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Digital Video Broadcasting (DVB); Implementation guidelines for the use of MPEG-2 systems, video and audio in satellite, cable and terrestrial broadcasting applications

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Foreword

This ETSI Technical Report (ETR) has been produced by the Joint Technical Committee (JTC) of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI). This ETR is based on the DVB document TM 1214 revision 9, dated September 1996, and it may be converted into an ETS after market feedback. For this purpose, the wording of an ETS rather than an ETR is used.

ETRs are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim European Telecommunication Standard (I-ETS) status. An ETR may be used to publish material which is either of an informative nature, relating to the use or the application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or an I-ETS.

NOTE: This EBU/ETSI Joint Technical Committee (JTC) was established in 1990 to co-ordinate the drafting of European Telecommunications Standards (ETSs) in the specific field of radio, television and data broadcasting.

The EBU is a professional association of broadcasting organizations whose work includes the co-ordination of its Members' activities in the technical, legal, programme-making and programme-exchange domains. The EBU has active members in about 60 Countries in the European Broadcasting area; its headquarters is in Geneva *.

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Introduction

This ETR presents guidelines covering coding and decoding using the MPEG-2 system defined in ISO/IEC IS *13818* [1].

The guidelines presented in this ETR for the Integrated Receiver-Decoder (IRD) are intended to represent a minimum functionality that all IRDs are assumed to either meet or exceed. It is necessary to specify the minimum IRD functionality for basic parameters, if broadcasters are not to be prevented from ever using certain features. For example, if a significant population of IRDs were produced that supported only the Simple Profile, broadcasters would never be able to transmit Main Profile bit-streams.

Where a feature is mandatory, the word "shall" is used and the text is in italic; all other features are optional. The functionality is specified in the form of constraints on MPEG-2 systems, video and audio which the IRDs are required to decode correctly.

The specification of these baseline features in no way prohibits IRD manufacturers from including additional features, and should not be interpreted as stipulating any form of upper limit to the performance. The guidelines do not cover features, such as the IRD's up-sampling filter, which affect the quality of the displayed picture rather than whether the IRD is able to decode pictures at all. Such issues are left to the marketplace.

The guidelines presented for IRDs observe the following principles:

- wherever practical, IRDs should be designed to allow for future compatible extensions to the bit-stream syntax;
- all "reserved" and "private" bits in MPEG-2 systems, video and audio should be ignored by IRDs not designed to make use of them.

The rules of operation for the encoders are features and constraints which the encoding system should adhere to in order to ensure that the transmissions can be correctly decoded by Baseline IRDs. These may be mandatory or optional. Where a feature or constraint is mandatory, the word "shall" is used and the text is italic; all other features are optional.

Clauses 4 to 6 provide the guidelines for the Digital Video Broadcasting (DVB) systems layer, video and audio respectively. For information, some of the key features are summarized below, but clauses 4 to 6 should be consulted for all definitions:

Systems:

- MPEG-2 Transport Stream (TS) is used;
- Service Information (SI) is based on MPEG-2 program-specific information;
- scrambling is as defined in ETR 289 [5];
- conditional access uses the MPEG-2 Conditional Access CA_descriptor;
- Partial Transport Streams are used for digital VCR applications.

Video:

- MPEG-2 Main Profile at Main Level is used;
- the frame rate is 25 Hz;
- encoded pictures may have either 4:3, 16:9 or 2.21:1 aspect ratio;
- IRDs support 4:3 and 16:9 and optionally 2.21:1 aspect ratios;
- IRDs support the use of pan vectors to allow a 4:3 monitor to give a full-screen display of a 16:9 coded picture;
- IRDs support a full-screen display of 720 x 576 pixels (and a nominal full-screen display of 704 x 576);
- IRDs provide appropriate up-conversion to produce a full-screen display of 544 x 576 and 480 x 576 and a nominal full-screen display of 352 x 576 and 352 x 288 pixels.

Audio:

- MPEG-2 Layer I and Layer II is supported by the IRD;
- the use of Layer II is recommended for the encoded bit-stream;
- IRDs support single channel, dual channel, joint stereo, stereo and the extraction of at least a stereo pair from MPEG-2 compatible multi-channel audio;
- sampling rates of 32 kHz, 44,1 kHz and 48 kHz are supported by IRDs;
- the encoded bit-stream does not use emphasis.

1 Scope

This ETR provides implementation guidelines for the use of MPEG-2 audio-visual coding in satellite and cable broadcasting systems offering conventional resolution digital television. Guidelines for devices equipped with a digital interface intended for digital VCR applications are also given in this ETR. It does not cover applications such as interactive services or HDTV which are likely to be the subject of subsequent "Guidelines" documents.

The rules of operation for the encoders are features and constraints which the encoding system should adhere to in order to ensure that the transmissions can be correctly decoded by Baseline IRDs. These may be recommended or optional.

2 References

For the purposes of this ETR, the following references apply:

[1] ISO/IEC IS 13818-1 (1994): "Coding of moving pictures and associated audio - Part 1: Systems".

[2] ISO/IEC IS 13818-2 (1994): "Coding of moving pictures and associated audio - Part 2: Video".

[3] ISO/IEC IS 13818-3: "Coding of moving pictures and associated audio - Part 3: Audio".

[4] ISO/IEC IS 13818-9: "Coding of moving pictures and associated audio - Part 9: Extension for Real-Time-Interface for systems decoders ".

[5] ETR 289: "Digital Video Broadcasting (DVB); Common Scrambling (CS) system description".

[6] ETS 300 468: "Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems".

[7] ETR 211: "Digital broadcasting systems for television, sound and data services; Guidelines for the usage of Service Information (SI) in Digital Video Broadcasting (DVB) systems".

[8] ISO/IEC 11172-1: "Information Technology - Coding of moving pictures and associated audio for digital storage media up to about 1,5 Mbit/s - Part 1: Systems".

[9] ITU-T Recommendation J.17 (1988): "Pre-emphasis used on sound-programme circuits".

[10] IEC CD - 100C/1883: Parts 1 and 4.

[11] EBU Recommendation R.68: "Alignment level in digital audio production equipment and in digital audio recorders".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of this ETR, the following definitions apply:

Baseline IRD: An IRD which provides the minimum functionality recommended in this ETR.

partial Transport Stream (TS): Bit-stream derived from an MPEG-2 Transport Stream (TS) by removing those TS packets that are not relevant to one particular selected programme, or a number of selected programmes.

3.2 Abbreviations

For the purposes of this ETR, the following abbreviations apply:

CA	Conditional Access
DVB	Digital Video Broadcasting
ES	Elementary Stream
ESCR	Elementary Stream Clock Reference
I-Frame	Intra-coded Frame
IRD	Integrated Receiver-Decoder
MPEG	Moving Pictures Experts Group
NIT	Network Information Table
PAT	Program Association Table
PCR	Program Clock Reference
PES	Packetized Elementary Stream
PID	Packet IDentifier
PMT	Program Map Table
PSI	Program Specific Information
PSW	Pan and Scan Window
SI	Service Information
STD	Standard Target Decoder
TS	Transport Stream
VCR	Video Cassette Recorder

4 Systems layer

This clause describes the guidelines for encoding the systems layer of MPEG-2 in DVB broadcast bit-streams, and for decoding this layer in the IRD. The source bit-stream may be transmitted via a satellite, cable or terrestrial channel, or via a digital interface. Subclause 2.1 applies to the encoding of all source bitstreams and their decoding by a Baseline IRD. Subclause 2.2 gives specific information relating to bit-streams transmitted via a digital interface intended for VCR applications and decoding by IRDs equipped with such an interface.

4.1 Broadcast bit-streams and Baseline IRDs

The multiplexing of baseband signals and associated data conforms to ISO/IEC IS 13818-1 [1]. Some of the parameters and fields are not used in the DVB System and these restrictions are described below. *To allow full compliance to ISO/IEC IS 13818-1 [1] and upward compatibility with future enhanced versions, a DVB IRD shall be able to skip over data structures which are currently "reserved", or which correspond to functions not implemented by the IRD. As an example of this capability, a descriptor tag not yet defined within the DVB System shall be interpreted as a no-action tag, its length field correctly decoded and subsequent data skipped*.

For the same reason, IRD design should be made under the assumption that any legal structure as permitted by ISO/IEC IS 13818-1 [1] may occur in the broadcast stream even if presently reserved or unused. Therefore, the following is assumed:

- *private data shall only be acted upon by decoders which are so enabled;*
- *filling out the bit-stream shall be carried out using the normal stuffing mechanism. Reserved fields shall not be used for this purpose. Data of reserved fields shall be set to 0xFF.*

The headings below in this subclause are based on ISO/IEC IS 13818-1 (1994) [1]. The numbers in brackets after the headings are the relevant chapter and section headings of ISO/IEC IS 13818-1 [1].

4.1.1 Introduction

(ISO/IEC IS 13818-1 [1], section 0)

MPEG-2 systems specify two types of multiplexed data stream: the transport stream and the program stream.

Encoding: *The transmitted multiplex shall use the transport stream.*

Decoding: *All Baseline IRDs shall be able to demultiplex the MPEG-2 transport stream.* Demultiplexing of program streams (as described in sections 0.2 and 0.3 of ISO/IEC IS 13818-1 [1]) is optional.

4.1.2 Packetized Elementary Stream (PES)

(ISO/IEC IS 13818-1 [1], section 0.4)

Encoding: The creation of a physical Packetized Elementary Stream (PES) by an encoder is not required. ESCR fields and ES rate fields need not be coded.

Decoding: ESCR fields and ES rate fields need not be decoded.

4.1.3 Transport stream system target decoder

(ISO/IEC IS 13818-1 [1], section 2.4.2)

Encoding: *The system clock frequency shall conform to the tolerance specified in section 2.4.2.1 of ISO/IEC IS 13818-1 [1].* It is recommended that the tolerance is within 5 parts per million.

Decoding: *The IRD shall operate over the full tolerance range of the system clock frequency specified in section 2.4.2.1 of ISO/IEC IS 13818-1 [1].*

4.1.4 Transport packet layer

(ISO/IEC *IS 1381*8-1 [1], section 2.4.3.2)

4.1.4.1 Null packets

Encoding: *The encoding of null packets (those with PID value 0x1FFF) shall be as specified in ISO/IEC IS 13818-1 [1].*

4.1.4.2 Transport packet header

4.1.4.2.1 transport_error_indicator

Encoding: It is recommended that any error detecting devices in a transmission path should set the **transport_error_indicator** bit when uncorrectable errors are detected.

Decoding: The **transport_error_indicator** flag is set in the transmitted stream it is recommended that the IRD should then invoke a suitable concealment or error recovery mechanism.

4.1.4.2.2 transport_priority

Decoding: The **transport_priority** bit has no meaning to the IRD, and may be ignored.

4.1.4.2.3 transport_scrambling_control

Encoding: *The transport_scrambling_control bits shall be set according to table 1, in accordance with ETR 289 [5].*

Table 1: Coding of transport_scrambling_control bits

Value	Description
00	no scrambling of TS packet payload
01	reserved for future DVB use
10	TS packet scrambled with Even key
11	TS packet scrambled with Odd key

Decoding: *These bits shall be read by the IRD, and the IRD shall respond in accordance with table1.*

4.1.4.2.4 Packet IDentifier (PID) values for Service Information (SI) Tables

Encoding: The assignment of PID values for SI data is given in ETS 300 468 [6].

4.1.5 Adaptation field

(ISO/IEC *IS 1381*8-1 [1], section 2.4.3.4)

4.1.5.1 Random_access_indicator

Encoding: It is recommended that the **random_access_indicator** bit is set whenever a random access point occurs in video streams (i.e. video sequence header immediately followed by an I-frame).

4.1.5.2 elementary_stream_priority_indicator

Decoding: The **elementary_stream_priority_indicator** bit may be ignored by the IRD.

4.1.5.3 Program Clock Reference (PCR)

Encoding: *The time interval between two consecutive PCR values of the same program shall not exceed 100 milliseconds as specified in section 2.7.3 of ISO/IEC IS 13818-1 [1].* It is recommended that this interval should be no greater than 40 milliseconds.

Decoding: *The IRD shall operate correctly with PCRs for a program arriving at intervals not exceeding 100 milliseconds.*

4.1.5.4 Other fields

This subclause covers the following fields:

- **original_program_clock_reference_base**;
- **original_program_clock_reference_extension**;
- **splice_countdown**;
- **private_data_byte**;
- **adaptation_field_extension** (including fields within).

Encoding: These fields are optional in a DVB bit-stream. *The flags that indicate the presence or absence of each of these fields shall be set appropriately.*

Decoding: *IRDs shall be able to accept bit-streams which contain these fields.* IRDs may ignore the data within the fields.

4.1.6 Packetized Elementary Stream (PES) Packet

(ISO/IEC *IS 1381*8-1 *[*1], section 2.4.3.6)

4.1.6.1 stream_id

Encoding: *Within a program, no two elementary streams shall have the same* ***stream_id****.*

4.1.6.2 PES_scrambling_control

Encoding: *The* ***PES_scrambling_control bit****s shall be set according to table 2, in accordance with ETR 289 [5].*

Table 2: Coding of PES_scrambling_control bits

Value	Description
00	no scrambling of PES packet payload
01	reserved for future DVB use
10	PES packet scrambled with Even key
11	PES packet scrambled with Odd key

Decoding: The **PES_scrambling_control bit**s shall be read by the IRD, and the IRD shall respond in accordance with table 2.

4.1.6.3 PES_priority

Decoding: The **PES_priority bit** may be ignored by the IRD.

4.1.6.4 copyright and original_or_copy

Encoding: The **copyright** and **original_or_copy bit**s may be set as appropriate.

Decoding: The IRD need not interpret these bits. The setting of these bits shall not be altered in any digital output from the IRD.

4.1.6.5 Trick mode fields

This subclause covers the following fields:

- **trick_mode_control**;
- **field_id**;
- **intra_slice_refresh**;
- **frequency_truncation**;
- **field_rep_cntrl**.

Encoding: *These trick mode fields shall not be transmitted in a broadcast bit-stream.* Bit-streams for other applications (e.g. for non-broadcast interactive services, storage applications, etc.) may use these fields.

Decoding: The IRD may skip over any data which is flagged as being in a trick mode, if it does not support decoding of trick modes. If the IRD has a digital interface intended for digital VCR applications, it is recommended that it supports decoding of trick modes as indicated in subclause 2.2.

4.1.6.6 additional_copy_info

Encoding: This field may used as appropriate.

Decoding: The IRD need not interpret this field*. The coding of the field shall not be altered in any digital output from the IRD.*

4.1.6.7 Optional fields

This subclause covers the following fields:

- **ESCR**;
- **ESCR_extension**;
- **ES_rate**;
- **previous_PES_packet_CRC**;
- **PES_private_data**;
- **pack_header()**;
- **program_packet_sequence_counter**;
- **MPEG1_MPEG2_identifier**;
- **original_stuff_length**;
- **P-STD_buffer_scale**;
- **P-STD_buffer_size**.

Encoding: These fields are optional in a DVB bit-stream. *The flags that indicate the presence or absence of each of these fields shall be set appropriately.*

Decoding: *The IRD shall be able to accept bit-streams which contain these fields.* The IRD may ignore the data within the fields.

4.1.6.8 PES_extension_field

The **PES_extension_field** data field is currently "reserved"

Encoding: *This extension field shall not be coded unless specified in the future by MPEG.*

Decoding: *The IRD shall be able to accept bit-streams which contain this field.* The IRD may ignore the data within the field.

4.1.7 Program Specific Information (PSI)

(ISO/IEC *IS 1381*8-1 [1], section 2.4.4)

The data format for the Network Information Table (NIT) in DVB bit-streams is given in ETS 300 468 [6]. This document also defines additional tables for service information which use Program Specific Information (PSI) private_section structure defined in ISO/IEC *IS 1381*8-1 [1].

It is recommended that the Program Association Table (PAT) and Program Map Table (PMT) are repeated with a maximum time interval of 100 milliseconds between repetitions.

4.1.8 Program and elementary stream descriptors

(ISO/IEC *IS 1381*8-1 [1], section 2.6)

4.1.8.1 video_stream_descriptor and audio_stream_descriptor

Encoding: *The **video_stream_descriptor** shall be used to indicate video streams containing still picture data,* otherwise these descriptors may be used when appropriate.
*If **profile_and_level_indication** is not present, then the video bit-stream shall comply with the constraints of Main Profile at Main Level.*

*If the **audio_stream_descriptor** is not present, then the audio bit-stream shall not use sampling frequencies of 16 kHz, 22,05 kHz or 24 kHz, and all audio frames in the stream shall have the same bitrate.*

Decoding: The IRD may use these descriptors when present to determine if it is able to decode the streams. If neither **video_stream_descriptor** nor **hierarchy_descriptor** is present for a video bit-stream, the IRD may assume that it complies with Main Profile at Main Level constraints.

4.1.8.2 hierarchy_descriptor

Encoding: *The **hierarchy_descriptor** shall be used if, and only if, video or audio is coded as more than one hierarchical layer.*

Decoding: *If the descriptor is present and indicates that the bit-stream is a base layer video stream, then the IRD shall be capable of selecting that bit if a **video_stream_descriptor** defines it as Main Profile at Main Level or less.*

4.1.8.3 registration_descriptor

Encoding: The **registration_descriptor** may be used when appropriate.

Decoding: The IRD need not make use of this descriptor.

4.1.8.4 data_stream_alignment_descriptor

Encoding: The **data_stream_alignment_descriptor** may be used when appropriate.

Decoding: The IRD need not make use of this descriptor.

4.1.8.5 target_background_grid_descriptor

Encoding: The **target_background_grid_descriptor** may be used when appropriate.

Decoding: *If this descriptor is absent, a default grid of 720 x 576 pixels shall be assumed by the IRD. The IRD shall read this descriptor, when present, to override this default.* The display of correctly windowed video on background grids other than 720 x 576 pixels is optional.

4.1.8.6 video_window_descriptor

Encoding: The **video_window_descriptor** may be used when appropriate, to indicate the required position of the video window on the screen.

Decoding: *The IRD shall read this descriptor, when present, and position the video window accordingly.*

4.1.8.7 Conditional Access CA_descriptor

Encoding: *The **CA_descriptor** shall be encoded as defined in ETR 289 [5].*

Decoding: *The IRD shall interpret this descriptor as defined in ETR 289 [5].*

4.1.8.8 ISO_639_Language_descriptor

Encoding: *The **ISO_639_Language_descriptor** shall be present if more than one audio (or video) stream with different languages are present within a program.* It is optional otherwise.

Decoding: *The IRD shall use the data from this descriptor to assist the selection of appropriate audio (or video) stream of program, if more than one stream is available.*

4.1.8.9 system_clock_descriptor

Encoding: It is recommended that the **system_clock_descriptor** is included in the program_info part of the Program Map Table for each program.

Decoding: The IRD need not make use of this descriptor.

4.1.8.10 multiplex_buffer_utilization_descriptor

Encoding: The **multiplex_buffer_utilization_descriptor** may be used when appropriate.

Decoding: The IRD need not make use of this descriptor.

4.1.8.11 copyright_descriptor

Encoding: The **copyright_descriptor** may be used when appropriate.

Decoding: The IRD need not make use of this descriptor.

4.1.8.12 maximum_bitrate_descriptor

Encoding: The **maximum_bitrate_descriptor** may be used when appropriate.

Decoding: The IRD need not make use of this descriptor.

4.1.8.13 private_data_indicator_descriptor

Encoding: The **private_data_indicator_descriptor** may be used when appropriate.

Decoding: The IRD need not make use of this descriptor.

4.1.8.14 STD_descriptor

Encoding: *The **STD_descriptor** shall be used as specified in ISO/IEC IS 13818-1 [1].*

Decoding: The IRD need not make use of this descriptor.

4.1.8.15 IBP_descriptor

Encoding: The **IBP_descriptor** may be used when appropriate.

Decoding: The IRD need not make use of this descriptor.

4.1.8.16 smoothing_buffer_descriptor

Encoding: It is recommended that the **smoothing_buffer_descriptor** is included in the Program Map Table in the extended program information.

Decoding: The IRD need not make use of this descriptor, but the information may be of assistance to digital VCRs.

Additional descriptors to those defined in ISO/IEC *IS 13818*-1 [1] are defined in ETS 300 468 [6], and guidelines for their use are provided in ETR 211 [7]: "Guidelines on implementation and usage of Service Information".

4.1.9 Compatibility with ISO/IEC 11172-1 [8]

(ISO/IEC *IS 13818*-1 [1], section 2.8)

Decoding: Compatibility with ISO/IEC 11172-1 [8] (MPEG-1 Systems) is optional.

4.1.10 Storage Media Interoperability

It is recommended that the total bitrate of the set of service components, associated PMT and PCR packets anticipated to be recorded by a consumer, should not exceed 9 000 000 bit/s.

It is recommended that the parameters sb_size and sb_leak_rate in the smoothing_buffer_descriptor remain constant for the duration of an event. The value of the sb_leak_rate should be the peak attained during the event. The short_smoothing_buffer_descriptor is defined in ETS 300 468 [6] and guidelines for its use are provided in ETR 211 [7].

4.2 Bit-streams from storage applications and IRDs with digital interfaces

This subclause covers both the treatment of Partial Transport Streams which result from external program selection and Trick Play information received from a storage device. MPEG-2 PSI and DVB SI tables for use specifically in storage applications are defined in ETS 300 468 [6].

4.2.1 Partial Transport Streams

Partial Transport Streams for transfer on a digital interface, e.g. for digital VCR applications, have been defined in IEC CD-100C/1883 [10]. A Partial Transport Stream may be created by selection of Transport Stream Packets from one or more program(s), including PSI Packets.

Encoding: *The Partial Transport Stream shall be fully MPEG compliant with reference to MPEG-2 "Extension for Real-Time-Interface for systems decoders" (ISO IEC IS 13818-9) [*4].

Decoding devices equipped with a digital interface intended for digital VCR applications shall accept the bursty character of a Partial Transport Stream with gaps of variable length between the Transport Stream Packets.

4.2.2 Decoding of Trick Play data

(ISO/IEC *IS 1381*8-1 [1], section 2.4.3.7)

Encoding: *Trick mode operation shall be signalled by use of the DSM_trick_mode flag in the header of the video Packetized Elementary Stream (PES) packets. During trick mode playback the storage device shall construct a bit-stream which is syntactically and semantically correct, except as outlined in the note below.*

Decoding: It is recommended that devices decode the DSM_trick_mode_flag and the eight bit trick mode field. *Devices which decode the trick mode data shall follow the normative requirements detailed in ISO/IEC IS 13818-1 [1], 2 for all values of the trick_mode_control field.*

Trick mode semantic constraints:

The *bit-stream* delivered to the decoder during trick mode shall comply with the syntax defined in the MPEG-2 standard. However, for the following video syntax elements, semantic exceptions apply in the presence of the DSM_trick_mode field:

- bit_rate
- vbv_delay
- repeat_first_field
- v_axis_positive
- field_sequence
- subcarrier
- burst_amplitude
- subcarrier_phase

A decoder cannot rely on the values encoded in these fields when in trick mode. Similarly, for the systems layer, the following semantic exceptions apply in the presence of the DSM_trick_mode field:

- maximum spacing of PSI information may exceed 400 ms;
- maximum spacing of PTS or DTS occurrences may exceed 700 ms;
- PES packets may be void of video data to indicate a change in trick mode byte;
- a PES packet void of video data may contain a PTS to indicate effective presentation time of new trick mode control;
- when trick_mode status is true, the elementary stream buffers in the T-STD may underflow.

5 Video

This clause describes the guidelines for encoding MPEG-2 video in DVB broadcast bit-streams, and for decoding this bit-stream in the IRD.

The video encoding shall conform to ISO/IEC IS 13818-2 [2]. Some of the parameters and fields are not used in the DVB System and these restrictions are described below. The IRD design should be made under the assumption that any legal structure as permitted by ISO/IEC *IS 1381*8-2 [2] may occur in the broadcast stream even if presently reserved or unused*. To allow full compliance to the MPEG-2 standard and upward compatibility with future enhanced versions, a DVB IRD shall be able to skip over data structures which are currently "reserved", or which correspond to functions not implemented by the IRD.*

This clause is based on ISO/IEC *IS 1381*8-2 [2].

5.1 Profile and level

Encoding: *Encoded bit-streams shall comply with the Main Profile Main Level restrictions, as described ISO/IEC IS 13818-2 [2], section 8.2.* The **profile_and_level_indication** is "01001000" or, if appropriate, "0nnnnnnn", where "0nnnnnnn" > "01001000", indicating a "simpler" profile or level than Main Profile, Main Level.

Decoding: *The IRD shall support the syntax of Main Profile.* Support for profiles and levels beyond Main Profile, Main Level is optional. *If the IRD encounters an extension which it cannot decode, such as one whose identification code is Reserved, Picture Sequence Scaleable, Picture Spatial Scaleable or Picture Temporal Scaleable, it shall discard the following data until the next start code (to allow backward compatible extensions to be added in the future).*

5.2 Frame rate

Encoding: *The frame rate shall be 25 Hz, i.e.* ***frame_rate_code*** *is "0011".*

Still pictures may be encoded by use of a video sequence consisting of a single intra-coded picture (see definition of still pictures in ISO/IEC *IS 1381*8-1 [1], section 2.1.48).

Decoding: *All IRDs shall support the frame rate of 25 Hz in the film mode and the field rate of 50 Hz in the video camera mode (i.e.* ***frame_rate_code*** *of "0011").* Support of other frame and field rates is optional.

IRDs shall be capable of decoding and displaying still pictures, i.e. video sequences consisting of a single intra-coded picture (see definition of still pictures in ISO/IEC IS 13818-1 [1], section 2.1.48)

5.3 Aspect ratio

Encoding: *The source aspect ratio in DVB bit-streams shall be either 4:3, 16:9 or 2,21:1.* As stated under "Decoding" below, decoding of 2,21:1 aspect ratio is optional for the Baseline IRD.

The field ***aspect_ratio_information*** *in the sequence header shall have one of the following two values:*

- *4:3 aspect ratio source: "0010";*
- *16:9 aspect ratio source: "0011".*

It is recommended that pan vectors for a 4:3 window are included in the transmitted bit-stream when the source aspect ratio is 16:9 or 2,21:1. *The vertical component of the transmitted pan vector shall be zero.*

If pan vectors are transmitted then the ***sequence_display_extension*** *shall be present in the bit-stream and the* ***aspect_ratio_information*** *shall be set to ´0010´ (4:3 display). The display_vertical_size shall be equal to the* ***vertical_size****. The* ***display_horizontal_size*** *shall contain the resolution of the target 4:3 display.* The value of the **display_horizontal_size** field may be calculated by the following equation:

$$\text{display\_horizontal\_size} = \frac{4}{3} \times \frac{\text{horizontal\_size}}{\text{source aspect ratio}}$$

Table 3 below gives some typical examples:

Table 3: Values for display_horizontal_size

horizontal_size × vertical_size	**Source aspect ratio**	**display_horizontal_size**
720 × 576	16:9	540
	2,21:1	434
544 × 576	16:9	408
	2,21:1	328
480 × 576	16:9	363
	2,21:1	289
352 × 576	16:9	264
	2,21:1	212
352 × 288	16:9	264
	2,21:1	212

Decoding: *The IRD shall be able to decode bit-streams with values of* ***aspect_ratio_information*** *of "0010" and "0011", corresponding to 4:3 and 16:9 aspect ratio respectively.* If the IRD has a digital interface, this should be capable of outputting bit-streams with aspect ratios which are not directly supported by the IRD to allow their decoding and display via an external unit.

All IRDs shall support the use of pan vectors and upsampling to allow a 4:3 monitor to give a full-screen display of a selected portion of a 16:9 coded picture with the correct aspect ratio. IRDs implementing the 2,21:1 aspect ratio should support the use of pan vectors and upsampling to allow a 4:3 monitor to give a full-screen display of a selected portion of a 2,21:1 picture with the correct aspect ratio. Support for pan vectors with non-zero vertical components is optional. *When no pan vectors are present in the transmitted bit-stream, the central portion of the wide-screen picture shall be displayed.* The support of vertical resampling to obtain the correct aspect ratio for a letterbox display of a 16:9 or 2.21:1 coded picture on a 4:3 monitor is optional.

5.4 Luminance resolution

Encoding: *The encoded picture shall have a full-screen luminance resolution (horizontal × vertical) of one of the following values:*

- *720 × 576;*
- *544 × 576;*
- *480 × 576;*
- *352 × 576;*
- *352 × 288.*

In addition, non full-screen pictures may be encoded for display at less than full-size (when using one of the standard up-conversion ratios at the IRD).

Decoding: *The IRD shall be capable of decoding pictures with luminance resolutions as shown in table 4 below and applying upsampling to allow the decoded pictures to be displayed at full-screen size. In addition, IRDs shall be capable of decoding lower picture resolutions and displaying them at less than full-size after using one of the standard up-conversions, e.g. a horizontal resolution of 704 pixels within the 720 pixel full-screen display.*

Table 4: Resolutions for full-screen display from IRD

Coded picture		**Displayed picture Horizontal upsampling**	
Luminance resolution (horizontal × vertical)	**Aspect Ratio**	**4:3 Monitors (PSW = Pan & Scan window)**	**16:9 Monitors**
720 × 576	4:3 16:9 2,21:1	× 1 PSW × 4/3 (PSW × 5/3)[2]	(× 3/4)(note 1) × 1 (PSW × 5/4)(note 2)
544 × 576	4:3 16:9 2,21:1	× 4/3 PSW × 16/9 (PSW × 20/9)(note 2)	(× 1)(note 1) × 4/3 (PSW × 5/3)(note 2)
480 × 576	4:3 16:9 2,21:1	× 3/2 PSW × 2 (PSW × 5/2)(note 2)	(× 9/8)(note 1) × 3/2 (PSW × 15/8)(note 2)
352 × 576	4:3 16:9 2,21:1	× 2 PSW × 8/3 (PSW × 10/3)(note 2)	(× 3/2)(note 1) × 2 (PSW × 5/2)(note 2)
352 × 288	4:3 16:9 2,21:1	× 2 PSW × 8/3 (PSW × 10/3)(note 2) (and vertical upsampling × 2)	(× 3/2)(note 1) × 2 (PSW × 5/2)(note 2) (and vertical upsampling × 2)

NOTE 1: Upsampling of 4:3 pictures for display on a 16:9 monitor is optional in the IRD, as 16:9 monitors can be switched to operate in 4:3 mode.
NOTE 2: Upsampling of pan and scan window from 2.21:1 pictures for display on a 4:3 or 16:9 monitor is optional in the IRD.

5.5 Chromaticity parameters

Encoding: It is recommended that the chromaticity co-ordinates of the source primaries, opto-electronic transfer characteristic of the source picture and matrix coefficients used in deriving luminance and chrominance signals from the red, green and blue primaries comply with ITU-R Recommendation BT.470-2 System B, G. This may be explicitly signalled in the encoded *bit-stream* by setting the value of 5 for each of the following 3 parameters in the **sequence_display_extension()**: **colour_primaries**, **transfer_characteristics**, and **matrix_coefficients**.

*Within DVB applications, if the **sequence_display_extension()** is not present in the bit-stream or **colour_description** is zero, the chromaticity shall be implicitly defined to be that corresponding to **colour_primaries** having the value 5, the transfer characteristics shall be implicitly defined to be those corresponding to **transfer_characterstics** having the value 5 and the matrix coefficients shall be implicitly defined to be those corresponding **matrix_coefficients** having the value 5.*

5.6 Chrominance

Encoding: *The operation used to downsample the chrominance information from 4:2:2 to 4:2:0 shall be indicated by the parameter **chroma_420_type** in the picture coding extension.* A value of zero indicates that the fields have been downsampled independently. A value of one indicates that the two fields have been combined into a single frame before downsampling. It is desirable that the fields are downsampled independently (i.e. **chroma_420_type** = 0) to allow the IRD to use less memory for picture reconstruction.

Decoding: It is desirable that the operation used to upsample the chrominance information from 4:2:0 to 4:2:2 should be dependent on the parameter **chroma_420_type** in the picture coding extension.

5.7 Video sequence header

Encoding: It is recommended that a video sequence header, immediately followed by an I-frame, be encoded at least once every 500 milliseconds. If quantiser matrices other than the default are used, the appropriate **intra_quantiser_matrix** and/or **non_intra_quantiser_matrix** are recommended to be included in every sequence header.

NOTE 1: Increasing the frequency of video sequence headers and I-frames will reduce channel hopping time but will reduce the efficiency of the video compression.

NOTE 2: Having a regular interval between I-frames may improve trick mode performance, but may reduce the efficiency of the video compression.

6 Audio

This clause describes the guidelines for encoding MPEG-2 audio in DVB broadcast bit-streams, and for decoding this bit-stream in the IRD.

The recommended level for reference tones for transmission is 18 dB below clipping level, in accordance with EBU Recommendation R.68 [11].

The audio encoding shall conform to ISO/IEC IS 13818-3 [4]. Some of the parameters and fields are not used in the DVB System and these restrictions are described below. The IRD design should be made under the assumption that any legal structure as permitted by ISO/IEC IS 13818-3 [4] may occur in the broadcast stream even if presently reserved or unused. *To allow full compliance to ISO/IEC IS 13818-3 [4] and upward compatibility with future enhanced versions, a DVB IRD shall be able to skip over data structures which are currently "reserved", or which correspond to functions not implemented by the IRD. For example, an IRD which is not designed to make use of the ancillary data field shall skip over that portion of the bit-stream.*

This clause is based on ISO/IEC *IS 13818*-3 [4].

6.1 Audio mode

Encoding: *The audio shall be encoded in one of the following modes:*

- *MPEG-1 single channel;*
- *MPEG-1 dual channel;*
- *MPEG-1 joint stereo;*
- *MPEG-1 stereo;*
- *MPEG-2 compatible multi-channel audio (dematrix procedure = 0 or 1).*

Decoding: *The IRD shall be capable of decoding the following audio modes:*

- *MPEG-1 single channel;*
- *MPEG-1 dual channel;*
- *MPEG-1 joint stereo;*
- *MPEG-1 stereo.*

The IRD shall be capable of decoding at least the basic stereo information from an MPEG-2 compatible multi-channel audio bit-stream. Full decoding of an MPEG-2 multi-channel audio bit-stream is optional.

6.2 Compression layer

Encoding: *The encoded bit-stream shall use either Layer I or Layer II coding (**layer** = "11" or "10" respectively).* Use of Layer II is recommended.

Decoding: *IRDs shall be capable of decoding at least Layer I and Layer II.* Support for Layer III decoding (**layer** = "01")is optional.

6.3 Bitrate

Encoding: *The value of bit**rate_index** in the encoded bit-stream shall be one of the 14 values from "0001" to "1110" (inclusive).*

For Layer I, these correspond to bitrates of: 32, 64, 96, 128, 160, 192, 224, 256, 288, 320, 352, 384, 416 or 448 kbits/s.

For Layer II, these correspond to bitrates of: 32, 48, 56, 64, 80, 96, 112, 128, 160, 192, 224, 256, 320, 384 kbits/s

For MPEG-2 encoded bit-streams with total bitrates greater than 448 kbit/s for Layer I or 384 kbit/s for Layer II, an extension bit-stream shall be used. The bitrate of that extension may be in the range of 0 to 682 kbit/s.

Decoding: *IRDs shall be capable of decoding bit-streams with a value of bit**rate_index** from "0001" to "1110" (inclusive).* Support for the free format bitrate (**bitrate_index** = "0000") is optional.

6.4 Sampling frequency

Encoding: *The audio sampling rate of primary sound services shall be 32 kHz, 44,1 kHz or 48 kHz.* Sampling rates of 16 kHz, 22,05 kHz, 24 kHz, 32 kHz, 44,1 kHz or 48 kHz may be used for secondary sound services.

Decoding: *The IRD shall be capable of decoding audio with sampling rates of 32 kHz, 44,1 kHz and 48 kHz.* Support for sampling rates of 16 kHz, 22,05 kHz and 24 kHz is optional.

6.5 Emphasis

Encoding: *The encoded bit-stream shall have no emphasis (**emphasis** = "00").*

Decoding: *The IRD shall be capable of decoding audio with no emphasis.* Support for 50/15 microseconds de-emphasis and ITU-T Recommendation J.17 [9] de-emphasis (**emphasis** = "01" or "11") is optional.

6.6 Cyclic redundancy code

Encoding: *The parity check word (**crc_check**) shall be included in the encoded bit-stream.*

Decoding: It is recommended that the IRD use **crc_check** to detect errors and subsequently invoke suitable concealment or muting mechanisms.

History

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