



Recommendation ITU-R BT.1877-2
(12/2019)

**Error-correction, data framing, modulation
and emission methods and selection
guidance for second generation digital
terrestrial television broadcasting systems**

BT Series
Broadcasting service
(television)

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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.1877-2

Error-correction, data framing, modulation and emission methods and selection guidance for second generation digital terrestrial television broadcasting systems

(Question ITU-R 132-5/6, 133-1/6)

(2010-2012-2019)

Scope

This Recommendation defines error-correction, data framing, modulation and emission methods for the second generation of digital terrestrial television broadcasting transmission systems¹ (referred to, outside ITU-R, as a DVB-T2, ATSC 3.0, or DTMB-A system, respectively). Some of these systems have been developed such that they are compatible with the provisions of the GE06 Agreement. This Recommendation is intended for the digital terrestrial broadcasting transmission system, when high flexibility in the system configuration and broadcasting interactivity is of importance allowing for a wide-ranging trade-off between operation under minimal C/N levels or maximum transmission capacity².

The ITU Radiocommunication Assembly,

considering

- a) that the digital terrestrial television systems for use in broadcasting systems have been developed in Recommendation ITU-R BT.1306, which are referred to as the current systems;
- b) that digital terrestrial television broadcasting (DTTB) is being introduced in the VHF/UHF bands by some administrations from 1997 and second generation systems are currently being deployed by some administrations;
- c) that it may be desirable to support the simultaneous transmission of a hierarchy of nested quality levels (including low definition television (LDTV), high definition television (HDTV), ultra-high definition television (UHDTV), standard definition TV (SDTV), and supplementary data within a single channel;
- d) that many types of interference, including co-channel and adjacent channel, ignition noise, multipath and other signal distortions exist in the VHF/UHF bands;
- e) that it is necessary that the frame synchronization be capable of robustness in channels subject to transmission errors;
- f) that it is desirable that the frame structure be adapted to different bit rate channels;
- g) that recent developments in the field of channel coding and modulation have produced new techniques with performances approaching the Shannon limit;

¹ The second generation of digital terrestrial television broadcasting transmission systems in this Recommendation is meant as systems offering higher bit rate capacity per Hz and better power efficiency in comparison to the systems described in Recommendation ITU-R BT.1306, and there is no general requirement for backward compatibility with first-generation systems.

² For the first-generation systems information on planning parameters, protection ratios, etc. is already contained in relevant ITU-R Recommendations. For the second-generation systems, there is a need to study and include such information in the relevant ITU-R Recommendations.

- h) that these new digital techniques would offer better spectrum and/or power efficiency, in comparison to the current systems, whilst maintaining the possibility to be flexibly configured to cope with the specific broadcasting bandwidth and power resources;
- i) that the recommended systems make use of such techniques and thus allow for a wide-ranging trade-off between operation under minimal C/N levels or maximum transmission capacity;
- j) that the recommended systems would be capable to handle the variety of advanced audiovisual formats currently available and under definition, including immersive audio and ultra-high definition transmissions;
- k) 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;
- l) that advances in digital television transmission techniques are required to support content delivery to mobile devices;
- m) that second generation systems may also support IMT-2020 data transport to supplement downlink capacity offload and provide flexibility and efficiencies for telecommunications platforms,

recommends

that administrations wishing to introduce the second generation DTTB systems may consider one of the families of error correction, framing, modulation and emission methods outlined within Annexes 1, 2 and 3, with the system selection guidelines provided in Annex 4, taking into account the *further recommends* below,

further recommends

that an evaluation of the recommended systems to facilitate system selection should be included in a future revision of this Recommendation, which should be based on criteria relevant to terrestrial digital broadcasting, and may consist of the following information:

- a) a list of requirements and their relevance to the system parameters and technical features;
- b) a list of system parameters of the recommended systems; and
- c) a list of technical features of the recommended systems that concern aspects relevant to implementation and deployment.

Annex 1

DVB-T2

Currently two variants of the system are considered (referred to, outside ITU-R, as a DVB-T2 system) – for fixed and mobile reception of SDTV and HDTV services (referred to as the T2-Base profile or simply DVB-T2) and for reception by very low capacity applications such as mobile broadcasting (referred to as the T2-Lite profile). T2-Lite signals may also be received by conventional stationary DVB-T2 receivers.

Table 1 provides general data about the second-generation multi-carrier system with multiple physical layer pipes (PLP) covering both profiles. Notes 9-13 to Table 1 contain information on restrictions with respect to the T2-Base and T2-Lite profiles. Specifications and implementation guidelines for both profiles of this system are found in Attachment 1 to Annex 1.

TABLE 1
Parameters for the DVB-T2 DTTB transmission system
Second-generation multi-carrier system with multiple physical layer pipes (PLP)⁽¹⁾

No.	Parameters	1.7 MHz multi-carrier (OFDM) ⁽²⁾	5 MHz multi-carrier (OFDM) ⁽²⁾	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM) ⁽²⁾
1	Used bandwidth	1.54 MHz in normal mode	4.76 MHz in normal mode 4.82 MHz in extended mode (8k mode) 4.86 MHz in extended mode (16k and 32k mode)	5.71 MHz in normal mode 5.79 MHz in extended mode (8k mode) 5.83 MHz in extended mode (16k and 32k mode)	6.66 MHz in normal mode 6.75 MHz in extended mode (8k mode) 6.80 MHz in extended mode (16k and 32k mode)	7.61 MHz in normal mode 7.72 MHz in extended mode (8k mode) 7.77 MHz in extended mode (16k and 32k mode)	9.51 MHz in normal mode 9.65 MHz in extended mode (8k mode) 9.71 MHz in extended mode (16k and 32k mode)
2	Number of radiated carriers						
	1k mode ⁽¹⁰⁾	853	853	853	853	853	853
	2k mode	1 705	1 705	1 705	1 705	1 705	1 705
	4k mode	3 409	3 409	3 409	3 409	3 409	3 409
	8k mode	6 817 (8k mode)	6 817 (8k mode) 6 913 (8k extended mode)	6 817 (normal mode) 6 913 (extended mode)	6 817 (normal mode) 6 913 (extended mode)	6 817 (normal mode) 6 913 (extended mode)	6 817 (8k mode) 6 913 (8k extended mode)
	16k mode		13 633 (16k mode) 13 921 (16k extended mode)	13 633 (normal mode) 13 921 (extended mode)	13 633 (normal mode) 13 921 (extended mode)	13 633 (normal mode) 13 921 (extended mode)	13 633 (16k mode) 13 921 (16k extended mode)
	32k mode ⁽¹⁰⁾		27 265 (32k mode) 27 841 (32k extended mode)	27 265 (normal mode) 27 841 (extended mode)	27 265 (normal mode) 27 841 (extended mode)	27 265 (normal mode) 27 841 (extended mode)	27 265 (32k mode) 27 841 (32k extended mode)
3	Modulation modes	Constant coding and modulation (CCM)/variable coding and modulation (VCM)					

TABLE 1 (continued)

No.	Parameters	1.7 MHz multi-carrier (OFDM) ⁽²⁾	5 MHz multi-carrier (OFDM) ⁽²⁾	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM) ⁽²⁾
4	Modulation method	QPSK, 16-QAM, 64-QAM, 256-QAM specific for each physical layer pipe					
5	Channel occupancy	To be defined ⁽²⁾			See Rec. ITU-R BT.1206		To be defined ⁽²⁾
6	Active symbol duration						
	1k mode ⁽¹⁰⁾	554.99 μ s	179.2 μ s	149.33 μ s	128 μ s	112 μ s	89.60 μ s
	2k mode	1 109.98 μ s	358.4 μ s	298.67 μ s	256 μ s	224 μ s	179.20 μ s
	4k mode	2 219.97 μ s	716.8 μ s	597.33 μ s	512 μ s	448 μ s	358.40 μ s
	8k mode	4 439.94 μ s	1 433.6 μ s	1 194.67 μ s	1 024 μ s	896 μ s	716.8 μ s
	16k mode		2 867.2 μ s	2 389.33 μ s	2 048 μ s	1 792 μ s	1 433.6 μ s
	32k mode ⁽¹⁰⁾		5 734.40 μ s	4 778.67 μ s	4 096 μ s	3 584 μ s	2 867.2 μ s
7	Carrier spacing						
	1k mode ⁽¹⁰⁾	1 801.91 Hz	5 580.63 Hz	6 696.75 Hz	7 812.88 Hz	8 929 Hz	11 161.25 Hz
	2k mode	900.86 Hz	2 790 Hz	3 348 Hz	3 906 Hz	4 464 Hz	5 580.00 Hz
	4k mode	450.43 Hz	1 395 Hz	1 674 Hz	1 953 Hz	2 232 Hz	2 790.00 Hz
	8k mode	225.21 Hz	697.50 Hz	837 Hz	976 Hz	1 116 Hz	1 395.00 Hz
	16k mode		348.75 Hz	418.5 Hz	488.25 Hz	558 Hz	697.50 Hz
	32k mode ⁽¹⁰⁾		174.38 Hz	209.25 Hz	244.125 Hz	279 Hz	348.75 Hz

TABLE 1 (continued)

No.	Parameters	1.7 MHz multi-carrier (OFDM) ⁽²⁾	5 MHz multi-carrier (OFDM) ⁽²⁾	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM) ⁽²⁾
8	Guard interval duration ⁽³⁾	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration
	1k mode ⁽¹⁰⁾	34.69, 69.37, 138.75 µs	11.2, 22.4, 44.8 µs	9.3, 18.6, 37.3 µs	8, 16, 32 µs	7, 14, 28 µs	5.6, 11.2, 22.4 µs
	2k mode	34.69, 69.37, 138.75, 277.50 µs	11.2, 22.4, 44.8, 89.6 µs	9.3, 18.6, 37.3, 74.6 µs	8, 16, 32, 64 µs	7, 14, 28, 56 µs	5.6, 11.2, 22.4, 44.8 µs
	4k mode	69.37, 138.75, 277.50, 554.99 µs	22.4, 44.8, 89.6, 179.2 µs	18.6, 37.3, 74.6, 149.3 µs	16, 32, 64, 128 µs	14, 28, 56, 112 µs	11.2, 22.4, 44.8, 89.6 µs
	8k mode	34.69, 138.75, 277.50, 329.53, 554.99, 659.05, 1 109.98 µs	11.2, 44.8, 89.6, 106.4, 179.2, 212.8, 358.4 µs	9.3, 37.3, 74.6, 88.6, 149.3, 177.3, 298.6 µs	8, 32, 64, 75.9, 128, 152, 256 µs	7, 28, 56, 66.5, 112, 133, 224 µs	5.6, 22.4, 44.8, 53.2, 89.6, 106.4, 179.2 µs
	16k mode		22.4, 89.6, 179.2, 212.8, 358.4, 425.6, 716.8 µs	18.6, 74.6, 149.3, 177.3, 298.6, 354.6, 597.3 µs	16, 64, 128, 152, 256, 304, 512 µs	14, 56, 112, 133, 224, 266, 448 µs	11.2, 44.8, 89.6, 106.4, 179.2, 212.8, 358.4 µs
	32k mode ⁽¹⁰⁾		44.8, 179.2, 358.4, 425.6, 716.8, 851.2 µs	37.33, 149.33, 298.67, 354.67, 597.33, 709.33 µs	32, 128, 256, 304, 512, 608 µs	28, 112, 224, 266, 448, 532 µs	22.4, 89.6, 179.2, 212.8, 358.4, 425.6 µs
9	Overall symbol duration						
	1k mode ⁽¹⁰⁾	589.68-4578.69 µs	190.4, 201.6, 224 µs	158.6, 168, 186.6 µs	136, 144, 160 µs	119, 126, 140 µs	95.20-112.00 µs
	2k mode	1 144.67-1 387.48 µs	369.6, 381, 403, 448 µs	308, 317, 336, 373.3 µs	264, 272, 288, 320 µs	231, 238, 252, 280 µs	184.80-224.00 µs
	4k mode	2 289.34-2 774.96 µs	739, 762, 806, 896 µs	616, 635, 672, 746.6 µs	527.9, 544, 576, 640 µs	462, 476, 504, 560 µs	369.60-448.00 µs
	8k mode	4 474.63-5 549.92 µs	1 444.8, 1 478.4, 1 523.2, 1 540, 1 612.8, 1 646.4, 1 792 µs	1 204, 1 232, 1 269.3, 1 283.3, 1 344, 1 372, 1 493.3 µs	1 032, 1 056, 1 088, 1 100, 1 152, 1 176, 1 280 µs	903, 924, 952, 962.5, 1 008, 1 29, 1 120 µs	722.4, 739.2, 761.6, 770, 806.4, 823, 896 µs
	16k mode		2 889, 2 956.8, 3 046.4, 3 080, 3 225.6, 3 292.8, 3 584 µs	2 408, 2 464, 2 538.6, 2 566.6, 2 686, 2 744, 2 986.6 µs	2 064, 2 112, 2 176, 2 200, 2 304, 2 352, 2 560 µs	1 806, 1 848, 1 904, 1 925, 2 016, 2 058, 2 240 µs	1 444.8, 1 478.4, 1 523.2, 1 540, 1 612.8, 1 646.4, 1 792 µs
	32k mode ⁽¹⁰⁾		5 779.20-6 585.60 µs	4 816-5 488 µs	4 128-4 704 µs	3 612, 3 696, 3 808, 3 850, 4 032, 4 116 µs	2 889.6, 2 956.8, 3 046.4, 3 080, 3 225.6, 3 292.8 µs

TABLE 1 (continued)

No.	Parameters	1.7 MHz multi-carrier (OFDM) ⁽²⁾	5 MHz multi-carrier (OFDM) ⁽²⁾	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM) ⁽²⁾
10	Transmission frame duration ⁽⁶⁾	Frame starts with preamble and has a configurable number of symbols, with maximum duration of 250 ms. Minimum number of data symbols is 3 (32k mode) or 7 (other modes). Super-frame length is configurable, maximum 256 frames, 64 s					
11	Input stream format ⁽⁴⁾	Either transport streams (TS) or generic streams (GS)					
12	System stream format	BB format ⁽⁵⁾	BB format				
13	Mode adaptation code	CRC-8					
14	Channel coding ⁽⁹⁾	LDPC/BCH code with block size of 64 800 (64 K) ⁽¹⁰⁾ or 16 200 (16 K) bits and code rates 1/3 ⁽⁹⁾ , 2/5 ⁽⁹⁾ , 4/9, 1/2, 3/5, 2/3, 11/15, 3/4 ⁽¹⁰⁾ , 4/5 ⁽¹⁰⁾ , 37/45 ⁽¹⁰⁾ , 5/6 ⁽¹⁰⁾					
15	Interleaving	Bit, cell and time interleaving separately for each physical layer pipe. Common frequency interleaving ⁽¹⁾					
16	Constellation rotation	None, 29 (QPSK), 16.8 (16-QAM), 8.6 (64-QAM) degrees or atn (1/16) (256-QAM) ⁽¹⁰⁾					
17	Physical layer pipes (PLP)	Mode A with single PLP and mode B with multiple PLPs. Modulation, coding and time interleaving depth selectable separately for each PLP ^{(1) (7)}					
18	Data randomization/energy dispersal	PRBS					
	Initial scan	Fast scan process with special preamble symbol P1					
19	Time/frequency synchronization	Preamble symbols P1 and P2. Scattered pilot carriers with 8 different pilot patterns available ⁽¹³⁾ . Continual pilots					
20	MISO	An optional 2 × 1 Multiple Input Single Output (MISO) with Alamouti coding					
21	Receiver power consumption reduction	Physical layer pipes are organized as subslices in the frame. When receiving a single PLP only the preamble and relevant subslices are received and processed					
22	Layer 1 signalling	L1 signalling is carried by P2 symbols in the preamble. L1 pre-signalling is modulated with BPSK and coded with 1/4 16k LDPC. L1 post-signalling has configurable modulation and 1/2 16k LDPC coding. Option for in-band signalling within the PLP					
23	Layer 1 signalling	Either within the data PLPs or with special common PLP at the beginning of the frame					

TABLE 1 (end)

No.	Parameters	1.7 MHz multi-carrier (OFDM) ⁽²⁾	5 MHz multi-carrier (OFDM) ⁽²⁾	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM) ⁽²⁾
24	PAPR (Peak-to-Average Power Ratio)	Active Constellation Extension (ACE) and Tone Reservation (TR) as options					
25	Future Extension Frames (FEF)	A super frame can include one or several FEF-parts. These can be used for future extensions of the system					
26	Net data rate	0.22-10.17 Mbit/s, depending on FFT-size, modulation, code rate, guard interval, pilot pattern, MISO, FEF, PAPR	3.01-31.55 Mbit/s, depending on FFT-size, modulation, code rate, guard interval, pilot pattern, MISO, FEF, PAPR	4.01-37.8 Mbit/s, depending on FFT-size, modulation, code rate, guard interval, pilot pattern, MISO, FEF, PAPR	4.68-44.1 Mbit/s, depending on FFT-size, modulation, code rate, guard interval, pilot pattern, MISO, FEF, PAPR	5.35-50.4 Mbit/s, depending on FFT-size, modulation, code rate, guard interval, pilot pattern, MISO, FEF, PAPR	5.93-63.23 Mbit/s, depending on FFT-size, modulation, code rate, guard interval, pilot pattern, MISO, FEF, PAPR
27	Carrier-to-noise ratio in an AWGN channel	Depending on modulation and channel code. –1 to 22 dB ⁽⁸⁾					
28	Time interleaving memory	$2^{19}+2^{15}$ cells ⁽¹¹⁾ , 2^{18} cells ⁽¹²⁾					

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

LDPC: Low density parity check.

OFDM: Orthogonal frequency division multiplex.

PRBS: Pseudo-random binary sequence....0.

QAM: Quadrature amplitude modulation.

QPSK: Quaternary phase shift keying.

Notes to Table 1

- (1) Possibility for one or multiple physical layer pipes (PLP), each having its own specific modulation, coding and time interleaving depth, thus enabling service-specific robustness.
- (2) Spectrum-shaping limits for digital terrestrial television systems using 5 MHz, 6 MHz and 10 MHz channels needs to be defined. The 1.7, 5 and 10 MHz channel variants are not normally used for TV-broadcasting purposes in the VHF III or UHF IV/V bands. The 7 and 8 MHz variants of the system are compatible with the GE06 Agreement with respect to spectrum usage. The 1.7 MHz variant is compatible with T-DAB frequency planning.
- (3) All the fractions are not available for all FFT-modes.
- (4) As defined in EN 302 755 (DVB-T2 standard), system support following input stream formats: GSE (Generic Stream Encapsulated format), GFPS (Generic Fixed-length Packetized Stream format), GCS (Generic Continuous Stream format) and MPEG-2 TS.
- (5) Base band format, used in this second-generation broadcasting system.
- (6) Values correspond to maximum frame length in OFDM symbols excluding P1 symbols. For 1k mode the maximum length is defined for guard interval duration of 1/16, 1/8 and 1/4. For 4k and 2k modes the maximum length is defined for 1/32, 1/16, 1/8 and 1/4. In the case of 32k mode non-applicable only 1/4 guard interval. For more information see EN 302 755 (DVB-T2 standard). Number of OFDM symbols for 1.7 MHz, 5 MHz, 6 MHz, 7 MHz, 10 MHz is to be defined.
- (7) The system has a future option to spread the PLP subslices over multiple RF-channels within the frame. Time interleaving is applied over all these. Single profile receivers based on the first release of the specification do not support this.
- (8) Simulated in Gaussian channels with BER 1×10^{-4} before BCH coding, without correction for pilot boosting (which is dependent on pilot pattern). The expected implementation loss due to real channel estimation needs also to be added to the figures. This will be significantly less than the corresponding figure for first-generation multi-carrier systems due to better optimization of the boosting and pattern densities for second-generation multi-carrier systems.
- (9) Not used in T2-Base profile.
- (10) Not used in T2-Lite profile.
- (11) Applies to the T2-Base profile.
- (12) Applies to the T2-Lite profile.
- (13) T2-Lite profile has 7 pilot patterns.

Attachment 1 to Annex 1

System standard

- ETSI EN 302 755. Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2).
- ETSI TR 102 831. Digital Video Broadcasting (DVB); Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2).

Annex 2

ATSC 3.0

ATSC 3.0 is a suite of voluntary technical Standards and Recommended Practices that is fundamentally different from, and an operational replacement for, the predecessor ATSC Standard (known as ATSC 1.0), which was essentially limited to video and audio.

Compared to the current ATSC 1.0 standard, the ATSC 3.0 standard is intended to allow substantial improvements in performance, functionality and efficiency sufficient to warrant implementation of a non-backwards-compatible system. With higher capacity to deliver dramatically improved quality for video services, robust mobile reception on a wide range of devices, improved efficiency, IP transport, advanced emergency alerting, personalization features, and interactive capability, the ATSC 3.0 suite of standards provides much more capability than previous generations of terrestrial broadcasting in the same spectrum bandwidth. It also provides a means to integrate broadcast and broadband services and thus can be part of the 5G transmission ecosystem.

The ATSC 3.0 transmission system parameters are considered from very robust mobile reception to high-capacity fixed reception of SDTV, HDTV, and UHD TV services. Table 2 provides general data about the ATSC 3.0 system with multiple physical layer pipes (PLPs) covering both mobile and fixed receptions. Specifications and implementation guidelines this system are found in Attachments 1 and 2 to Annex 2.

TABLE 2

**Parameters for the ATSC 3.0 DTTB transmission system
Multi-carrier system with multiple physical layer pipes (PLP)⁽¹⁾**

No.	Parameters	1.7 MHz multi-carrier (OFDM) ⁽²⁾	5 MHz multi-carrier (OFDM) ⁽²⁾	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM) ⁽²⁾
1	Used bandwidth Reduced coefficient (Cred_coeff) 0 1 2 3 4	NA	NA	5.832 MHz 5.751 MHz 5.670 MHz 5.589 MHz 5.508 MHz	6.804 MHz 6.710 MHz 6.615 MHz 6.521 MHz 6.426 MHz	7.777 MHz 7.669 MHz 7.561 MHz 7.453 MHz 7.345 MHz	NA
2	Number of radiated carriers 8k mode 16k mode 32k mode	NA	NA	6 913 (Cred_coeff=0) 6 817 (Cred_coeff=1) 6 721 (Cred_coeff=2) 6 625 (Cred_coeff=3) 6 529 (Cred_coeff=4) 13 825 (Cred_coeff=0) 13 633 (Cred_coeff=1) 13 441 (Cred_coeff=2) 13 249 (Cred_coeff=3) 13 057 (Cred_coeff=4) 27 649 (Cred_coeff=0) 27 265 (Cred_coeff=1) 26 881 (Cred_coeff=2) 26 497 (Cred_coeff=3) 26 113 (Cred_coeff=4)	6 913 (Cred_coeff=0) 6 817 (Cred_coeff=1) 6 721 (Cred_coeff=2) 6 625 (Cred_coeff=3) 6 529 (Cred_coeff=4) 13 825 (Cred_coeff=0) 13 633 (Cred_coeff=1) 13 441 (Cred_coeff=2) 13 249 (Cred_coeff=3) 13 057 (Cred_coeff=4) 27 649 (Cred_coeff=0) 27 265 (Cred_coeff=1) 26 881 (Cred_coeff=2) 26 497 (Cred_coeff=3) 26 113 (Cred_coeff=4)	6 913 (Cred_coeff=0) 6 817 (Cred_coeff=1) 6 721 (Cred_coeff=2) 6 625 (Cred_coeff=3) 6 529 (Cred_coeff=4) 13 825 (Cred_coeff=0) 13 633 (Cred_coeff=1) 13 441 (Cred_coeff=2) 13 249 (Cred_coeff=3) 13 057 (Cred_coeff=4) 27 649 (Cred_coeff=0) 27 265 (Cred_coeff=1) 26 881 (Cred_coeff=2) 26 497 (Cred_coeff=3) 26 113 (Cred_coeff=4)	NA

TABLE 2 (continued)

No.	Parameters	1.7 MHz multi-carrier (OFDM) ⁽²⁾	5 MHz multi-carrier (OFDM) ⁽²⁾	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM) ⁽²⁾
3	Guard interval duration	NA	NA	192, 384, 512, 768, 1024, 1536, 2048, 2432, 3072, 3648, 4096, 4864 sample duration	192, 384, 512, 768, 1024, 1536, 2048, 2432, 3072, 3648, 4096, 4864 sample duration	192, 384, 512, 768, 1024, 1536, 2048, 2432, 3072, 3648, 4096, 4864 sample duration	NA
	8k mode			27.778, 55.556, 74.074, 111.111, 148.148, 222.222, 296.296 µs (192, 384, 512, 768, 1024, 1536, 2048 sample duration)	23.810, 47.619, 63.492, 95.238, 126.984, 190.476, 253.968 µs (192, 384, 512, 768, 1024, 1536, 2048 sample duration)	20.833, 41.667, 55.556, 83.333, 111.111, 166.667, 222.222 µs (192, 384, 512, 768, 1024, 1536, 2048 sample duration)	
	16k mode			27.778, 55.556, 74.074, 111.111, 148.148, 222.222, 296.296, 351.852, 444.444, 527.778, 592.593 µs (192, 384, 512, 768, 1024, 1536, 2048, 2432, 3072, 3648, 4096 sample duration)	23.810, 47.619, 63.492, 95.238, 126.984, 190.476, 253.968, 301.587, 380.952, 452.381, 507.937 µs (192, 384, 512, 768, 1024, 1536, 2048, 2432, 3072, 3648, 4096 sample duration)	20.833, 41.667, 55.556, 83.333, 111.111, 166.667, 222.222, 263.889, 333.333, 395.833, 444.444 µs (192, 384, 512, 768, 1024, 1536, 2048, 2432, 3072, 3648, 4096 sample duration)	
	32k mode			27.778, 55.556, 74.074, 111.111, 148.148, 222.222, 296.296, 351.852, 444.444, 527.778, 592.593, 703.704 µs (192, 384, 512, 768, 1024, 1536, 2048, 2432, 3072, 3648, 4096, 4864 sample duration)	23.810, 47.619, 63.492, 95.238, 126.984, 190.476, 253.968, 301.587, 380.952, 452.381, 507.937, 603.175 µs (192, 384, 512, 768, 1024, 1536, 2048, 2432, 3072, 3648, 4096, 4864 sample duration)	20.833, 41.667, 55.556, 83.333, 111.111, 166.667, 222.222, 263.889, 333.333, 395.833, 444.444, 527.778 µs (192, 384, 512, 768, 1024, 1536, 2048, 2432, 3072, 3648, 4096, 4864 sample duration)	

TABLE 2 (continued)

No.	Parameters	1.7 MHz multi-carrier (OFDM) ⁽²⁾	5 MHz multi-carrier (OFDM) ⁽²⁾	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM) ⁽²⁾
4	Active symbol duration 8k mode 16k mode 32k mode	NA	NA	1 185.185 μ s 2 370.370 μ s 4 740.740 μ s	1 015.873 μ s 2 031.746 μ s 4 063.492 μ s	888.889 μ s 1 777.778 μ s 3 555.556 μ s	NA
5	Carrier spacing 8k mode 16k mode 32k mode	NA	NA	843.75 Hz 421.875 Hz 210.9375 Hz	984.375 Hz 492.1875 Hz 246.09375 Hz	1 125 Hz 562.5 Hz 281.25 Hz	NA
6	Overall symbol duration 8k mode 16k mode 32k mode	NA	NA	1 212.963, 1 240.741, 1 259.259, 1 296.296, 1 333.333, 1 407.407, 1 481.481 μ s 2 398.148, 2 425.926, 2 444.444, 2 481.481, 2 518.518, 2 592.592, 2 666.666, 2 722.222, 2 814.814, 2 898.148, 2 962.963 μ s 4 768.518, 4 796.296, 4 814.814, 4 851.851, 4 888.888, 4 962.962, 5 037.036, 5 092.592, 5 185.184, 5 268.518, 5 333.333, 5 444.444 μ s	1 039.683, 1 063.492, 1 079.365, 1 111.111, 1 142.857, 1 206.349, 1 269.841 μ s 2 055.556, 2 079.365, 2 095.238, 2 126.984, 2 158.730, 2 222.222, 2 285.714, 2 333.333, 2 412.698, 2 484.127, 2.539.683 μ s 4 087.302, 4 111.111, 4 126.984, 4 158.730, 4 190.476, 4 253.968, 4 317.460, 4 365.079, 4 444.444, 4 515.873, 4 571.429, 4 666.667 μ s	909.722, 930.556, 944.445, 972.222, 1 000.000, 1 055.556, 1 111.111 μ s 1 798.611, 1 819.445, 1 833.334, 1 861.111, 1 888.889, 1 944.445, 2 000.000, 2 041.667, 2 111.111, 2 173.611, 2.222.222 μ s 3 576.389, 3 597.223, 3 611.112, 3 638.889, 3 666.667, 3 722.223, 3 777.778, 3 819.445, 3 888.889, 3 951.389, 4 000.000, 4 083.334 μ s	NA

TABLE 2 (continued)

No.	Parameters	1.7 MHz multi-carrier (OFDM) ⁽²⁾	5 MHz multi-carrier (OFDM) ⁽²⁾	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM) ⁽²⁾
7	Transmission frame duration	Frame starts with bootstrap and has a configurable number of preamble symbols and subframes. The minimum frame length is 50 ms and the maximum frame length is 5 seconds					
8	Frame length mode	Symbol-aligned, Time-aligned (5ms unit)					
9	Input stream format	ATSC Link-Layer Protocol (ALP) Packet					
10	System stream format	Baseband Packet (BBP) format					
11	Channel coding	Inner code: LDPC code with block size of 64 800 (64 K) or 16 200 (16 K) bits and code rates 2/15, 3/15, 4/15, 5/15, 6/15, 7/15, 8/15, 9/15, 11/15, 12/15, 13/15 Outer code: BCH, CRC, None					
12	Modulation	QPSK, 16-NUC, 64-NUC, 256-NUC, 1024-NUC, 4096-NUC specific for each physical layer pipe					
13	Modulation modes	Constant coding and modulation (CCM)/variable coding and modulation (VCM)					
14	Interleaving Type	Bit Interleaver: separately for each physical layer pipe Time Interleaver: separately for each physical layer pipe Frequency Interleaver: OFDM symbol base					
15	Time Interleaving	Convolutional Time Interleaver Hybrid Time Interleaver (HTI): Cell Interleaver, Twisted Block Interleaver, Convolutional Delay Line					
16	Maximum Time interleaving memory	2 ¹⁹ cells for normal mode 2 ²⁰ cells for extended interleaving mode (only for QPSK)					
17	Frequency Interleaving	Always applied to all of the Preamble symbol(s), but optional for data symbol					
18	Physical layer pipes (PLP)	Single PLP or multiple PLPs. Modulation, coding and time interleaving depth selectable separately for each PLP ⁽¹⁾⁽⁷⁾					
19	PLP Multiplexing	TDM, FDM, LDM, and combination of them (e.g. TFDM, LTDM, LFDM)					

TABLE 2 (continued)

No.	Parameters	1.7 MHz multi-carrier (OFDM) ⁽²⁾	5 MHz multi-carrier (OFDM) ⁽²⁾	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM) ⁽²⁾
20	Data randomization/ energy dispersal	PRBS					
	Initial scan	Fast scan process with bootstrap					
21	Time/frequency synchronization	Bootstrap and preamble symbol. Scattered pilot. Continual pilots. Edge pilots					
22	MISO	TDCFS (64 or 256 taps) as option					
23	Receiver power consumption reduction	Physical layer pipes are cell-multiplexed in the frame. When receiving a PLP, only the bootstrap, preamble, and relevant cells of the PLP are received and processed					
24	Layer 1 signalling	<p>Bootstrap: Essential parameters enabling emergency alert wake up and decoding the L1-Basic portion of the preamble</p> <p>L1-Basic (fixed 200 bits) in preamble: Signalling parameters that enable the decoding of L1-Detail and the initial processing of the first subframe</p> <p>L1-Detail (variable length) in preamble: Signalling parameters that enable the decoding of the remaining subframes and each PLP</p> <p>L1-Basic has five error protection modes and L1-Detail has seven different error protection modes</p>					
25	PAPR	Active Constellation Extension (ACE) and Tone Reservation (TR) as options					
26	Channel Bonding	Two RF channel bonding only as option					
27	MIMO	Cross-polarized MIMO only as option					
28	Future Extension Frames (FEF)	Bootstrap can indicate different version of frame. Non ATSC 3.0 frame can be used for future extensions of the system					
29	Net data rate	NA	NA	0.93-57.9 Mbit/s, depending on FFT-size, modulation, code rate, guard interval, pilot pattern, MISO, FEF, PAPR	1.08-67.5 Mbit/s, depending on FFT-size, modulation, code rate, guard interval, pilot pattern, MISO, FEF, PAPR	1.24-77.2 Mbit/s, depending on FFT-size, modulation, code rate, guard interval, pilot pattern, MISO, FEF, PAPR	NA

TABLE 2 (*end*)

No.	Parameters	1.7 MHz multi-carrier (OFDM) ⁽²⁾	5 MHz multi-carrier (OFDM) ⁽²⁾	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM) ⁽²⁾
30	Carrier-to-noise ratio in an AWGN channel	Depending on modulation and channel code. –6 to 33 dB ⁽³⁾					

AWGN: Additive white Gaussian noise

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

FDM: Frequency division multiplexing

LDM: Layered division multiplexing

LDPC: Low density parity check

LFDM: Layered frequency division multiplexing

LTDM: Layered time division multiplexing

MISO: Multiple input single output

MIMO: Multiple input multiple output

NUC: Non-uniform constellation

OFDM: Orthogonal frequency division multiplex

PAPR: Peak-to-average power ratio

PRBS: Pseudo-random binary sequence

QAM: Quadrature amplitude modulation

QPSK: Quaternary phase shift keying

TDCFS: Transmit diversity code filter sets

TDM : Time division multiplexing

TFDM : Time-frequency division multiplexing

Notes to Table 2:

- (1) Possibility for one or multiple physical layer pipes (PLP), each having its own specific modulation, coding and time interleaving depth, thus enabling service-specific robustness.
- (2) Spectrum-shaping limits for digital terrestrial television systems using 5 MHz, 6 MHz and 10 MHz channels needs to be defined. The 1.7, 5 and 10 MHz channel variants are not normally used for TV-broadcasting purposes in the VHF III or UHF IV/V bands. The 7 and 8 MHz variants of the system are compatible with the GE06 Agreement with respect to spectrum usage. ATSC 3.0 specification supports only 6 MHz, 7 MHz and 8 MHz bandwidths.
- (3) Simulated in Gaussian channels with BER 1×10^{-6} after LDPC and BCH decoding, without correction for pilot boosting (which is dependent on pilot pattern). The expected implementation loss due to real channel estimation needs also to be added to the figures.

Attachment 1 to Annex 2

ATSC System standard reference documents

- ATSC “ATSC System Discovery and Signaling,” Doc. A/321:2016, Advanced Television System Committee, Washington, D.C., 23 March 2016.
- ATSC “ATSC Physical Layer Protocol,” Doc. A/322:2017, Advanced Television System Committee, Washington, D.C., 6 June 2017.
- ATSC “Guidelines for the Physical Layer Protocol,” Doc. A/327:2018, Advanced Television System Committee, Washington, D.C., 2 October 2018.

Attachment 2 to Annex 2

Brief presentation of the ATSC 3.0 digital transmission standard

1 Introduction

The Advanced Television Systems Committee is a non-profit organization developing voluntary standards for digital television. The ATSC’s 130-plus member organizations represent the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.

ATSC 3.0 is a major version of the ATSC standards for digital television transmission over terrestrial, cable, and satellite networks. It is largely a replacement for the analogue NTSC standard, and like that standard, used mostly in the United States of America, Mexico, Canada and Korea. The new standard was created by the Advanced Television Systems Committee (ATSC). The standard reflects 25 sections including 21 Approved Standards and 4 Recommended Practices, which provide engineering guidance for implementation.

For reference purposes to this Recommendation, summaries of the key standards are reflected below.

A/300:2017 – ATSC 3.0 System

This Standard describes the entire suite of the ATSC 3.0 digital television system. ATSC 3.0 is a suite of voluntary technical Standards and Recommended Practices that is fundamentally different from predecessor ATSC systems and is therefore largely incompatible with them. This divergence from earlier design is intended to allow substantial improvements in performance, functionality, and efficiency sufficient to warrant implementation of a non-backwards-compatible system. With higher capacity to deliver Ultra High-Definition services, robust reception on a wide range of devices, improved efficiency, IP transport, advanced emergency alerting, personalization features and interactive capability, the ATSC 3.0 Standard provides much more capability than previous generations of terrestrial broadcasting.

In the fall of 2011, ATSC formed Technology Group 3 (TG-3) to design a next-generation broadcast system. TG-3 issued a Call for Input to solicit requirements for the system from a broad, international base of interests and organizations. Using this input, thirteen Usage Scenarios were developed, from which were derived a comprehensive set of system requirements. The system requirements established the capabilities of the overall system and thereby served as a guide in the preparation of the ATSC 3.0 suite of standards. The ATSC 3.0 Standard uses a layered architecture. Three layers are defined: Physical, Management and Protocols, and Application and Presentation. To facilitate flexibility and extensibility, different elements of the system are specified in separate Standards. The complete list and structure of these Standards is provided in Section 5.

Each ATSC 3.0 Standard is designed for maximum flexibility in its operation and is extensible to accommodate future adaptation. As a result, it is critical for implementers to use the most up-to-date revision of each Standard. The overall documentation structure also enables individual components of the system to be revised or extended without affecting other components. In some cases, multiple, fully parallel options are specified for certain operations, from which broadcasters can choose whichever method is more suitable to their operations or preferences. Examples include the use of either the MMT or ROUTE transport protocol, or the use of either the AC-4 or MPEG-H 3D Audio system.

Detailed Standard specifics are reflected at:

<https://www.atsc.org/wp-content/uploads/2017/10/A300-2017-ATSC-3-System-Standard-3.pdf>

A/321:2016 – System discovery and signalling

This document describes the system discovery and signalling architecture (the “bootstrap”) for the ATSC 3.0 physical layer. Broadcasters anticipate providing multiple wireless-based services, in addition to conventional broadcast television in the future. Such services may be time-multiplexed together within a single RF channel. The bootstrap provides a universal entry point into a broadcast waveform. The bootstrap employs a fixed configuration (e.g. sampling rate, signal bandwidth, subcarrier spacing, time-domain structure) known to all receiver devices and carries information to enable processing and decoding the wireless service associated with a detected bootstrap. This capability ensures that broadcast spectrum can be adapted to carry new services and/or waveforms for public interest to continue to be served in the future.

Broadcasters anticipate providing multiple wireless-based services, in addition to just broadcast television, in the future. Such services may be time-multiplexed together within a single RF channel. As a result, there exists a need to indicate, at a low level, the type or form of a signal that is being transmitted during a particular time period, so that a receiver can discover and identify the signal, which in turn indicates how to receive the services that are available via that signal. To enable such discovery, a bootstrap signal can be used. This comparatively short signal precedes, in time, a longer transmitted signal that carries some form of data. New signal types, at least some of which have likely not yet even been conceived, could also be provided by a broadcaster and identified within a transmitted waveform through the use of a bootstrap signal associated with each particular time-multiplexed signal. Some future signal types indicated by a particular bootstrap signal may even be outside the scope of the ATSC. The bootstrap provides a universal entry point into a broadcast waveform. The bootstrap employs a fixed configuration (e.g. sampling rate, signal bandwidth, subcarrier spacing, time-domain structure) known to all receiver devices and carries information to enable processing and decoding the signal associated with a detected bootstrap. This capability ensures that broadcast spectrum can be adapted to carry new signal types that are preceded by the universal entry point provided by the bootstrap, for public interest to continue to be served in the future. The bootstrap has been designed to be a very robust signal and detectable even at low signal levels. As a result of this robust encoding, individual signalling bits within the bootstrap are comparatively expensive in terms of the physical resources that they occupy for

transmission. Hence, the bootstrap is generally intended to signal only the minimum amount of information required for system discovery (i.e. identification of the associated signal) and for initial decoding of the following signal.

Detailed Standard specifics are reflected at:

<https://www.atsc.org/wp-content/uploads/2016/03/A321-2016-System-Discovery-and-Signaling-3.pdf>

A/322:2017 – Physical layer protocol

This Standard describes the RF/Transmission of a physical layer waveform. This waveform enables flexible configurations of physical layer resources to target a variety of operating modes. The intent is to signal the applied technologies and allow for future technology adaptation.

The ATSC physical layer protocol is intended to offer far more flexibility, robustness and efficient operations than the ATSC A/53 standard, and as a result it is non-backwards compatible with A/53. This physical layer allows broadcasters to choose from among a wide variety of physical layer parameters for personalized broadcaster performance that can satisfy many different broadcaster needs. There is the capability to have high-capacity/low-robustness and low-capacity/high robustness modes in the same emission. Technologies can be selected for special use cases like Single Frequency Networks, Multiple Input Multiple Output channel operation, channel bonding and more, well beyond a single transmitting tower. There is a large range of selections for robustness including, but not limited to, a wide range of guard interval lengths, forward error correction code lengths and code rates. Significant flexibility comes from a signalling structure that allows the physical layer to change technologies and evolve over time, while maintaining support of other ATSC systems. The starting point of this change is a physical layer offering highly spectral efficient operation with strong robustness across many different modes of operation.

Detailed Standard specifics are reflected at:

<https://www.atsc.org/wp-content/uploads/2016/10/A322-2017a-Physical-Layer-Protocol-1.pdf>

A/327:2018 – Guidelines for the physical layer protocol

This document provides recommended practices for the ATSC 3.0 physical layer protocol standards specified by A/321 and A/322. The intent of this document is to make recommendations for physical layer operating modes so that readers can make informed decisions about physical layer configurations. Also, this document provides some implementation guidelines to aid with flexible configurations of physical layer design resources in transmitter and receiver manufacturers' equipment.

The ATSC 3.0 physical layer protocol is designed to provide a toolbox of technology that allows flexible operating modes for a variety of harsh channel conditions (e.g. indoor or mobile) while maintaining efficient use of spectrum resources. This document provides recommended parameter and technology choices in A/321 and A/322 so that broadcasters can optimally deliver intended service(s). It also contains detailed guidelines for transmitter and receiver design implementations based on engineering studies of the latest technologies in the ATSC 3.0 physical layer. Guidelines for broadcasters' mobile service(s) are provided with operating modes and parameter choices of A/322 in aspects of robustness and power consumption. The ATSC 3.0 system performance and recommended service examples cover aspects of real field experiences and are intended to provide practical guidance for all readers.

Detailed Recommended Practice specifics are reflected at:

<https://www.atsc.org/wp-content/uploads/2018/10/A327-2018-Physical-Layer-RP.pdf>

Annex 3

DTMB-A

Digital Television Terrestrial Multimedia Broadcasting-Advanced (DTMB-A) is the advanced version of digital television terrestrial broadcasting (DTTB) system (i.e. DTMB), which can support higher data throughput than that of DTMB with more robust performance. DTMB-A supports ultra-high definition, high-definition, standard-definition TV, and data broadcasting services under indoor/outdoor and fixed/mobile reception conditions, and can be used for the large-area coverage within both multiple and single frequency networks. DTMB-A adopts multi-carrier modulation methods and advanced coding and modulation scheme with fast system synchronization, high receiving sensitivity, better performance against multi-path effect, high spectrum efficiency and the flexibility for the future extension.

Table 3 provides the system parameters about DTMB-A.

TABLE 3

Parameters for the Digital Television/Terrestrial Multimedia Broadcasting – Advanced

No.	Parameters		6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)
1	Used bandwidth		5.67 MHz with the roll off factor of 0.05, 5.83 MHz with the roll off factor of 0.025	6.62 MHz with the roll off factor of 0.05, 6.81 MHz with the roll off factor of 0.025	7.56 MHz with the roll off factor of 0.05, 7.78 MHz with the roll off factor of 0.025
2	Number of radiated carriers	4k mode	4 096	4 096	4 096
		8k mode	8 192	8 192	8 192
		32k mode	32 768	32 768	32 768
3	Modulation modes		Constant coding and modulation (CCM)/ variable coding and modulation (VCM)		
4	Modulation method		QPSK, 16-APSK, 64-APSK, 256-/APSK specific for each Service Channel		
5	Channel occupancy ⁽¹⁷⁾		See Recommendation ITU-R BT.1206		
6	Active symbol duration	4k mode	722.40 μ s with the roll off factor of 0.05, 702.17 μ s with the roll off factor of 0.025	619.20 μ s with the roll off factor of 0.05, 601.86 μ s with the roll off factor of 0.025	541.80 μ s with the roll off factor of 0.05, 526.63 μ s with the roll off factor of 0.025
		8k mode	1444.80 μ s with the roll off factor of 0.05, 1404.34 μ s with the roll off factor of 0.025	1238.40 μ s with the roll off factor of 0.05, 1203.72 μ s with the roll off factor of 0.025	1083.60 μ s with the roll off factor of 0.05, 1053.26 μ s with the roll off factor of 0.025
		32k mode	5779.19 μ s with the roll off factor of 0.05, 5617.37 μ s with the roll off factor of 0.025	4953.60 μ s with the roll off factor of 0.05, 4814.89 μ s with the roll off factor of 0.025	4334.40 μ s with the roll off factor of 0.05, 4213.03 μ s with the roll off factor of 0.025

TABLE 3 (continued)

No.	Parameters		6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)
7	Carrier spacing	4k mode	1 384 Hz with the roll off factor of 0.05, 1 424 Hz with the roll off factor of 0.025	1 615 Hz with the roll off factor of 0.05, 1 662 Hz with the roll off factor of 0.025	1 846 Hz with the roll off factor of 0.05, 1 899 Hz with the roll off factor of 0.025
		8k mode	692 Hz with the roll off factor of 0.05, 712 Hz with the roll off factor of 0.025	807 Hz with the roll off factor of 0.05, 831 Hz with the roll off factor of 0.025	923 Hz with the roll off factor of 0.05, 949 Hz with the roll off factor of 0.025
		32k mode	173 Hz with the roll off factor of 0.05, 178 Hz with the roll off factor of 0.025	202 Hz with the roll off factor of 0.05, 208 Hz with the roll off factor of 0.025	231 Hz with the roll off factor of 0.05, 237 Hz with the roll off factor of 0.025
8	Guard interval duration	4k mode (1/8, 1/4, 1/2)	90.3, 181, 361 μ s with the roll off factor of 0.05. 87.8, 176, 351 μ s with the roll off factor of 0.025	77.4, 155, 310 μ s with the roll off factor of 0.05. 75.2, 150, 301 μ s with the roll off factor of 0.025	67.7, 135, 271 μ s with the roll off factor of 0.05. 65.8, 132, 263 μ s with the roll off factor of 0.025
		8k mode (1/16, 1/8, 1/4)	90.3, 181, 361 μ s with the roll off factor of 0.05. 87.8, 176, 351 μ s with the roll off factor of 0.025	77.4, 155, 310 μ s with the roll off factor of 0.05. 75.2, 150, 301 μ s with the roll off factor of 0.025	67.7, 135, 271 μ s with the roll off factor of 0.05. 65.8, 132, 263 μ s with the roll off factor of 0.025
		32k mode (1/64, 1/32, 1/16)	90.3, 181, 361 μ s with the roll off factor of 0.05. 87.8, 176, 351 μ s with the roll off factor of 0.025	77.4, 155, 310 μ s with the roll off factor of 0.05. 75.2, 150, 301 μ s with the roll off factor of 0.025	67.7, 135, 271 μ s with the roll off factor of 0.05. 65.8, 132, 263 μ s with the roll off factor of 0.025
9	Overall symbol duration	4k mode	813, 903, 1 084 μ s with the roll off factor of 0.05. 790, 878, 1 053 μ s with the roll off factor of 0.025	679, 774, 929 μ s with the roll off factor of 0.05. 677, 752, 903 μ s with the roll off factor of 0.025	610, 677, 813 μ s with the roll off factor of 0.05. 592, 658, 790 μ s with the roll off factor of 0.025
		8k mode	1 535, 1 625, 1 806 μ s with the roll off factor of 0.05. 1 492, 1 580, 1 755 μ s with the roll off factor of 0.025	1 316, 1 393, 1 548 μ s with the roll off factor of 0.05. 1 279, 1 354, 1 505 μ s with the roll off factor of 0.025	1 151, 1 219, 1 354 μ s with the roll off factor of 0.05. 1 119, 1 185, 1 317 μ s with the roll off factor of 0.025
		32k mode	5 869, 5 960, 6 140 μ s with the roll off factor of 0.05. 5 705, 5 793, 5 968 μ s with the roll off factor of 0.025	5 031, 5 108, 5 263 μ s with the roll off factor of 0.05. 4 890, 4 965, 5 116 μ s with the roll off factor of 0.025	4 402, 4 470, 4 605 μ s with the roll off factor of 0.05. 4 279, 4 345, 4 467 μ s with the roll off factor of 0.025
10	Super frame duration		Super frame starts with super-frame synchronization channel and a control channel for service channel signalling. Each super-frame has configurable number of data signal frames, with maximum duration of 250 μ s		
11	Input stream format		Transport streams (TS)		

TABLE 3 (end)

No.	Parameters	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)
12	Channel coding	LDPC/BCH code with block size of 61 440 or 15 360 bits and code rates of 1/2, 2/3, 5/6		
13	Interleaving	Bit interleaving, bit permutation and time interleaving separately for each service channel		
14	Service Channel	Support for multiple service channels. Modulation, coding and time interleaving depth selectable separately for each service channel		
15	Data randomization/energy dispersal			
	Initial scan	Fast scan process with special super-frame synchronization channel		
16	Time/frequency synchronization	Super-frame synchronization channel and dual PN-MC symbols of each signal frame		
17	Multiple input single output (MISO)	An optional 2 × 1 MISO configuration with Alamouti coding in the space-frequency domain		
18	Receiver power consumption reduction	Service channels are organized in both time and frequency domains. When receiving a single service channel only the service channel signalling and relevant slices are received and processed		
19	Service channel signalling	Service channel signalling is carried by control channel in the super frame. The signal frame size for the control channel is 4096, and the PM-MC symbol length is 1024, modulated with QPSK and coded with punctured 2/3 15360 LDPC for OFDM.		
20	Peak-to-average power ratio (PAPR)	Special active constellation extension (ACE) for APSK constellation as options		
21	Extension Frame	A super frame can include extension frame. The extension frame can be used as NULL signals or for uplink services		
22	Payload	3.75-37 Mbit/s with the roll off factor of 0.05, 3.86-38 Mbit/s with the roll off factor of 0.025, depending on FFT-size, modulation, code rate, guard interval	4.38-43.1 Mbit/s with the roll off factor of 0.05, 4.5-44.4 Mbit/s with the roll off factor of 0.025, depending on FFT-size, modulation, code rate, guard interval	5.0-49.31 Mbit/s with the roll off factor of 0.05, 5.14-50.73 Mbit/s with the roll off factor of 0.025, depending on FFT-size, modulation, code rate, guard interval
23	Carrier-to-noise ratio over AWGN channel	Depending on modulation and channel code. 0.62-21.08 dB @ BER=1E-5, for the 7.56 MHz system bandwidth		

APSK: Amplitude and phase shift keying

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

LDPC: Low density parity check

OFDM: Orthogonal frequency division multiplex

PN-MC: Multi-carrier PN-sequence

PRBS: Pseudo-random binary sequence

QPSK: Quaternary phase shift keying

Attachment 1 to Annex 3

System standard

DTMB-A Chinese Standard GD/J 068-2015. Frame Structure, Channel Coding and Modulation for Digital Television/Terrestrial Multimedia Broadcasting-Advanced (DTMB-A).

Annex 4

System selection guidelines

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 4 may be used to assess which of the systems would best meet a particular broadcasting requirement.

TABLE 4
Guidelines for the initial selection

Requirements		Table Reference A – ATSC 3.0 B – DVB-T2 C – DTMB-A
Maximum data rate in a Gaussian channel for a given C/N threshold	Required	A, B, or C
	Not required	A, B, or C
Maximum ruggedness against multipath interference ⁽¹⁾	Required	A, B, or C
	Not required	A, B, or C
Single frequency networks (SFNs)	Required	A, B, or C
	Not required	A, B, or C
Mobile reception ⁽¹⁾	Required	A, B, or C
	Not required	A, B, or C
Simultaneous transmission of different quality levels (hierarchical transmission)	Required	A, B, or C
	Not required	A, B, or C
Independent decoding of data sub-blocks (for example, to facilitate sound broadcasting)	Required	A, B, or C
	Not required	A, B, or C
Maximum coverage from central transmitter at a given power in a Gaussian environment ⁽²⁾	Required	A, B, or C
	Not required	A, B, or C
Maximum ruggedness against impulse interference	Required	A, B, or C
	Not required	A, B, or C

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

⁽²⁾ For all systems in situations with coverage holes, gap filler transmitters will be required.

Phase II: Assessment of the weighted differences in performance

After an initial assessment has been made on the basis of Table 4, 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 the existing 1st gen DTTB and 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		A	B	C
1	Characteristics of transmitted signals							
2	Robustness of signal							
3	Immunity of electrical interference							
4	Efficiency of transmitted signal							
5	Effective coverage							
6	Reception using indoor antenna							
7	Adjacent channel performance							
8	Co-channel performance							
9	Resilience to distortions							
10	Resilience to multipath distortions							
11	Mobile reception							
12	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 4. Studies continue on this matter.
