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Radiocommunication Sector of ITU

Recommendation ITU-R BT.1306-8

(04/2020)

Error-correction, data framing, modulation and emission methods for digital terrestrial television broadcasting

BT Series

Broadcasting service (television)

International Telecommunication Union

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Note*: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R BT.1306-8

Error-correction, data framing, modulation and emission methods for digital terrestrial television broadcasting

(Question ITU-R 132-5/6)

(1997-2000-2005-2006-2009-03/2011-12/2011-2015-2020)

Scope

This Recommendation defines error-correction, data framing, modulation and emission methods for the existing digital terrestrial television broadcasting systems.

Keywords

Error correction, data framing, modulation characteristics, emission methods, DTTB

The ITU Radiocommunication Assembly,

considering

a) that digital terrestrial television broadcasting (DTTB) is being introduced in the VHF/UHF bands by some administrations from 1997;

b) that DTTB should fit into existing 6, 7, 8 MHz channels intended for analogue television transmission;

c) that it may be desirable to support the simultaneous transmission of a hierarchy of nested quality levels (including high definition television (HDTV)), standard definition TV (SDTV) and low definition TV (LDTV) within a single channel;

d) that it may be necessary for DTTB services to coexist with existing analogue television transmissions for a temporary period;

e) that many types of interference, including co-channel and adjacent channel, ignition noise, multipath and other signal distortions exist in the VHF/UHF bands;

f) that commonalities with alternative media, such as cable and satellite, could be advantageous at the level of outer coding scheme;

g) that it is necessary that the frame synchronization be capable of robustness in channels subject to transmission errors;

h) that it is desirable that the frame structure be adapted to different bit rate channels;

i) that both single carrier and multi-carrier modulation methods may be introduced;

j) that it is desirable that there be maximum commonality of characteristics between systems;

k) that it is desirable that there be maximum commonality between digital terrestrial television transmissions that are required to coexist with existing analogue television transmissions and those that are not;

l) that with the rapid evolution of digital technologies, digital terrestrial TV systems, proposed at different times, open new attractive possibilities and services;

m) that the selection of a modulation option needs to be based on specific conditions such as spectrum resource, policy, coverage requirements, existing network structure, reception conditions, type of service required, cost to the consumer and broadcasters,

recommends

that administrations wishing to introduce DTTB should use one of the families of error correction, framing, modulation and emission methods outlined in Annex 1.

Annex 1

Table 1a) provides data for single carrier systems; Table 1b) provides data about multi-carrier systems; Table 1c) provides data about multi-carrier systems with RF band segmentation; and Table 1d) provides data about the combined single- and multi-carrier systems. Specifications for Systems A, B, C and D are found in Attachments 1, 2, 3 and 4.

Selection guidelines for Systems A, B, C and D are described in Attachment 5 to Annex 1.

TABLE 1

Parameters for DTTB transmission systems

a) Single carrier systems

	Parameters	**6 MHz**	**7 MHz**	**8 MHz**
1	Used bandwidth	5.38 MHz (−3 dB)	6.00 MHz (−3 dB)	7.00 MHz (−3 dB)
2	Number of radiated carriers	1	1	1
3	Modulation method	8-VSB	8-VSB	8-VSB
4	Spectrum shaping function	Root raised cosine roll-off R = 5.8%	Root raised cosine roll-off R = 8.3%	Root raised cosine roll-off R = 7.1%
5	Channel occupancy(17)	See Rec. ITU-R BT.1206	–	–
6	Active symbol duration	92.9 ns	83.3 ns	71.4 ns
7	Overall symbol or segment duration	77.3 µs (segment)	69.3 µs (segment)	59.4 µs (segment)
8	Transmission frame duration	48.4 ms	43.4 ms	37.2 ms
9	Channel equalization			
10	Inner interleaving	12 (independently encoded streams interleaved in time)	24 (independently encoded streams interleaved in time)	28 (independently encoded streams interleaved in time)
	Inner channel	R = 2/3 trellis, concatenated R = 1/2 or R = 1/4 trellis	R = 2/3 trellis, concatenated R = 1/2 or R = 1/4 trellis	R = 2/3 trellis, concatenated R = 1/2 or R = 1/4 trellis
11	Outer channel Reed-Solomon (RS) code	RS (207,187, T = 10), concatenated RS (184,164, T = 10)	RS (207,187, T = 10), concatenated RS (184,164, T = 10)	RS (207,187, T = 10), concatenated RS (184,164, T = 10)
12	Outer interleaving	52 segment convolutional byte interleaved, concatenated 46 segment byte interleaved	52 segment convolutional byte interleaved, concatenated 46 segment byte interleaved	52 segment convolutional byte interleaved, concatenated 46 segment byte interleaved
13	Data randomization/ Energy dispersal	16 bit PRBS	16 bit PRBS	16 bit PRBS

TABLE 1 (*continued*)

a) Single carrier systems (*end*)

	Parameters	**6 MHz**	**7 MHz**	**8 MHz**
14	Time/frequency synchronization	Segment sync, pilot carrier	Segment sync, pilot carrier	Segment sync, pilot carrier
15	Frame synchronization	Frame sync	Frame sync	Frame sync
16	Data equalization	Frame sync, PN.511 and 3 × PN.63	Frame sync, PN.511 and 3 × PN.63	Frame sync, PN.511 and 3 × PN.63
17	Transmission mode identification	Mode symbols in frame sync	Mode symbols in frame sync	Mode symbols in frame sync
18	Net data rate	Depending on modulation code rate 4.23-19.39 Mbit/s	Depending on modulation code rate 4.72-21.62 Mbit/s	Depending on modulation code rate 5.99-27.48 Mbit/s
19	Carrier-to-noise ratio in an additive white Gaussian noise (AWGN) channel	Depending on channel code, 15.19 dB, 9.2 dB, 6.2 dB(1), (2)	Depending on channel code, 15.19 dB, 9.2 dB, 6.2 dB(2)	Depending on channel code, 15.19 dB, 9.2 dB, 6.2 dB(2)

b) Multi-carrier systems

	Parameters	**6 MHz multi-carrier (OFDM)**	**7 MHz multi-carrier (OFDM)**	**8 MHz multi-carrier (OFDM)**
1	Used bandwidth	5.71 MHz	6.66 MHz	7.61 MHz
2	Number of radiated carriers	1 705 (2k mode)(3) 3 409 (4k mode) 6 817 (8k mode)	1 705 (2k mode)(3) 3 409 (4k mode) 6 817 (8k mode)	1 705 (2k mode)(3) 3 409 (4k mode) 6 817 (8k mode)
3	Modulation mode	Constant coding and modulation (CCM)	Constant coding and modulation (CCM)	Constant coding and modulation (CCM)
4	Modulation method	QPSK, 16-QAM, 64-QAM, MR-16-QAM, MR-64-QAM(4)	QPSK, 16-QAM, 64-QAM, MR-16-QAM, MR-64-QAM(4)	QPSK, 16-QAM, 64-QAM, MR-16-QAM, MR-64-QAM(4)
5	Channel occupancy(17)	See Rec. ITU-R SM.1541	See Recs ITU-R BT.1206 or ITU-R SM.1541	See Recs ITU-R BT.1206 or ITU-R SM.1541
6	Active symbol duration	298.67 μs (2k mode) 597.33 μs (4k mode) 1 194.67 μs (8k mode)	256 μs (2k mode) 512 μs (4k mode) 1 024 μs (8k mode)	224 μs (2k mode) 448 μs (4k mode) 896 μs (8k mode)
7	Carrier spacing	3 348.21 Hz (2k mode) 1 674.11 Hz (4k mode) 837.05 Hz (8k mode)	3 906 Hz (2k mode) 1 953 Hz (4k mode) 976 Hz (8k mode)	4 464 Hz (2k mode) 2 232 Hz (4k mode) 1 116 Hz (8k mode)

TABLE 1 (*continued*)

b) Multi-carrier systems (*continued*)

	Parameters	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)
8	Guard interval duration	1/32, 1/16, 1/8, 1/4 of active symbol duration 9.33, 18.67, 37.33, 74.67 µs (2k mode) 18.67, 37.33, 74.67, 149.33 (4k mode) 37.33, 74.67, 149.33, 298.67 µs (8k mode)	1/32, 1/16, 1/8, 1/4 of active symbol duration 8, 16, 32, 64 µs (2k mode) 16, 32, 64, 128 µs (4k mode) 32, 64, 128, 256 µs (8k mode)	1/32, 1/16, 1/8, 1/4 of active symbol duration 7, 14, 28, 56 µs (2k mode) 14, 28, 56, 112 µs (4k mode) 28, 56, 112, 224 µs (8k mode)
9	Overall symbol duration	308.00, 317.33, 336.00, 373.33 µs (2k mode) 616.00, 634.67, 672.00, 746.67 µs (4k mode) 1 232.00, 1 269.33, 1 344.00, 1 493.33 µs (8k mode)	264, 272, 288, 320 µs (2k mode) 528, 544, 576, 640 µs (4k mode) 1 048, 1 088, 1 152, 1 280 µs (8k mode)	231, 238, 252, 280 µs (2k mode) 462, 476, 504, 560 µs (4k mode) 924, 952, 1 008, 1 120 µs (8k mode)
10	Transmission frame duration	68 OFDM symbols. One super frame consists of 4 frames	68 OFDM symbols. One super-frame consists of 4 frames	68 OFDM symbols. One super-frame consists of 4 frames
11	Inner channel code	Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8	Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8	Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8
12	Inner interleaving	Bit interleaving, combined with native or in-depth(5) symbol interleaving	Bit interleaving, combined with native or in-depth(5) symbol interleaving	Bit interleaving, combined with native or in-depth(5) symbol interleaving
13	Outer channel Reed-Solomon (RS) code	RS (204,188, T = 8)	RS (204,188, T = 8)	RS (204,188, T = 8)
14	Outer interleaving	Bytewise convolutional interleaving, I = 12	Bytewise convolutional interleaving, I = 12	Bytewise convolutional interleaving, I = 12
15	Data randomization/ energy dispersal	PRBS	PRBS	PRBS
16	Time/frequency synchronization	Pilot carriers(6)	Pilot carriers(6)	Pilot carriers(6)
17	IP outer channel code Reed-Solomon (RS) code	MPE-FEC RS (255,191)(7)	MPE-FEC RS (255,191)(7)	MPE-FEC RS (255,191)(7)
18	Receiver power consumption reduction	Time-slicing(8)	Time-slicing(8)	Time-slicing(8)

TABLE 1 (*continued*)

b) Multi-carrier systems (*end*)

	Parameters	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)
19	Transmission parameter signalling (TPS)(9)	Carried by TPS pilot carriers	Carried by TPS pilot carriers	Carried by TPS pilot carriers
20	System transport stream format	MPEG-2 TS	MPEG-2 TS	MPEG-2 TS
21	Net data rate	Depending on modulation, code rate and guard interval (3.69-23.5 Mbit/s for non-hierarchical modes)(10)	Depending on modulation, code rate and guard interval (4.35-27.71 Mbit/s for non-hierarchical modes)(10)	Depending on modulation, code rate and guard interval (4.98-31.67 Mbit/s for non-hierarchical modes)(10)
22	Carrier-to-noise ratio in an AWGN channel	Depending on modulation and channel code. 3.1-20.1 dB(11)	Depending on modulation and channel code. 3.1-20.1 dB(11)	Depending on modulation and channel code. 3.1-20.1 dB(11)

c) Multi-carrier systems with radio-frequency band segmentation(12)

	Parameters	6 MHz multi-carrier (segmented OFDM)	7 MHz multi-carrier (segmented OFDM)	8 MHz multi-carrier (segmented OFDM)
1	Numbers of segments (Ns)	13(13)	13(13)	13(13)
2	Segment bandwidth (Bws)	6 000/14 = 428.57 kHz	7 000/14 = 500 kHz	8 000/14 = 571.428 kHz
3	Used bandwidth (Bw)	Bw × Ns + Cs 5.575 MHz (Mode 1) 5.573 MHz (Mode 2) 5.572 MHz (Mode 3)	Bw × Ns + Cs 6.504 MHz (Mode 1) 6.502 MHz (Mode 2) 6.501 MHz (Mode 3)	Bw × Ns + Cs 7.434 MHz (Mode 1) 7.431 MHz (Mode 2) 7.430 MHz (Mode 3)
4	Number of radiated carriers	1 405 (Mode 1) 2 809 (Mode 2) 5 617 (Mode 3)	1 405 (Mode 1) 2 809 (Mode 2) 5 617 (Mode 3)	1 405 (Mode 1) 2 809 (Mode 2) 5 617 (Mode 3)
5	Modulation method	DQPSK, QPSK, 16-QAM, 64-QAM	DQPSK, QPSK, 16-QAM, 64-QAM	DQPSK, QPSK, 16-QAM, 64-QAM
6	Channel occupancy(17)	See Recs ITU-R BT.1206 or ITU-R SM.1541	See Recs ITU-R BT.1206 or ITU-R SM.1541	See Recs ITU-R BT.1206 or ITU-R SM.1541
7	Active symbol duration	252 µs (Mode 1) 504 µs (Mode 2) 1 008 µs (Mode 3)	216 µs (Mode 1) 432 µs (Mode 2) 864 µs (Mode 3)	189 µs (Mode 1) 378 µs (Mode 2) 756 µs (Mode 3)
8	Carrier spacing (Cs)	Bws/108 = 3.968 kHz (Mode 1) Bws/216 = 1.984 kHz (Mode 2) Bws/432 = 0.992 kHz (Mode 3)	Bws/108 = 4.629 kHz (Mode 1) Bws/216 = 2.314 kHz (Mode 2) Bws/432 = 1.157 kHz (Mode 3)	Bws/108 = 5.291 kHz (Mode 1) Bws/216 = 2.645 kHz (Mode 2) Bws/432 = 1.322 kHz (Mode 3)

TABLE 1 (*continued*)

c) Multi-carrier systems with radio-frequency band segmentation[(12)] (*continued*)

	Parameters	6 MHz multi-carrier (segmented OFDM)	7 MHz multi-carrier (segmented OFDM)	8 MHz multi-carrier (segmented OFDM)
9	Guard interval duration	1/4, 1/8, 1/16, 1/32 of active symbol duration 63, 31.5, 15.75, 7.875 µs (Mode 1) 126, 63, 31.5, 15.75 µs (Mode 2) 252, 126, 63, 31.5 µs (Mode 3)	1/4, 1/8, 1/16, 1/32 of active symbol duration 54, 27, 13.5, 6.75 µs (Mode 1) 108, 54, 27, 13.5 µs (Mode 2) 216, 108, 54, 27 µs (Mode 3)	1/4, 1/8, 1/16, 1/32 of active symbol duration 47.25, 23.625, 11.8125, 5.90625 µs (Mode 1) 94.5, 47.25, 23.625, 11.8125 µs (Mode 2) 189, 94.5, 47.25, 23.625 µs (Mode 3)
10	Overall symbol duration	315, 283.5, 267.75, 259.875 µs (Mode 1) 630, 567, 535.5, 519.75 µs (Mode 2) 1 260, 1 134, 1 071, 1 039.5 µs (Mode 3)	270, 243, 229.5, 222.75 µs (Mode 1) 540, 486, 459, 445.5 µs (Mode 2) 1 080, 972, 918, 891 µs (Mode 3)	236.25, 212.625, 200.8125, 194.90625 µs (Mode 1) 472.5, 425.25, 401.625, 389.8125 µs (Mode 2) 945, 850.5, 803.25, 779.625 µs (Mode 3)
11	Transmission frame duration	204 OFDM symbols	204 OFDM symbols	204 OFDM symbols
12	Inner channel code	Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8	Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8	Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8
13	Inner interleaving	Intra and inter segments interleaving (frequency interleaving). Symbolwise convolutional interleaving 0, 380, 760, 1 520 symbols (Mode 1) 0, 190, 380, 760 symbols (Mode 2) 0, 95, 190, 380 symbols (Mode 3) (time interleaving)	Intra and inter segments interleaving (frequency interleaving). Symbolwise convolutional interleaving 0, 380, 760, 1 520 symbols (Mode 1) 0, 190, 380, 760 symbols (Mode 2) 0, 95, 190, 380 symbols (Mode 3) (time interleaving)	Intra and inter segments interleaving (frequency interleaving). Symbolwise convolutional interleaving 0, 380, 760, 1 520 symbols (Mode 1) 0, 190, 380, 760 symbols (Mode 2) 0, 95, 190, 380 symbols (Mode 3) (time interleaving)
14	Outer channel code	RS (204,188, T = 8)	RS (204,188, T = 8)	RS (204,188, T = 8)
15	Outer interleaving	Bytewise convolutional interleaving, I = 12	Bytewise convolutional interleaving, I = 12	Bytewise convolutional interleaving, I = 12
16	Data randomization/ energy dispersal	PRBS	PRBS	PRBS
17	Time/frequency synchronization	Pilot carriers	Pilot carriers	Pilot carriers
18	Transmission and multiplexing configuration	Carried by TMCC pilot carriers	Carried by TMCC pilot carriers	Carried by TMCC pilot carriers

TABLE 1 (*continued*)

c) Multi-carrier systems with radio-frequency band segmentation(12) (*end*)

	Parameters	6 MHz multi-carrier (segmented OFDM)	7 MHz multi-carrier (segmented OFDM)	8 MHz multi-carrier (segmented OFDM)
19	Net data rate	Depending on number of segments, modulation, code rate, hierarchical structure and guard interval 3.65-23.2 Mbit/s	Depending on number of segments, modulation, code rate, hierarchical structure and guard interval 4.26-27.1 Mbit/s	Depending on number of segments, modulation, code rate, hierarchical structure and guard interval 4.87-31.0 Mbit/s
20	Carrier-to-noise ratio in an AWGN channel	Depending on modulation and channel code 5.0-23 dB(14)	Depending on modulation and channel code 5.0-23 dB(14)	Depending on modulation and channel code 5.0-23 dB(14)

d) Single- and multi-carrier combined systems

	Parameters	6 MHz	7 MHz	8 MHz
1	Used bandwidth	5.67 MHz	6.62 MHz	7.56 MHz
2	Number of radiated carriers	1 (single-carrier mode) 3 780 (multi-carrier mode)	1 (single-carrier mode) 3 780 (multi-carrier mode)	1 (single-carrier mode) 3 780 (multi-carrier mode)
3	Modulation mode	Constant coding and modulation (CCM)	Constant coding and modulation (CCM)	Constant coding and modulation (CCM)
4	Modulation method	4-QAM-NR, 4-QAM, 16-QAM, 32-QAM, 64-QAM	4-QAM-NR, 4-QAM, 16-QAM, 32-QAM, 64-QAM	4-QAM-NR, 4-QAM, 16-QAM, 32-QAM, 64-QAM
5	Channel occupancy(17)	See Rec. ITU-R BT.1206	See Rec. ITU-R BT.1206	See Rec. ITU-R BT.1206
6	Active symbol duration	0.176 μs (single-carrier mode) 666.67 μs (multi-carrier mode)	0.151 μs (single-carrier mode) 571.43 μs (multi-carrier mode)	0.132 μs (single-carrier mode) 500 μs (multi-carrier mode)
7	Carrier spacing	5.67 MHz (single-carrier mode) 1.5 kHz (multi-carrier mode)	6.62 MHz (single-carrier mode) 1.75 kHz (multi-carrier mode)	7.56 MHz (single-carrier mode) 2.0 kHz (multi-carrier mode)
8	Frame header duration	1/9, 1/6, 1/4 of frame body of the signal frame duration 74.07, 104.94, 166.67 μs	1/9, 1/6, 1/4 of frame body of the signal frame duration 63.49, 89.95, 142.86 μs	1/9, 1/6, 1/4 of frame body of the signal frame duration 55.56, 78.70, 125.00 μs
9	Overall signal frame duration	740.74, 771.60, 833.33 μs	634.92, 661.38, 714.29 μs	555.56, 578.70, 625.00 μs
10	Transmission frame duration	Day-frame of 24 hours, minute-frame of 60 s, super-frame of 166.7 ms, and signal-frames of 740.74, 771.60, 833.33 μs	Day-frame of 24 hours, minute-frame of 60 s, super-frame of 142.8 ms, and signal-frames of 634.92, 661.38, 714.29 μs	Day-frame of 24 hours, minute-frame of 60 s, super-frame of 125 ms, and signal-frames of 555.56, 578.70, 625.00 μs
11	Inner channel LDPC code	0.4 (7 488, 3 008), 0.6 (7 488, 4 512), 0.8 (7 488, 6 016)	0.4 (7 488, 3 008), 0.6 (7 488, 4 512), 0.8 (7 488, 6 016)	0.4 (7 488, 3 008), 0.6 (7 488, 4 512), 0.8 (7 488, 6 016)
12	Inner interleaving in frequency domain	Inside one signal frame (multi-carrier mode)	Inside one signal frame (multi-carrier mode)	Inside one signal frame (multi-carrier mode)

TABLE 1 (*continued*)

d) Single- and multi-carrier combined systems (*end*)

	Parameters	6 MHz	7 MHz	8 MHz
13	Outer channel BCH code	BCH (762, 752) derived from BCH (1 023, 1 013)	BCH (762, 752) derived from BCH (1 023, 1 013)	BCH (762, 752) derived from BCH (1 023, 1 013)
14	Outer convolutional interleaving in time domain	Number of interleaving branches B = 52, interleaving depth M = 240, 720	Number of interleaving branches B = 52, interleaving depth M = 240, 720	Number of interleaving branches B = 52, interleaving depth M = 240, 720
15	Data randomization/ energy dispersal	PRBS	PRBS	PRBS
16	Time/frequency synchronization	PN sequence as the frame header of signal frame(15)	PN sequence as the frame header of signal frame(15)	PN sequence as the frame header of signal frame(15)
17	System information	Carried by 36 system information symbols per signal frame	Carried by 36 system information symbols per signal frame	Carried by 36 system information symbols per signal frame
18	System transport stream format	MPEG-2 TS	MPEG-2 TS	MPEG-2 TS
19	Net data rate	Depending on modulation, code and frame header (3.610-24.436 Mbit/s)	Depending on modulation, code and frame header (4.211-28.426 Mbit/s)	Depending on modulation, code and frame header (4.813-32.486 Mbit/s)
20	Carrier-to-noise ratio in an AWGN channel	Depending on modulation and channel code. 2.5-22.0 dB(16)	Depending on modulation and channel code. 2.5-22.0 dB(16)	Depending on modulation and channel code. 2.5-22.0 dB(16)

Notes to Table 1:

BCH: Bose – Chandhuri – Hocquenghem multiple error correction binary block code

LDPC: low-density parity check

MPE-FEC: multi-protocol encapsulation-forward error correction

NR: nordstrom robinson

OFDM: orthogonal frequency division multiplex

PRBS: pseudo-random binary sequence

QPSK: quaternary phase shift keying

TMCC: transmission and multiplexing configuration control

VSB: vestigial side band.

(1) Measured value. After RS decoding, error rate 3×10^{-6}.

(2) The *C/Ns* are 9.2 dB for 1/2 rate concatenated trellis coding, and 6.2 dB for 1/4 rate concatenated trellis coding.

(3) The 2k mode can be used for single transmitter operation, for single frequency gap-fillers and for small single frequency network. The 8k mode can be used for the same network structures and also for large single frequency network. The 4k mode offers an additional trade-off between transmission cell size and mobile reception capabilities, providing an additional degree of flexibility for network planning of handheld and mobile coverage.

(4) 16-QAM, 64-QAM, MR-16-QAM and MR-64-QAM (MR-QAM: non-uniform QAM constellations) may be used for hierarchical transmission schemes. In this case, two layers of modulation carry two different MPEG-2 transport streams. The two layers may have different code rates and can be decoded independently.

Notes du Table 1 (end):

(5) In-depth symbol interleaver for the 2k and 4k modes for further improving their robustness in mobile environment and impulse noise conditions.

(6) Pilot carriers are continual pilots, carried by 45 (2k mode) or 177 (8k mode) carriers on all OFDM symbols, and scattered pilots, spread in time and frequency.

(7) For improvement in *C/N* performance and Doppler performance in mobile channels.

(8) In order to reduce the average power consumption of the terminal and enabling seamless frequency handover.

(9) TPS pilots carry information on modulation, code rate and other transmission parameters.

(10) The choice of modulation, code rate and guard interval depends on service requirements and planning environment.

(11) Simulated with perfect channel estimation, non-hierarchical modes. Error rate before RS decoding 2×10^{-4}, error rate after RS decoding 1×10^{-11}.

(12) Radio-frequency band segmentation allows use of appropriate modulation and error correction scheme segment by segment, and reception of a centre segment with narrow-band receivers.

(13) Multi-carrier systems with radio-frequency band segmentation uses 13 segments for television services while any number of segments may be used for other services such as sound services.

(14) Error rate before RS decoding 2×10^{-4}, error rate after RS decoding 1×10^{-11}.

(15) The signal frame consists of frame header (FH) and frame body (FB). FH uses pseudo-random binary sequence and single-carrier modulation as both the guard interval and the training sequence for the synchronization as well as channel estimation. FB has 3 744 data and 36 information symbols and could be modulated using either the single-carrier or multi-carrier scheme.

(16) Error rate after BCH decoding 3×10^{-6}.

(17) The parameter “Channel occupancy” is related to spectrum limit mask. Recommendation ITU-R SM.1541 provides out-of-band domain emission limits regarded as generic spectrum limit masks, which include digital terrestrial television broadcasting systems. Recommendation ITU-R BT.1206 provides specific spectrum limit masks for digital terrestrial television broadcasting systems for specific environments to enhance compatibility with other radiocommunication services.

Attachment 1 to Annex 1

System A Standard

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Attachment 2
to Annex 1

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Attachment 3
to Annex 1

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Attachment 4
to Annex 1

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Attachment 5
to Annex 1

System selection guideline

The process of selecting a suitable system may be thought of as an iterative one involving three phases:

– Phase I: an initial assessment of which system is most likely to meet the broadcaster's main requirements taking into account the prevailing technical/regulatory environment.

– Phase II: a more detailed assessment of the 'weighted' differences in performance.

– Phase III: an overall assessment of the commercial and operational factor impacting the system choice.

Given below is a fuller description of these three phases.

Phase I: Initial assessment

As a starting point, Table 2 may be used to assess which of the systems would best meet a particular broadcasting requirement.

TABLE 2

Guideline for the initial selection

Requirements		**Suitable systems**
Maximum data rate in a Gaussian channel for a given *C*/*N* threshold	Required	A or D
	Not required	A, B, C or D
Maximum ruggedness against multipath interference (1)	Required	B, C or D
	Not required	A, B, C or D
Single frequency networks (SFNs)	Required	B, C or D
	Not required	A, B, C or D
Mobile reception (1), (2)	Required	B, C or D
	Not required	A, B, C or D
Simultaneous transmission of different quality levels (hierarchical transmission)	Of primary importance	C
	Required	B or C
	Not required	A, B, C or D
Independent decoding of data sub-blocks (for example, to facilitate sound broadcasting)	Required	C
	Not required	A, B, C or D
Maximum coverage from central transmitter at a given power in a Gaussian environment (3)	Required	A or D
	Not required	A, B, C or D
Maximum ruggedness against impulse interference (4)	Required	A, C or D
	Not required	A, B, C or D

Notes relating to Table 2:

(1) Tradable against bandwidth efficiency and other system parameters.

(2) It may not be possible to provide HDTV reception in this mode.

(3) For all systems in situations with coverage holes, gap filler transmitters will be required.

(4) Systems B and C in 8K mode are applied for this comparison.

Phase II: Assessment of the weighted differences in performance

After an initial assessment has been made on the basis of Table 2, a more thorough selection process will require comparative evaluation of the performance of the candidate systems. This is the case because the choice of selection parameters itself is not a simple ‘black or white’ selection. In any given situation, any particular criterion will be of greater or lesser significance in the broadcasting environment under study which means that there has to be a means to identify a balance between small differences in performance and more important or less important selection parameters. In other words, it is clear that a small difference between systems against a critical parameter is likely to influence the choice more than large differences against relatively less important selection criteria.

The following methodology is recommended for this phase of system assessment:

Step 1: requires the identification of performance parameters that are relevant to the circumstances of the administration or broadcaster wishing to choose a DTTB system. These parameters might include the inherent performance capabilities of the digital system in itself, its compatibility with existing analogue services and the need for interoperability with other image communications or broadcasting services.

Step 2: requires the assignment of ‘weights’ to the parameters in order of importance or criticality to the environment in which the digital TV service is to be introduced. This weighting might be a simple multiplier such as 1 for ‘normal’ and 2 for ‘important’.

Step 3: involves the accumulation of test data from (preferably both) laboratory and field trials. This data can be gathered direct by the parties involved in the evaluation or may be obtained from others who have undertaken trials or evaluations. It is expected that Radiocommunication Study Group 6 (formerly Study Group 11) will, in the near future, prepare a report providing full technical evidence on the different DTTB systems, which may be used where adequate test data is not available from other reliable sources.

Step 4: then requires the matching of test data with performance parameters and the determination of a ‘rating’ against each parameter. The overall rating is used to choose a system that best matches the requirements. A tabular structure that uses a simple numerical rating and weighting scale has been found useful by some administrations. It is taken as a ‘given’ that all candidate systems are able to provide a viable DTTB service. Accordingly, the differences between systems will be relatively small. It is desirable to avoid unnecessary exaggeration of the differences but, at the same time, take care to ensure that the selection process is matched to the needs of the intended service. A simple and compact numerical rating scale can be one way to achieve these goals.

The following scales are examples that might be useful:

Performance	**Rating**
Satisfactory	1
Better	2
Best	3

In this scale a 0 (or null) value is given for a system that does not provide satisfactory performance against a given parameter or for a parameter that is unable to be evaluated.

Importance	**Weighting**
Normal	1
Significant	2
Critical	3

The following is an example of a tabular structure that might be used for comparative assessment of various systems.

No.	Criterion	System performance				Weighting	System rating			
		A	B	C	D		A	B	C	D
1	Characteristics of transmitted signals									
A	Robustness of signal									
	Immunity of electrical interference									
	Efficiency of transmitted signal									
	Effective coverage									
	Reception using indoor antenna									
	Adjacent channel performance									
	Co-channel performance									
B	Resilience to distortions									
	Resilience to multipath distortions									
	Mobile reception									
	Portable reception									

Phase III: Assessment of commercial and operational aspects

The final phase is an assessment of the commercial and operational aspects to ascertain which of the systems is indeed the best solution overall. Such an assessment will take into account the required timescales to service implementation, cost and availability of equipment, interoperability within an evolving broadcasting environment, etc.

Compatible receiver

In the cases where it is necessary to receive more than one modulation system option, compatible receivers will be needed. The cost of such receivers, taking into account the progress in digital technologies, should not be significantly more than receivers for a single modulation system, but the advantages of such receivers could be important. They may open the door to attractive additional possibilities and services for the consumer and broadcaster as indicated by Table 2. Studies continue on this matter.