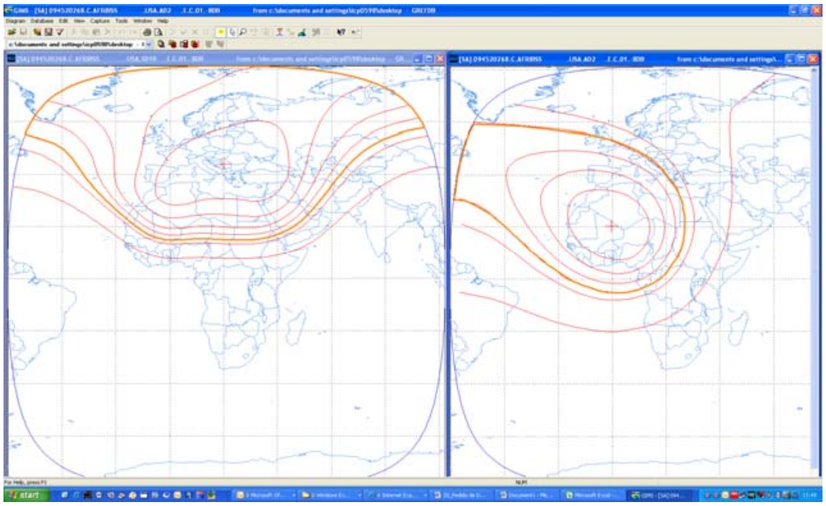


Figure 8: Two sets of footprints of AFRIBSS beams, SD1R on the left and AD2 on the right

Appendix 2: Planning Field Strengths

The general methodology for the calculation of the E_{med}, the minimum median field strength (which stands for the minimum wanted field strength used for planning), is similar to that indicated in Annex 3.4 of Chapter 3 to Annex 2 of the Final Acts of GE06 Agreement. Concerning E_{min} (minimum equivalent field strength at the location of the receiving antenna, necessary for the receiver to successfully decode the receiving signal – see Note 3 of § 1.3.9 of Annex 2 of GE06 [21]), it is possible to obtain a formula in terms of certain parameters, such as B (receiver noise bandwidth, 1.536 MHz for a T-DAB block), F (receiver noise figure), C/N (minimum RF S/N ratio at the receiver input required by the system), G_d (antenna gain related to half-wave dipole), and f (frequency, c_0/λ), as follows:

P_n (receiver input noise power, as $F+kT_0B$, where the Boltzmann's constant k is $1.38*10^{-23}$ J/K and the absolute temperature T_0 is 290 K) $\Leftrightarrow P_n = F + 10\log_{10}(B_{Hz}) - 204$ (dBW)
$P_{s\,min}$ (minimum receiver input signal power) $\Leftrightarrow P_{s\,min} = P_n + C/N$ (dBW)
G_i (antenna gain related to isotropic radiator) $\Leftrightarrow g_i = g_d*1.64 \Leftrightarrow G_i = G_d+2.15$ (dBi)
A_a (effective antenna aperture) $\Leftrightarrow A_a = 10\log_{10}(g_i.\lambda^2/4\pi) = G_d+20\log_{10}(\lambda_m)-8.8$ (dBm^2)
φ_{min} (min. power flux density at receiving place) $\Leftrightarrow \varphi_{min} = P_{s\,min} - A_a$ (dBW/m^2)
$E_{min(dB\mu V/m)}+20\log_{10}(10^{-6})=\varphi_{min(dBW/m^2)}+10\log_{10}(z_0)$ (z_0 is the free-space impedance of a plane wave, equal to $(\mu_0/\varepsilon_0)^{1/2}=\mu_0*c_0\approx 4\pi 10^{-7}.3.10^8=120\pi\ \Omega$) $\Leftrightarrow E_{min} = \varphi_{min} + 145.8$ (dBµV/m)
$E_{min} = 10\log_{10}(B_{Hz}) - 204 + F + C/N - G_d + 20\log_{10}(f_{MHz}) - 49.5 + 8.8 + 145.8$ (dBµV/m)

$$\Leftrightarrow E_{min} = 10\log_{10}(B_{Hz}) + F + C/N - G_d + 20\log_{10}(f_{MHz}) - 98.9 \text{ (dB}\mu\text{V/m).}$$

The E_{med} is based on E_{min} by adding, where relevant, appropriate correction factors, such as P_{mmn} (allowance for man made noise, 0 dB in L band), C_l (location correction factor, 12.8 dB for 99%L) and L_h (height loss correction factor, 0 dB for a receiving height of 1.5 m AGL), as follows:

$$E_{med} = E_{min} + P_{mmn} + C_l + L_h \text{ (dB}\mu\text{V/m).}$$

The calculation of E_{min} and E_{med} values is presented in Table 63 below for five cases. The last case is related to a case study, somehow corresponding to an appropriate combined reception mode, which may be considered to be adopted for T-DAB/S-DAB coordination in L-band.

	MA02revCO07	**Annex B of Tech 3317 (DAB mode I, PL3, Block 12B, 192 kbps)**			**Case study**
Reception mode	$MO_{Rayleigh}$	$MO_{TU\ 50km/h}$	$PO_{TU\ 0.7km/h}$	$MO_{RA\ 100km/h}$	MO – PO
B (Hz)	$1.5\ 10^6$	$1.536\ 10^6$	$1.536\ 10^6$	$1.536\ 10^6$	$1.536\ 10^6$
$10\log_{10}(B_{Hz})$	61.8	61.9	61.9	61.9	61.9
F (dB)	6	$6^{(Note\ 1)}$	$6^{(Note\ 1)}$	$6^{(Note\ 1)}$	$6^{(Note\ 1)}$
C/N (dB)	12	13.3	16.6	16.5	15
G_d (dBd)	$-2.15^{(Note\ 2)}$	0	0	0	$0^{(Note\ 1)}$
$20\log_{10}(f_{MHz})$ {1467(1479.5)}	63.3(4)	63.3(4)	63.3(4)	63.3(4)	63.3(4)
E_{min} (dBµV/m)	46	46	49	49	47
$E_{med1.5magl}=E_{min}+C_l$ (dBµV/m)	59	58(9)	62	62	60

Table 63: Calculation of E_{med} at 1.5 m AGL for T-DAB mobile and portable reception in the sub-band 1467-1479.5 MHz (⇔ 7 T-DAB blocks LJ-LP, being $20\log_{10}(f\geq 1470.7)_{LL-LP}=63.4$)

Note 1: See §2.5, §6.2 of EBU doc. BPN 003 (Feb-2003) where F of 6 dB is assumed in L-band (instead of 7 dB in VHF), and G_d of 0 dBd corresponds to an adapted antenna (Class C), which is the case of a half-wave dipole.
Note 2: In MA02revCO07 [1] (see § 2.1 of Annex 2), it is assumed that the representative receiving antenna for mobile and portable reception is at a height of 1.5 m agl, omni-direccional, and has a gain slightly lower than that of a dipole; however, in EBU contribution FM32(02)31 (7-Apr-2002) a value of -24.8 dBm^2 is indicated for A_a (effective antenna aperture) at 1470 MHz, which corresponds to an isotropic antenna with -2.15 dBd for G_d (indeed, similar to the VHF value of -2.2 dBd used for G_d in Table A.3.5-13 of RRC-04).

Appendix 3: Propagation Correction and Polarisation Discrimination Factors

Propagation Correction Factor

The propagation correction factor (PCF) is calculated by the formula “$2.33*sqrt((\sigma_w)^2+(\sigma_i)^2-2*\rho*\sigma_w*\sigma_i)$”, valid for T-DAB mobile and portable outdoor reception modes, where the coverage is needed for 99% of locations (distribution factor equal to 2.33); being the signals uncorrelated, it means that the correlation factor ρ is equal to 0.

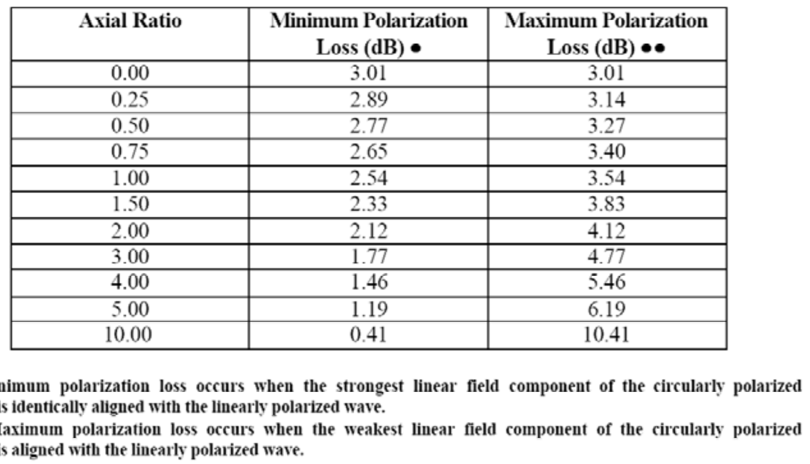
Concerning the calculation of the PCF, two extreme scenarios (see § 4.2.4) may be considered.

In a hybrid scenario, where the satellite may not be in the LoS of the victim, the receiving S-DAB signal may be considered as a variable distribution resulting of a combination of Gauss, Rice and Rayleigh statistics. So a standard deviation should be assumed at outdoor locations for S-DAB signal as a result of log-normal shadowing, multipath reflections from distant objects, and scattering, therefore having an estimated value up to 5.5 dB. Under the worst case when there is no LoS at all, it can be assumed σ_i=σ_w= 5.5 dB, and supposing no correlation between both signals (ρ=0), the PCF would become equal to 18 dB.

Supposing a satellite LoS scenario only, the satellite signal can be assumed for simplicity without standard deviation (σ_i=0 dB), however for T-DAB mobile reception a standard deviation (σ_w) of 5.5 dB is assumed [18], and then the PCF would become equal to 13 dB.

Polarisation Discrimination Factor

Concerning the polarisation discrimination factor (PDF), it can be said when the other service is S-DAB (1.5 GHz band) and in the case of a possible LoS S-DAB scenario, that it seems to be possible to take account of it. When considering the available information in Table 64, polarisation mismatch between a linearly and circularly polarised wave as a function of the circularly polarised wave’s axial ratio, then it may be possible to get a value for the PDF, if the value of the axial ratio of the WorldSpace signal is known; it seems that the PDF corresponds to a value to be chosen in the column of minimum polarisation loss.



Axial Ratio	Minimum Polarization Loss (dB) •	Maximum Polarization Loss (dB) ••
0.00	3.01	3.01
0.25	2.89	3.14
0.50	2.77	3.27
0.75	2.65	3.40
1.00	2.54	3.54
1.50	2.33	3.83
2.00	2.12	4.12
3.00	1.77	4.77
4.00	1.46	5.46
5.00	1.19	6.19
10.00	0.41	10.41

• Minimum polarization loss occurs when the strongest linear field component of the circularly polarized wave is identically aligned with the linearly polarized wave.
•• Maximum polarization loss occurs when the weakest linear field component of the circularly polarized wave is aligned with the linearly polarized wave.

Table 64: Polarisation Mismatch between a Linearly and Circularly Polarised Wave as a Function of the Circularly Polarised Wave’s Axial Ratio

Furthermore, it can be added that for S-DAB terminals, typical values of axial ratio range from 1 to 2 dB for vehicular antennas and up to 3 dB for low-cost handheld terminals, assuming linearly polarised antennas that are designed to receive both T-DAB and S-DAB signals in the 1452-1492 MHz band.”. So, unless better information may become available, it seems reasonable to choose a round value of 2 dB for the PDF in case of the LoS scenario.

Concerning the hybrid S-DAB scenario, it can be assumed the existence of a linearly polarised terrestrial delivery component of the S-DAB signal, likely of the same nature of the T-DAB signal, and which may be the dominant part, then it might be accepted that polarisation discrimination should not be considered for mobile and portable outdoor reception modes (as assumed, similarly, in § 3.2.2.8 of Annex 2 of Final Acts of RRC-06).

ANNEX 2: LIST OF REFERENCES

[1] Maastricht, 2002, Special Arrangement, as revised in Constanța, 2007 (MA02revCO07)
[2] Resolution 528 WARC 92 Rev. WRC03: Introduction of the broadcasting-satellite service (sound) systems and complementary terrestrial broadcasting in the bands allocated to these services within the range 1-3 GHz
[3] ECC/DEC/(03)02: Designation of 1479.5-1492 MHz for use by Satellite Digital Audio Broadcasting systems
[4] EBU BPN 067: Broadcasting to Hand-helds: Systems and Services consideration
[5] ETSI TS 102 427: Digital Audio Broadcasting (DAB); Data Broadcasting - MPEG-2 TS streaming
[6] ETSI TS 102 428: Digital Audio Broadcasting (DAB); DMB video service; User Application Specification
[7] ACTS - AC 318 MOTIVATE (Deliverable 06) Reference Receiver Model for planning of Mobile DVB-T Services
[8] ETSI TR 102 377 V1.4.1 (2009-06) and Draft TR 102 377 V1.3.1 (2009-03) Digital Video Broadcasting (DVB); DVB-H Implementation Guidelines
[9] EN 300 744 v 1.4.1 (2009-06): Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television
[10] ETSI TS 102 584 Digital Video Broadcasting (DVB); DVB-SH Implementation Guidelines
[11] ETSI EN 302 583: Digital Video Broadcasting (DVB); Framing Structure, channel coding and modulation for Satellite Services to Handheld devices (SH) below 3 GHz
[12] ETSI TS 102 585: Digital Video Broadcasting (DVB); System Specifications for Satellite services to Handheld devices (SH) below 3 GHz
[13] ETSI TS 102 589: Forward Link Only Air Interface;Specification for Terrestrial Mobile; Multimedia Multicast
[14] http://www.mediaflo.com/news/pdf/MediaFLO_field_test_report.pdf
[15] Recommendation ITU-R M.1225: Guidelines for Evaluation of Radio Transmission Technologies for IMT-2000
[16] Institut für Rundfunktechnik/Qualcomm report, "DVB-T and FLO Technology Coexistence Study", http://www.irt.de/fileadmin/media/downloads/pressemitteilungen/FLO_DVBT_co-existence_paper_final_090519.pdf
[17] EBU BPN 003 rev3: Technical Bases for T-DAB Services Network Planning and Compatibility with existing Broadcasting Services - Third Issue
[18] ITU-R Recommendation P.1546: Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz
[19] ECC Report 049: Technical criteria of Digital Video Broadcasting (DVB-T) and Terrestrial Digital Audio Broadcasting (T-DAB) allotment planning, Copenhagen, April 2004
[20] Measurements of the vehicle penetration loss characteristics at 800 MHz. 48th IEEE Vehicular technology Symposium, May 1998
[21] GE06 Agreement, Geneva, June 2006
[22] ITU-R Recommendation BT.1368-7: Planning criteria for digital terrestrial television services in the VHF/UHF bands
[23] ITU-R Recommendation BT.655-7: Radio-frequency protection ratios for AM vestigial sideband terrestrial television systems interfered with by unwanted analogue vision signals and their associated sound signals
[24] http://www.dvb.org/technology/dvb-ngh
[25] http://www.dvb.org/technology/dvb-ngh/DVB-NGH-Commercial-Requirements.pdf
[26] ECC Report 121: Compatibility studies between Professional Wireless Microphone Systems (PWMS) and other services/systems in the bands 1452-1492 MHz, 1492-1530 MHz, 1533-1559 MHz also considering the services/systems in the adjacent bands (below 1452 MHz and above 1559 MHz)
[27] ECC Report 147: Additional compatibility studies relating to PWMS in the 1518.1559 MHz excluding the band 1543.45-1543.95 MHz and 1544-1545 MHz
[28] ETSI TR 102 546: Electromagnetic compatibility and Radio spectrum Matters (ERM); Technical characteristics for Professional Wireless Microphone Systems (PWMS); System Reference Document
[29] ETSI EN 300 422: Technical characteristics and test methods for wireless microphones in the 25 MHz to 3 GHz frequency range
[30] EBU Tech 3317: Planning parameters for hand-held reception, considering the use of DVB-H and T-DMB in Bands III, IV, V and 1.5 GHz
[31] Recommendation ITU-R BO.1130-4 Systems for digital satellite broadcasting to vehicular, portable and fixed receivers in the bands allocated to BSS (sound) in the frequency range 1 400-2 700 MHz