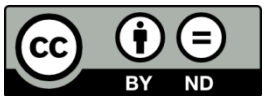
Video Services Forum (VSF)
Technical Recommendation
TR-10-15 Part 2

Internet Protocol Media Experience (IPMX):
H.265 Codec Requirements for Compressed Video

June 4, 2026



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Executive Summary

Internet Protocol Media Experience (IPMX) was created to foster the adoption of open standards-based protocols for interoperability over IP in the media and entertainment and professional audio/video industries. IPMX is based on the SMPTE ST 2110 standard and as such the VSF TR-10 suite of Technical Recommendations is a set of differences between SMPTE ST 2110 and IPMX.

This Technical Recommendation documents the minimum requirements for an IPMX device with respect to the use of the H.265 video codec in TR-10-7 streaming use-cases.

Table of Contents

1 Introduction (Informative)

IPMX, which stands for Internet Protocol Media Experience, is based on two families of specifications. The SMPTE ST 2110 Professional Media Over Managed IP Networks suite of standards for the transport of video, audio, and ancillary/control signals over IP networks, and the NMOS REST APIs from AMWA, which provide discovery, connection management, and control.

IPMX is an accessible, open standard that meets the needs of professional and consumer video and audio users in a wide variety of contexts while giving manufacturers and developers what they need to build low-latency, interoperable, IP based audiovisual products or applications.

This document covers the H.265 video codec requirements for IPMX. Other aspects of the IPMX system and their individual requirements are documented in other parts of this Technical Recommendation.

2 Contributors

The following individuals participated in the Video Services Forum IPMX working group that developed this technical recommendation.

Alain Bouchard (Matrox)	Jed Deame (Nextera)
Amanda Douglass (Macnica)	Jeroen Steendam (DekTec)
Andre Testa (Matrox)	Kai Hagseth (Bridge Technologies)
Andreas Hildebrand (RAVENNA)	Kenneth Klette Jonassen (Bridge Technologies)
Andrew Starks (Macnica)	Kyle Wilken (Cobalt Digital)
Daniel Bouquet (ANALOG WAY)	Leigh Whitcomb (Meinberg)
Danny Pierini (Matrox)	Phil Bernal (PB Technologies Group)
David Konz (plexusAV)	Phil Nguyen (Nextera)
Hung Lam (EvertzAV)	Raymond Hermans (Adeas)
Jack Douglass (PacketStorm)	Ryan Wallenberg (Cobalt)
Jean Lapierre (Matrox)	Steve Kolta (Meinberg)
Jean-Jacques Osytiguy (Matrox)	

3 About the Video Services Forum

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- providing forums to identify issues involving the development, engineering, installation, testing and maintenance of audio and video services;
- exchanging non-proprietary information to promote the development of video transport service technology and to foster resolution of issues common to the video services industry;
- identification of video services applications and educational services utilizing video transport services;
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Normative text describes elements of the design that are indispensable or contain the conformance language keywords: "shall," "should," or "may."

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All text in this document is, by default, normative, except the Introduction and any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed to conform to the document and from which no deviation is permitted.

The keywords "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; followed by formal languages; then figures; and then any other language forms.

5 Normative References

- TR-10-1:2024 Internet Protocol Media Experience (IPMX): System Timing and Definitions
- TR-10-7:2024 Internet Protocol Media Experience (IPMX): Compressed Video Transport
- Internet Engineering Task Force (IETF) RFC 3550 RTP: A Transport Protocol for Real-Time Applications available at https://www.ietf.org/rfc/rfc3550.txt
- Internet Engineering Task Force (IETF) RFC 7798 RTP Payload Format for High Efficiency Video Coding (HEVC) available at https://datatracker.ietf.org/doc/html/rfc7798
- BCP-004-01 NMOS Receiver Capabilities available at https://specs.amwa.tv/bcp-004-01
- BCP-004-02 NMOS Sender Capabilities available at https://specs.amwa.tv/bcp-004-02
- BCP-006-03 NMOS With H.265 available at https://specs.amwa.tv/bcp-006-03
- H.265 "High efficiency video coding" available at https://www.itu.int/rec/T-REC-H.265

6 Definitions

For the purposes of this document, the terms, and definitions of VSF TR-10-1 and the following apply.

HEVC Sender	An IPMX Sender configured to produce an H.265 coded stream.
HEVC Receiver	An IPMX Receiver capable of consuming an H.265 coded stream.
NMOS	AMWA Networked Media Open Specifications
CBR	H.265 HRD cbr_flag = 1, as per TR-10-7
VBR	H.265 HRD cbr_flag = 0, as per TR-10-7
VPS	H.265 Video Parameter Set
SPS	H.265 Sequence Parameter Set
PPS	H.265 Picture Parameter Set
SEI	H.265 Supplemental Enhancement Information
Encoder CPB	An encoder transmit buffer used to queue coded access units prior to transmission for pacing/shaping purposes.

7 General Provisions

An IPMX Sender producing an H.265 coded stream shall comply with the VSF TR-10-7 Technical Recommendation.

An IPMX Sender producing an H.265 coded stream shall comply with the BCP-006-03 specification.

The H.265 coded bitstream produced by an IPMX Sender shall conform to the H.265 specification, as well as the requirements defined in BCP-006-03 and this Technical Recommendation.

An IPMX Receiver shall communicate its capabilities for the “video/H265” media type through BCP-004-01, Receiver Capabilities.

An IPMX Sender shall communicate its capabilities for the “video/H265” media type through BCP-004-02, Sender Capabilities. An IPMX Sender may publish partial capabilities.

Note: Partial capabilities can occur when certain parameters depend on variable external conditions (e.g., detected signal characteristics), and are therefore not fully determinable at all times.

8 Picture

The vui_parameters( ) shall be present in sequence parameter sets (SPS) and shall describe the uncompressed YCbCr video signal encoded in the H.265 coded stream, either directly or as a result of an RGB-to-YCbCr conversion.

The vui_parameters( ) shall have the following flags set to 1: video_signal_type_present_flag, colour_description_present_flag, vui_timing_info_present_flag, and vui_hrd_parameters_present_flag. The vui_parameters( ) shall have the frame_field_info_present_flag set to 1 for interlaced video and the pic_timing SEI message shall include a valid pic_struct.

A separate alpha channel may be supported. If supported, the alpha channel shall be transported as an independent monochrome bitstream using the KEY 4:0:0 sampling, ALPHA colorimetry and UNSPECIFIED transfer characteristics. Refer to the ST 2110-20 specification for a definition of the KEY, ALPHA and UNSPECIFIED values.

The video may be progressive or interlaced.

9 Packets

UDP/IP packets shall comply with the “RTP Payload Format” and “Packetization Rules” defined in RFC 7798, along with the additional restrictions specified in NMOS BCP-006-03.

PAyload Content Information (PACI) packets defined in RFC 7798 shall not be produced by an IPMX Sender.

A UDP/IP packet shall not contain more than one VCL NAL Unit.

10 Timing

H.265 coded video shall be transmitted and decoded using the HRD transmitter and decoder schedules.

The Virtual Receiver Buffer Model defined in ST 2110 does not apply; therefore, the concept of "gapped" transmission does not exist for H.265. The traffic shaping mode shall be set to TP=2110TPW and explicitly declared in the fmtp attribute of the SDP transport file.

The IPMX Network Compatibility Model applies to the burstiness of the transmission.

Buffering Period SEI messages shall be provided at each recovery point

Picture Timing SEI messages shall be provided for each access unit. The pic_struct() shall be provided in the pic_timing() for interlaced video.

vps_timing_info_present_flag shall equal 1 and vps_num_units_in_tick shall be equal to the frame rate denominator, vps_time_scale shall be equal to the frame rate numerator

vui_timing_info_present_flag shall equal 1 and vui_num_units_in_tick shall be equal to the frame rate denominator, vui_time_scale shall be equal to the frame rate numerator

max_vps_num_reorder_pics, sps_max_num_reorder_pics should be 0. NoBackwardPredFlag should equal to 1. The coded sequence may use IDR, CRA, BLA, I, and P. It may also use B if only using references to pictures that come before the current picture in output order. Decode order shall equal output order

When using temporal layers, HRD parameters shall be specified for the bitrate of each layer and HRD parameters shall be specified for each temporal layer. When not using temporal layers, HRD parameters shall be specified for the bitrate of the base layer and HRD parameters shall be specified for the base layer. The cpb_cnt_minus1 value of hrd_parameters() shall be 0.

A coded bitstream shall conform to Type II HRD and nal_hrd_parameters_present_flag shall equal 1

The HRD parameters shall be specified in the vui_parameters of the SPS.

The low_delay flag may be set to 1, in which case an encoder may skip frames.

If sub-picture HRD mode is used: tick_divisor_minus2 shall be from 0 to 254 (1/2 to 1/256th of picture), sub_pic_hrd_params_present_flag shall be 1, sub_pic_cpb_params_in_pic_timing_sei_flag shall be 0 and a decoding_unit_info SEI message shall be provided for each slice with a valid du_spt_cpb_removal_delay_increment value.

Informative Note: The objective of this requirement is to standardize a single method for implementing a sub-picture HRD.

11 Random Access Point

A coded stream shall include a random access point at least once every 5 seconds. Each random access point shall provide the following NAL Units:

- H.265: (IDR or CRA or BLA) and VPS and SPS and PPS, or SEI recovery_point with information about the picture state

- The use of GDR (Gradual Decoding Refresh) shall be signaled through the recovery point SEI recovery_poc_cnt attribute.

12 IPMX HEVC Profile

An HEVC Sender compliant with the IPMX HEVC Profile shall support producing a bitstream compliant with either a) the Main profile using the YCbCr-420 color sampling, and 8-bit sample depth, or b) the Main10 profile using the YCbCr-420 color sampling, and the 8 and 10-bit sample depths.

An HEVC Sender supporting a monochrome bitstream shall support producing a bitstream compliant with either a) the Main-444 profile, using 4:0:0 chroma subsampling, and the 8-bit sample depth, or b) the Main10-444 profile, using 4:0:0 chroma subsampling, and the 8 and 10-bit sample depths.

An HEVC Sender may support additional profiles, color samplings, and bit depths beyond these minimum requirements.

An HEVC Receiver compliant with the IPMX HEVC Profile shall be capable of consuming a bitstream compliant with a) the Main profile using the YCbCr-420 color sampling, and the 8-bit sample depth, and b) the Main10 profile using the YCbCr-420 color sampling, and the 8 and 10-bit sample depths.

An HEVC Receiver supporting a monochrome bitstream shall support consuming a bitstream compliant with a) the Main-444 profile, using 4:0:0 chroma subsampling, and 8-bit sample depth, and b) the Main10-444 profile, using 4:0:0 chroma subsampling and the 8 and 10-bit sample depths.

An HEVC Receiver compliant with the IPMX HEVC Profile decoder shall be capable of consuming a bitstream compliant with Level 5.1 of the main tier.

An HEVC Receiver may support additional profiles, levels, color sampling, and bit depths beyond these minimum requirements.

12.1 IPMX HEVC 4:4:4 Profile Mode (IPMX-HEVC-444)

An HEVC Sender compliant with the IPMX HEVC 4:4:4 Profile Mode shall be compliant with the IPMX HEVC Profile.

An HEVC Sender compliant with the IPMX HEVC 4:4:4 Profile Mode shall support producing a stream compliant with either a) the Main-444 profile using the YCbCr-444 color sampling, and the 8-bit sample depth, or b) the Main10-444 profile using the YCbCr-444 color sampling, and the 10-bit sample depth.

An HEVC Receiver compliant with the IPMX HEVC 4:4:4 Profile Mode shall be compliant with the IPMX HEVC Profile.

An HEVC Receiver compliant with the IPMX HEVC 4:4:4 Profile Mode shall be capable of consuming a bitstream compliant with a) the Main-444 profile using the YCbCr-444 color sampling, and the 8-bit sample depth, and b) the Main10-444 profile using YCbCr-444 color sampling, and the 10-bit sample depth.

13 Rate Control

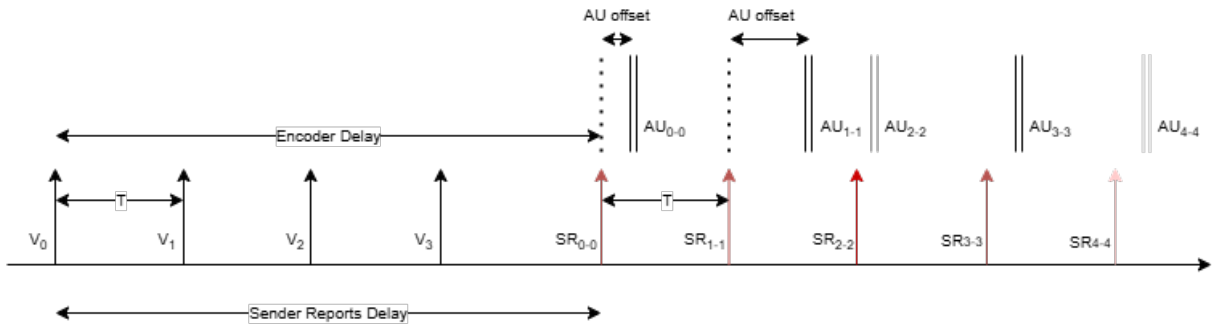
An encoder may produce either an H.265 CBR or VBR bitstream.

A decoder shall support consuming both H.265 CBR and VBR bitstreams.

14 Advanced Features

Annexes F, G, H, and I of H.265 shall not be used. Multi-layer video coding shall be disabled, and nuh_layer_id shall be set to 0.

15 Sender Reports



The Media Info Block of a sender report shall provide stream parameters that are compliant with the active VPS, SPS and PPS of the coded stream. In all cases, the information from the active VPS, SPS, and PPS prevails over the information from the Media Info Block. Information not provided by the coded stream active VPS, SPS, PPS shall be taken from the Media Info Block.

Section 8.8.2 of VSF_TR-10-1, titled "Video RTCP Sender Report schedule", is modified to replace the paragraph "The RTCP Sender Report shall be sent before the first video media packet of the associated frame or field but after the first video media packet of the previous frame or field." by this new one "The RTCP Sender Report shall be sent before the first video media packet of the associated frame or field, if any" with additional requirements as follow:

- Frames/Fields of video to be encoded are denoted Vi where i is the index in presentation order of the frame/field. For each video frame/field, there is an associated sender report SRi-j where i is the associated video frame/field index in presentation order, and j is the associated access unit index in decoder order. For each video frame/field there is an associated access unit AUj-i where j is the associated access unit index in decoder order and i is the associated video frame/field index in presentation order.

- The nominal period (T) between video frames/fields is a constant value in seconds.
    - The encoder is expected to transmit sender reports at this same nominal interval.

    - Coded access units are expected to be inserted into the encoder Coded Picture Buffer (Encoder CPB) for later transmission at this same nominal interval.

    - The encoder shall start inserting access units into the Encoder CPB after a constant delay (encoder_delay) from the time the frame/field is captured from baseband.

    - The encoder_delay shall remain constant once streaming starts, such that the encoder continues to insert access units into the Encoder CPB after the same constant delay (encoder_delay) from the time the frame/field is captured from baseband.

  Note: The encoder_delay constant does not have to be the same for every stream transmitted by the Sender, nor be the same at each activation of the Sender. It is established when the encoder inserts the first access unit into the Encoder CPB.

- The encoder shall transmit the sender report for a frame/field no more than encoder_delay seconds after capturing the frame/field. This means the sender report can be transmitted either immediately upon capturing a frame/field or when the associated access unit is inserted into the Encoder CPB, but always before transmitting the coded access unit. The sender_reports_delay shall remain constant once streaming starts, such that the encoder continues to transmit sender reports after a constant delay (sender_reports_delay) from the time the frame/field is captured from baseband.

Note: The sender_reports_delay constant does not have to be the same for every stream transmitted by the Sender, nor be the same at each activation of the Sender. It is established when the encoder transmits the first sender report.

- Sender reports shall be transmitted in presentation order. If a frame/field is skipped by the encoder, it shall not skip the associated sender report.

- The AU offset is the time difference between when an access unit is inserted into the Encoder CPB and when it starts being transmitted, ranging from zero up to the Encoder CPB size divided by the maximum bitrate.

16 H.265 Media Info Block

An H.265 coded stream shall carry, in the Sender Report, an additional Media Info Block of type 0x0009, immediately following the Media Info Block of type 0x0005 described in TR-10-7.

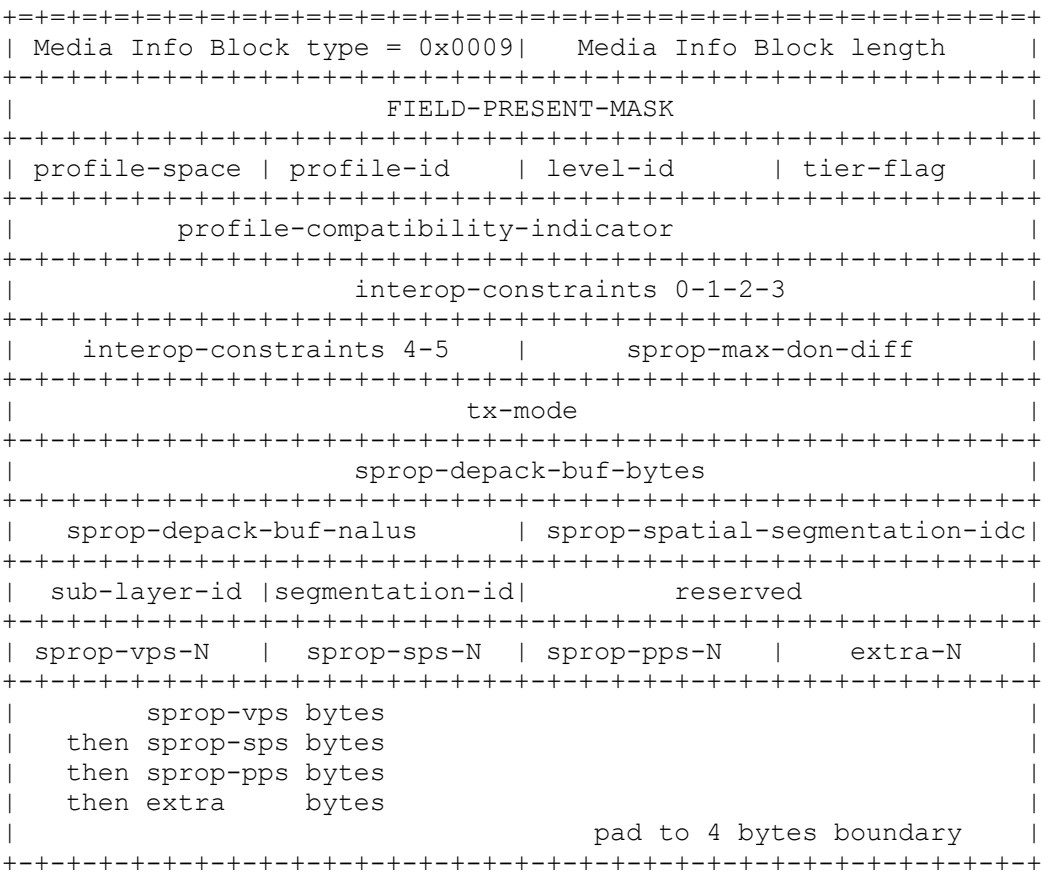
Media Info Blocks of type 0x0009 carry H.265 codec specific -information in the following binary format. Multi-byte fields are expressed in network byte order (big-endian). The binary structure contains required and optional parameters described in this specification, and possibly additional vendor-specific ones. The parameters shall use the same syntax as in the 'a=fmtp' line of the associated SDP transport file.

Table 1 describes the size of each parameter of the binary structure and its associated flag in the FIELD-PRESENT-MASK which indicate when set to ‘1’ that the parameter value is provided in the binary structure, and when set to ‘0’ that no value is provided. When a value is not provided for a parameter, the associated bytes in the binary structure shall be 0x00 and for N-byte parameters the length shall be set to 0. For N-byte parameters, the FIELD-PRESENT-MASK bit indicates if the associated length (N) has a valid value, indicating the number of bytes included at the end of the binary structure for the associated parameter. Unused bits of the FIELD-PRESENT-MASK shall be set to 0.

Parameter	Size	FIELD-PRESENT-MASK
profile-space	1-byte	bit 0 (least significant bit)
profile-id	1-byte	bit 1
level-id	1-byte	bit 2
tier-flag	1-byte	bit 3
profile-compatibility-indicator	4-byte	bit 4
interop-constraints	6-byte	bit 5
sprop-max-don-diff	2-byte	bit 6
tx-mode	4-byte	bit 7

sprop-depack-buf-bytes	4-byte	bit 8
sprop-depack-buf-nalus	2-byte	bit 9
sprop-spatial-segmentation-idc	2-byte	bit 10
sprop-sub-layer-id	1-byte	bit 11
sprop-segmentation-id	1-byte	bit 12
sprop-vps	N-byte	bit 13
sprop-sps	N-byte	bit 14
sprop-pps	N-byte	bit 15
extra bytes	N-byte	bit 16

Table 1



Media Info Block type 0x0009.

There shall be (sprop-vps-N + sprop-sps-N + sprop-pps-N + extra-N) rounded to a multiple of 4 bytes following the 44th byte of the binary structure.

Note: sprop-vps, sprop-sps and sprop-pps bytes are base64 characters as represented in the SDP transport file, possibly including an ',' to separate the list elements and possibly terminating the list with an ',' to indicate that in-band ones may complement the out of band ones.

As described by TR-10-1, the Media Info Block shall be aligned on a 32-bit boundary, and its length shall be the number of 32-bit words in the Media Info Block minus one.

If the following parameters are present in the 'a=fmtp' line of the stream's SDP transport file, they shall also be present in the media info block: **profile-space, profile-id, profile-compatibility-indicator, interop-constraints, level-id, tier-flag, sprop-vps, sprop-sps, and sprop-pps**.

If the following parameters are present in the 'a=fmtp' line of the stream's SDP transport file, they shall also be present in the media info block: **sprop-sub-layer-id, tx-mode, sprop-max-don-diff, sprop-depack-buf-nalus, sprop-depack-buf-bytes, sprop-segmentation-id, sprop-spatial- segmentation-idc**.

Note: The only parameters that are considered here are those described as bitstream properties in sendonly mode in Table 1 of RFC 7798.

16.1 Example

An SDP transport file having the following `fmtp` attribute would have a Media Sender Report with those parameters.

```
a=fmtp:96 width=1920; height=1080; depth=10; exactframerate=60;
sampling=YCbCr-4:2:2; colorimetry=BT709; TP=2110TPW; MAXUDP=1460; TCS=SDR;
RANGE=NARROW; measuredpixclk=124416000; vtotal=1080; htotal=1920; IPMX;
profile-id=4; level-id=90; interop-constraints=BD0800000000; profile-
compatibility-indicator=00000010; tx-mode=SRST
```

From this SDP “a=fmtp” example we establish that 5 fields are presents: profile-id, level-id, interop-constraints, profile-compatibility-indicator and tx-mode. The value of FIELD-PRESENT-MASK is then 0x000000B6 according to Table 1.