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# Abstract

This document is the draft text for changes to the High Efficiency Video Coding (HEVC) standard (Rec. ITU-T H.265 | ISO/IEC 23008-2) to specify additional supplemental enhancement information (SEI) messages for content colour volume, omnidirectional 360° projection, regional nesting, and motion-constrained tile sets extraction information.

**Changes to the specification text:**

*In 5.8, renumber formulae 5-16 and 5-17 as 5-17 and 5-18, and add the following function definition:*

Sin( x ) the trigonometric sine function operating on an argument x in units of radians (5‑16)

*In 8.7.2.1, replace the following paragraph:*

The deblocking filter process is applied to all prediction block edges and transform block edges of a picture, except the edges that are at the boundary of the picture, for which the deblocking filter process is disabled by slice\_deblocking\_filter\_disabled\_flag, that coincide with tile boundaries when loop\_filter\_across\_tiles\_enabled\_flag is equal to 0, or that coincide with upper or left slice boundaries of slices with slice\_loop\_filter\_across\_slices\_enabled\_flag equal to 0. For the transform units and prediction units with block edges less than 8 samples in either the vertical or horizontal direction, only the edges lying on the 8x8 sample grid of the considered component are filtered.

*with the following:*

The deblocking filter process is applied to all prediction block edges and transform block edges of a picture, except the following types of edges:

– Edges that are at the boundary of the picture

– Edges that coincide with tile boundaries when loop\_filter\_across\_tiles\_enabled\_flag is equal to 0

– Edges that coincide with upper or left boundaries of slices with slice\_loop\_filter\_across\_slices\_enabled\_flag equal to 0 or slice\_deblocking\_filter\_disabled\_flag equal to 1

– Edges within slices with slice\_deblocking\_filter\_disabled\_flag equal to 1

– Edges that do not correspond to 8x8 sample grid boundaries of the considered component

– Edges within chroma components for which both sides of the edge use inter prediction

– Edges of chroma transform blocks that are not edges of the associated transform unit

*Replace D.2.1 with the following:*

**D.2.1 General SEI message syntax**

|  |  |
| --- | --- |
| sei\_payload( payloadType, payloadSize ) { | **Descriptor** |
| if( nal\_unit\_type = = PREFIX\_SEI\_NUT ) |  |
| if( payloadType = = 0 ) |  |
| buffering\_period( payloadSize ) |  |
| else if( payloadType = = 1 ) |  |
| pic\_timing( payloadSize ) |  |
| else if( payloadType = = 2 ) |  |
| pan\_scan\_rect( payloadSize ) |  |
| else if( payloadType = = 3 ) |  |
| filler\_payload( payloadSize ) |  |
| else if( payloadType = = 4 ) |  |
| user\_data\_registered\_itu\_t\_t35( payloadSize ) |  |
| else if( payloadType = = 5 ) |  |
| user\_data\_unregistered( payloadSize ) |  |
| else if( payloadType = = 6 ) |  |
| recovery\_point( payloadSize ) |  |
| else if( payloadType = = 9 ) |  |
| scene\_info( payloadSize ) |  |
| else if( payloadType = = 15 ) |  |
| picture\_snapshot( payloadSize ) |  |
| else if( payloadType = = 16 ) |  |
| progressive\_refinement\_segment\_start( payloadSize ) |  |
| else if( payloadType = = 17 ) |  |
| progressive\_refinement\_segment\_end( payloadSize ) |  |
| else if( payloadType = = 19 ) |  |
| film\_grain\_characteristics( payloadSize ) |  |
| else if( payloadType = = 22 ) |  |
| post\_filter\_hint( payloadSize ) |  |
| else if( payloadType = = 23 ) |  |
| tone\_mapping\_info( payloadSize ) |  |
| else if( payloadType = = 45 ) |  |
| frame\_packing\_arrangement( payloadSize ) |  |
| else if( payloadType = = 47 ) |  |
| display\_orientation( payloadSize ) |  |
| else if( payloadType = = 56 ) |  |
| green\_metadata( payloadsize ) /\* specified in ISO/IEC 23001-11 \*/ |  |
| else if( payloadType = = 128 ) |  |
| structure\_of\_pictures\_info( payloadSize ) |  |
| else if( payloadType = = 129 ) |  |
| active\_parameter\_sets( payloadSize ) |  |
| else if( payloadType = = 130 ) |  |
| decoding\_unit\_info( payloadSize ) |  |
| else if( payloadType = = 131 ) |  |
| temporal\_sub\_layer\_zero\_index( payloadSize ) |  |
| else if( payloadType = = 133 ) |  |
| scalable\_nesting( payloadSize ) |  |
| else if( payloadType = = 134 ) |  |
| region\_refresh\_info( payloadSize ) |  |
| else if( payloadType = = 135 ) |  |
| no\_display( payloadSize ) |  |
| else if( payloadType = = 136 ) |  |
| time\_code( payloadSize ) |  |
| else if( payloadType = = 137 ) |  |
| mastering\_display\_colour\_volume( payloadSize ) |  |
| else if( payloadType = = 138 ) |  |
| segmented\_rect\_frame\_packing\_arrangement( payloadSize ) |  |
| else if( payloadType = = 139 ) |  |
| temporal\_motion\_constrained\_tile\_sets( payloadSize ) |  |
| else if( payloadType = = 140 ) |  |
| chroma\_resampling\_filter\_hint( payloadSize ) |  |
| else if( payloadType = = 141 ) |  |
| knee\_function\_info( payloadSize ) |  |
| else if( payloadType = = 142 ) |  |
| colour\_remapping\_info( payloadSize ) |  |
| else if( payloadType = = 143 ) |  |
| deinterlaced\_field\_identification( payloadSize ) |  |
| else if( payloadType = = 144 ) |  |
| content\_light\_level\_info( payloadSize ) |  |
| else if( payloadType = = 145 ) |  |
| dependent\_rap\_indication( payloadSize ) |  |
| else if( payloadType = = 146 ) |  |
| coded\_region\_completion( payloadSize ) |  |
| else if( payloadType = = 147 ) |  |
| alternative\_transfer\_characteristics( payloadSize ) |  |
| else if( payloadType = = 148 ) |  |
| ambient\_viewing\_environment( payloadSize ) |  |
| else if( payloadType = = 149 ) |  |
| content\_colour\_volume( payloadSize ) |  |
| else if( payloadType = = 150 ) |  |
| omnidirectional\_projection\_indication( payloadSize ) |  |
| else if( payloadType = = 151 ) |  |
| regional\_nesting( payloadSize ) |  |
| else if( payloadType = = 152 ) |  |
| mcts\_extraction\_info\_set( payloadSize ) |  |
| else if( payloadType = = 153 ) |  |
| mcts\_extraction\_info\_nesting( payloadSize ) |  |
| else if( payloadType = = 160 ) |  |
| layers\_not\_present( payloadSize ) /\* specified in Annex F \*/ |  |
| else if( payloadType = = 161 ) |  |
| inter\_layer\_constrained\_tile\_sets( payloadSize ) /\* specified in Annex F \*/ |  |
| else if( payloadType = = 162 ) |  |
| bsp\_nesting( payloadSize ) /\* specified in Annex F \*/ |  |
| else if( payloadType = = 163 ) |  |
| bsp\_initial\_arrival\_time( payloadSize ) /\* specified in Annex F \*/ |  |
| else if( payloadType = = 164 ) |  |
| sub\_bitstream\_property( payloadSize ) /\* specified in Annex F \*/ |  |
| else if( payloadType = = 165 ) |  |
| alpha\_channel\_info( payloadSize ) /\* specified in Annex F \*/ |  |
| else if( payloadType = = 166 ) |  |
| overlay\_info( payloadSize ) /\* specified in Annex F \*/ |  |
| else if( payloadType = = 167 ) |  |
| temporal\_mv\_prediction\_constraints( payloadSize ) /\* specified in Annex F \*/ |  |
| else if( payloadType = = 168 ) |  |
| frame\_field\_info( payloadSize ) /\* specified in Annex F \*/ |  |
| else if( payloadType = = 176 ) |  |
| three\_dimensional\_reference\_displays\_info( payloadSize ) /\* specified in Annex G \*/ |  |
| else if( payloadType = = 177 ) |  |
| depth\_representation\_info( payloadSize ) /\* specified in Annex G \*/ |  |
| else if( payloadType = = 178 ) |  |
| multiview\_scene\_info( payloadSize ) /\* specified in Annex G \*/ |  |
| else if( payloadType = = 179 ) |  |
| multiview\_acquisition\_info( payloadSize ) /\* specified in Annex G \*/ |  |
| else if( payloadType = = 180 ) |  |
| multiview\_view\_position( payloadSize ) /\* specified in Annex G \*/ |  |
| else if( payloadType = = 181 ) |  |
| alternative\_depth\_info( payloadSize ) /\* specified in Annex I \*/ |  |
| else |  |
| reserved\_sei\_message( payloadSize ) |  |
| else /\* nal\_unit\_type = = SUFFIX\_SEI\_NUT \*/ |  |
| if( payloadType = = 3 ) |  |
| filler\_payload( payloadSize ) |  |
| else if( payloadType = = 4 ) |  |
| user\_data\_registered\_itu\_t\_t35( payloadSize ) |  |
| else if( payloadType = = 5 ) |  |
| user\_data\_unregistered( payloadSize ) |  |
| else if( payloadType = = 17 ) |  |
| progressive\_refinement\_segment\_end( payloadSize ) |  |
| else if( payloadType = = 22 ) |  |
| post\_filter\_hint( payloadSize ) |  |
| else if( payloadType = = 132 ) |  |
| decoded\_picture\_hash( payloadSize ) |  |
| else if( payloadType = = 146 ) |  |
| coded\_region\_completion( payloadSize ) |  |
| else |  |
| reserved\_sei\_message( payloadSize ) |  |
| if( more\_data\_in\_payload( ) ) { |  |
| if( payload\_extension\_present( ) ) |  |
| **reserved\_payload\_extension\_data** | u(v) |
| **payload\_bit\_equal\_to\_one** /\* equal to 1 \*/ | f(1) |
| while( !byte\_aligned( ) ) |  |
| **payload\_bit\_equal\_to\_zero** /\* equal to 0 \*/ | f(1) |
| } |  |
| } |  |

*Renumber clause D.2.40 (Reserved SEI message syntax) as D.2.45.*

*Add clauses D.2.40 through D.2.44, as follows:*

**D.2.40 Content colour volume SEI message syntax**

|  |  |
| --- | --- |
| content\_colour\_volume( payloadSize ) { | **Descriptor** |
| **ccv\_cancel\_flag** | u(1) |
| if( !ccv\_cancel\_flag ) { |  |
| **ccv\_persistence\_flag** | u(1) |
| **ccv\_primaries\_present\_flag** | u(1) |
| **ccv\_min\_luminance\_value\_present\_flag** | u(1) |
| **ccv\_max\_luminance\_value\_present\_flag** | u(1) |
| **ccv\_avg\_luminance\_value\_present\_flag** | u(1) |
| **ccv\_reserved\_zero\_2bits** | u(2) |
| if( ccv\_primaries\_present\_flag ) |  |
| for( c = 0; c < 3; c++ ) { |  |
| **ccv\_primaries\_x**[ c ] | i(16) |
| **ccv\_primaries\_y**[ c ] | i(16) |
| } |  |
| if( ccv\_min\_luminance\_value\_present\_flag ) |  |
| **ccv\_min\_luminance\_value** | u(32) |
| if( ccv\_max\_luminance\_value\_present\_flag ) |  |
| **ccv\_max\_luminance\_value** | u(32) |
| if( ccv\_avg\_luminance\_value\_present\_flag ) |  |
| **ccv\_avg\_luminance\_value** | u(32) |
| } |  |
| } |  |

**D.2.41 Omnidirectional projection indication SEI message syntax**

|  |  |
| --- | --- |
| omnidirectional\_projection\_indication( payloadSize ) { | **Descriptor** |
| **omnidirectional\_projection\_indication\_cancel\_flag** | u(1) |
| if( !omnidirectional\_projection\_indication\_cancel\_flag ) { |  |
| **omnidirectional\_projection\_information\_persistence\_flag** | u(1) |
| **geometry\_type** | u(5) |
| **sub\_geometry\_flag** | u(1) |
| **projection\_type** | u(8) |
| if( geometry\_type = = 1 && sub\_geometry\_flag = = 1 &&  projection\_type = = 1 ) { |  |
| **yaw\_center** | i(16) |
| **pitch\_center** | i(16) |
| **roll\_center** | i(16) |
| **yaw\_range** | u(16) |
| **pitch\_range** | u(16) |
| } |  |
| } |  |
| } |  |

**D.2.42 Regional nesting SEI message syntax**

|  |  |
| --- | --- |
| regional\_nesting( payloadSize ) { | **Descriptor** |
| **regional\_nesting\_id** | u(16) |
| **regional\_nesting\_num\_rect\_regions** | u(8) |
| for( i = 0; i < regional\_nesting\_num\_rect\_regions; i++) { |  |
| **regional\_nesting\_rect\_region\_id**[ i ] | u(8) |
| **regional\_nesting\_rect\_left\_offset**[ i ] | u(16) |
| **regional\_nesting\_rect\_right\_offset**[ i ] | u(16) |
| **regional\_nesting\_rect\_top\_offset**[ i ] | u(16) |
| **regional\_nesting\_rect\_bottom\_offset**[ i ] | u(16) |
| } |  |
| **num\_sei\_messages\_in\_regional\_nesting\_minus1** | u(8) |
| for( i = 0; i <= num\_sei\_messages\_in\_regional\_nesting\_minus1; i++ ) { |  |
| **num\_regions\_for\_sei\_message**[ i ] | u(8) |
| for(j = 0; j < num\_regions\_for\_sei\_message[ i ]; j++ ) |  |
| **regional\_nesting\_sei\_region\_idx**[ i ][ j ] | u(8) |
| sei\_message( ) |  |
| } |  |
| } |  |

**D.2.43 Motion-constrained tile sets extraction information set SEI message syntax**

|  |  |
| --- | --- |
| mcts\_extraction\_info\_set( ) { | **Descriptor** |
| **num\_extraction\_info\_sets\_minus1** | ue(v) |
| for( i = 0; i <= num\_extraction\_information\_sets\_minus1; i++ )  { |  |
| **num\_associated\_tile\_set\_identifiers\_minus1**[ i ] | ue(v) |
| for( j = 0; j <=  num\_associated\_tile\_set\_identifiers\_minus1[ i ]; j++ ) |  |
| **mcts\_identifier**[ i ][ j ] | ue(v) |
| **num\_vps\_in\_extraction\_info\_set\_minus1**[ i ] | ue(v) |
| for( j = 0; j <= num\_vps\_in\_extraction\_set\_minus1[ i ]; j++ ) |  |
| **vps\_rbsp\_data\_length**[ i ][ j ] | ue(v) |
| **num\_sps\_in\_extraction\_info\_set\_minus1**[ i ] | ue(v) |
| for( j = 0; j <= num\_sps\_in\_extraction\_set\_minus1[ i ]; j++ ) |  |
| **sps\_rbsp\_data\_length**[ i ][ j ] | ue(v) |
| **num\_pps\_in\_extraction\_info\_set\_minus1**[ i ] | ue(v) |
| for( j = 0; j <= num\_pps\_in\_extraction\_set\_minus1[ i ]; j++ ) { |  |
| **pps\_nuh\_temporal\_id\_plus1**[ i ][ j ] | u(3) |
| **pps\_rbsp\_data\_length**[ i ][ j ] | ue(v) |
| } |  |
| while( !byte\_aligned() ) |  |
| **mcts\_alignment\_bit\_equal\_to\_zero** | f(1) |
| for( j = 0; j <= num\_vps\_in\_extraction\_set\_minus1[ i ]; j++ ) |  |
| for( k = 0; k <= vps\_rbsp\_data\_length[ i ][ j ]; k++ ) |  |
| **vps\_rbsp\_data\_bytes**[ i ][ j ][ k ] | u(8) |
| for( j = 0; j <= num\_sps\_in\_extraction\_set\_minus1[ i ]; j++ ) |  |
| for( k = 0; k <= sps\_rbsp\_data\_length[ i ][ j ]; k++ ) |  |
| **sps\_rbsp\_data\_bytes**[ i ][ j ][ k ] | u(8) |
| for( j = 0; j <= num\_pps\_in\_extraction\_set\_minus1[ i ]; j++ ) |  |
| for( k = 0; k <= pps\_rbsp\_data\_length[ i ][ j ]; k++ ) |  |
| **pps\_rbsp\_data\_bytes**[ i ][ j ][ k ] | u(8) |
| } |  |
| } |  |

**D.2.44 Motion-constrained tile sets extraction information nesting SEI message syntax**

|  |  |
| --- | --- |
| mcts\_extraction\_info\_nesting( ) { | **Descriptor** |
| **all\_tile\_sets\_flag** | u(1) |
| if( !all\_tile\_sets\_flag ) { |  |
| **num\_associated\_mcts\_identifiers\_minus1** | ue(v) |
| for( i = 0; i <= num\_associated\_mcts\_identifiers\_minus1; i++ ) |  |
| **mcts\_identifier**[ i ] | ue(v) |
| } |  |
| **num\_sei\_messages\_in\_mcts\_extraction\_nesting\_minus1** | ue(v) |
| while( !byte\_aligned( ) ) |  |
| **mcts\_nesting\_zero\_bit** /\* equal to 0 \*/ | u(1) |
| for( i = 0; i  <=  num\_sei\_messages\_in\_mcts\_extraction\_nesting\_minus1; i++ ) |  |
| sei\_message( ) |  |
| } |  |

*In D.3.1, replace the following paragraphs:*

The list SingleLayerSeiList is set to consist of the payloadType values 3, 6, 9, 15, 16, 17, 19, 22, 23, 45, 47, 56, 128, 129, 131, 132, and 134 to 148, inclusive.

The list VclAssociatedSeiList is set to consist of the payloadType values 2, 3, 6, 9, 15, 16, 17, 19, 22, 23, 45, 47, 56, 128, 131, 132, and 134 to 148, inclusive.

The list PicUnitRepConSeiList is set to consist of the payloadType values 0, 1, 2, 6, 9, 15, 16, 17, 19, 22, 23, 45, 47, 56, 128, 129, 131, 132, 133, and 135 to 148, inclusive.

*with the following:*

The list SingleLayerSeiList is set to consist of the payloadType values 3, 6, 9, 15, 16, 17, 19, 22, 23, 45, 47, 56, 128, 129, 131, 132, and 134 to 153, inclusive.

The list VclAssociatedSeiList is set to consist of the payloadType values 2, 3, 6, 9, 15, 16, 17, 19, 22, 23, 45, 47, 56, 128, 131, 132, and 134 to 153, inclusive.

The list PicUnitRepConSeiList is set to consist of the payloadType values 0, 1, 2, 6, 9, 15, 16, 17, 19, 22, 23, 45, 47, 56, 128, 129, 131, 132, 133, and 135 to 153, inclusive.

*In Table D.1, append the following rows to the end of the table:*

|  |  |
| --- | --- |
| Content colour volume | The CLVS containing the SEI message |
| Omnidirectional projection information | The CLVS containing the SEI message |
| Regional nesting | Depending on the SEI messages contained in the regional nesting SEI message; each of these nested SEI messages has the same persistence scope as if the SEI message was not contained in a regional nesting SEI message |
| Motion-constrained tile sets extraction information set | The CLVS containing the SEI message |
| Motion-constrained tile sets extraction information nesting | The access unit containing the SEI message |

*Renumber clause D.3.40 (Reserved SEI message semantics) as D.3.45.*

*Add clauses D.3.40 through D.3.44, as follows:*

**D.3.40 Content colour volume SEI message semantics**

The content colour volume SEI message provides information about the colour volume characteristics of the associated picture. This SEI message describes the colour volume characteristics of the associated picture in terms of a nominal range, and deviations from this range may occur.

The variable transferCharacteristics is specified as follows:

– If an alternative transfer characteristics SEI message is present for the CLVS, transferCharacteristics is set equal to preferred\_transfer\_characteristics;

– Otherwise, (an alternative transfer characteristics SEI message is not present for the CLVS), transferCharacteristics is set equal to transfer\_characteristics.

This SEI message shall not be present when any of the values of transferCharacteristics, colour\_primaries, and matrix\_coeffs has a value defined as unspecified.

The following applies when converting the signal from non-linear to a linear representation:

– If the value of transferCharacteristics is equal to 1, 6, 7, 14, or 15, the Rec. ITU‑R BT.1886 reference electro-optical transfer function should be used to convert the signal back to its linear representation, where the value of screen luminance for white is set equal to 100 cd/m2, the value of screen luminance for black is set equal to 0 cd/m2, and the value of the exponent of the power function is set equal to 2.40.

– Otherwise, if the value of transferCharacteristics is equal to 18, the hybrid log-gamma reference electro-optical transfer function specified in Rec. ITU-R BT.2100 should be used, where the value of nominal peak luminance of the display is set equal to 1000 cd/m2, the value of the display luminance for black is set equal to 0 cd/m2, and the value of system gamma is set equal to 1.2.

– Otherwise (the value of transferCharacteristics is not equal to 1, 6, 7, 14, 15, or 18), the exact inverse of the transfer function specified in Table E.4 should be used to convert the non-linear signal to a linear representation.

**ccv\_cancel\_flag** equal to 1 indicates that the content colour volume SEI message cancels the persistence of any previous content colour volume SEI message in output order that applies to the current layer. ccv\_cancel\_flagequal to 0 indicates that content colour volume information follows.

**ccv\_persistence\_flag** specifies the persistence of the content colour volume SEI message for the current layer.

ccv\_persistence\_flag equal to 0 specifies that the content colour volume applies to the current decoded picture only.

Let picA be the current picture. ccv\_persistence\_flag equal to 1 specifies that the content colour volume SEI message persists for the current layer in output order until any of the following conditions are true:

– A new CLVS of the current layer begins.

– The bitstream ends.

– A picture picB in the current layer in an access unit containing a content colour volume SEI message that is applicable to the current layer is output for which PicOrderCnt( picB ) is greater than PicOrderCnt( picA ), where PicOrderCnt( picB ) and PicOrderCnt( picA ) are the PicOrderCntVal values of picB and picA, respectively, immediately after the invocation of the decoding process for the picture order count of picB.

**ccv\_primaries\_present\_flag** equal to 1 specifies that the syntax elements ccv\_primaries\_x[ c ] and ccv\_primaries\_y[ c ] are present. ccv\_primaries\_present\_flag equal to 0 specifies that the syntax elements ccv\_primaries\_x[ c ] and ccv\_primaries\_y[ c ] are not present.

**ccv\_min\_luminance\_value\_present\_flag** equal to 1 specifies that the syntax element ccv\_min\_luminance\_value is present. ccv\_min\_luminance\_value\_present\_flag equal to 0 specifies that the syntax element ccv\_min\_luminance\_value is not present.

**ccv\_max\_luminance\_value\_present\_flag** equal to 1 specifies that the syntax element ccv\_max\_luminance\_value is present. ccv\_max\_luminance\_value\_present\_flag equal to 0 specifies that the syntax element ccv\_max\_luminance\_value is not present.

**ccv\_avg\_luminance\_value\_present\_flag** equal to 1 specifies that the syntax element ccv\_avg\_luminance\_value is present. ccv\_avg\_luminance\_value\_present\_flag equal to 0 specifies that the syntax element ccv\_avg\_luminance\_value is not present.

It is a requirement of bitstream conformance that the values of ccv\_primaries\_present\_flag, ccv\_min\_luminance\_value\_present\_flag, ccv\_max\_luminance\_value\_present\_flag, and ccv\_avg\_luminance\_value\_present\_flag shall not all be equal to 0.

**ccv\_reserved\_zero\_2bits**[ i ] shall be equal to 0 in bitstreams conforming to this version of this document. Other values for reserved\_zero\_2bits[ i ] are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore the value of reserved\_zero\_2bits[ i ].

**ccv\_primaries\_x**[ c ] and **ccv\_primaries\_y**[ c ] specify the normalized x and y chromaticity coordinates, respectively, of the colour primary component c of the nominal content colour volume in increments of 0.00002, according to the CIE 1931 definition of x and y as specified in ISO 11664-1 (see also ISO 11664-3 and CIE 15). For describing colour volumes that use red, green, and blue colour primaries, it is suggested that index value c equal to 0 should correspond to the green primary, c equal to 1 should correspond to the blue primary, and c equal to 2 should correspond to the red colour primary (see also Annex E and Table E.3).

The values of ccv\_primaries\_x[ c ] and ccv\_primaries\_y[ c ] shall be in the range of −5 000 000 to 5 000 000, inclusive.

When ccv\_primaries\_x[ c ] and ccv\_primaries\_y[ c ] are not present, they should be inferred as equal to the normalized x and y chromaticity coordinates specified by colour\_primaries.

**ccv\_min\_luminance\_value** specifies the normalized minimum luminance value, according to CIE 1931, that is expected to be present in the content, where values are normalized to Lo or Lc as specified in Table E.4 and according to the indicated transfer characteristics of the signal. The values of ccv\_min\_luminance\_value are in normalized increments of 0.0000001 in the linear representation. When not present, ccv\_min\_luminance\_value should be inferred to be equal to 0.

NOTE 1 – The resulting domain from this conversion process may or may not represent light in a source or display domain – it is merely a gamut representation domain rather than necessarily being a representation of actual light in either the scene or display domain. Therefore, the values corresponding to ccv\_min\_luminance\_value might not necessarily correspond to a true luminance value.

**ccv\_max\_luminance\_value** specifies the maximum luminance value, according to CIE 1931, that is expected to be present in the content, where values are normalized to Lo or Lc as specified in Table E.4 and according to the transfer characteristics of the signal. The values of ccv\_max\_luminance\_value are in normalized increments of 0.0000001 inclusive in the linear representation. When not present, ccv\_max\_luminance\_value should be inferred to be equal to 10000000.

NOTE 2 – The resulting domain from this conversion process may or may not represent light in a source or display domain – it is merely a gamut representation domain rather than necessarily being a representation of actual light in either the scene or display domain. Therefore, the values corresponding to ccv\_max\_luminance\_value might not necessarily correspond to a true luminance value.

**ccv\_avg\_luminance\_value** specifies the average luminance value, according to CIE 1931, that is expected to be present in the content, where values are normalized to Lo or Lc as specified in Table E.4 and according to the transfer characteristics of the signal. The values of ccv\_avg\_luminance\_value are in normalized increments of 0.0000001 inclusive in the linear representation. When not present, ccv\_avg\_luminance\_value can be inferred to be equal to ( ccv\_min\_luminance\_value + ccv\_max\_luminance\_value ) / 2 or computed directly from the bitstream.

NOTE 3 – The resulting domain from this conversion process may or may not represent light in a source or display domain – it is merely a gamut representation domain rather than necessarily being a representation of actual light in either the scene or display domain. Therefore, the values corresponding to ccv\_avg\_luminance\_value might not necessarily correspond to a true luminance value.

ccv\_min\_luminance\_value should be less than or equal to ccv\_avg\_luminance\_value. ccv\_avg\_luminance\_value should be less than or equal to ccv\_max\_luminance\_value.

When the visually relevant region does not correspond to the entire cropped decoded picture, such as for "letterbox" encoding of video content with a wide picture aspect ratio within a taller cropped decoded picture, the indicated ccv\_min\_luminance\_value, ccv\_max\_luminance\_value and ccv\_avg\_luminance\_value should be performed only within the visually relevant region.

**D.3.41 Omnidirectional projection indication SEI message semantics**

The omnidirectional projection indication SEI message provides information to enable remapping of the colour samples of the output decoded pictures onto an alternative coordinate space for use in panoramic video applications.

When an omnidirectional projection indication SEI message is present for any picture of a CLVS of a particular layer, an omnidirectional projection indication SEI message shall be present for the first picture of the CLVS. The omnidirectional projection SEI message persists for the current layer in decoding order from the current picture until the end of the CLVS.

The luma dimensions of the cropped output picture are computed as follows:

croppedWidthY = pic\_width\_in\_luma\_samples −  
 SubWidthC \* ( conf\_win\_right\_offset + conf\_win\_left\_offset ) (D‑51)

croppedHeightY = pic\_height\_in\_luma\_samples −  
 SubHeightC \* ( conf\_win\_bottom\_offset + conf\_win\_top\_offset ) (D‑52)

croppedWidthC = croppedWidthY / SubWidthC (D‑53)

croppedHeightC = croppedHeightY / SubHeightC (D‑54)



**Figure D.12 cropped output of decoded picture luma samples**

**omnidirectional\_projection\_information\_cancel\_flag** equal to 1 indicates that the SEI message cancels the persistence of any previous spherical orientation SEI message in output order. omnidirectional\_projection\_information\_cancel\_flag equal to 0 indicates that spherical orientation information follows.

**omnidirectional\_projection\_information\_persistence\_flag** specifies the persistence of the spherical orientation SEI message for the current layer.

omnidirectional\_projection\_information\_persistence\_flag equal to 0 specifies that the spherical orientation SEI message applies to the current decoded picture only.

Let picA be the current picture. omnidirectional\_projection\_information\_persistence\_flag equal to 1 specifies that the spherical orientation SEI message persists for the current layer in output order until one or more of the following conditions are true:

– A new CLVS of the current layer begins.

– The bitstream ends.

– A picture picB in the current layer in an access unit containing a spherical orientation SEI message that is applicable to the current layer is output for which PicOrderCnt( picB ) is greater than PicOrderCnt( picA ), where PicOrderCnt( picB ) and PicOrderCnt( picA ) are the PicOrderCntVal values of picB and picA, respectively, immediately after the invocation of the decoding process for picture order count for picB.

**geometry type** indicates the mathematical convention where points within a space can be uniquely identified by a location in one or more dimensions. When geometry\_type is equal to 1, the projection indicator is given in spherical coordinates, where φ is the azimuth (longitude) and θ is the elevation (latitude) as depicted in Figure D.13.

|  |  |
| --- | --- |
|  | cid:cab8af07-d2c8-4868-afb5-509c0681d1e3@namprd03.prod.outlook.com |
| **(a) region with yaw and pitch offsets** | **(b) region (lighter shade) with yaw, pitch, and roll offsets** |

**Figure D.13 Spherical surface coordinates φ, θ with yaw, pitch, and roll of the projection image relative to the equator and 0 meridian**

**sub\_geometry\_flag** indicates the presence of sub geometry elements that further describe or limit the geometry of this SEI message.

**projection\_type** indicates the particular mapping of the rectangular decoder picture output samples onto the coordinate system specified by geometry\_type.

**yaw\_center** specifies the value of yaw that corresponds to the center in the projection image, in increments of 0.01 degrees. The values of yaw\_center shall be in the range of -18000 and 17999. When not present, the value of yaw\_center should be inferred to be equal to 0.

**pitch\_center** specifies the value of pitch that corresponds to the center in the projection image, in increments of 0.01 degrees. The values of pitch\_center shall be in the range of -9000 and 9000. When not present, the value of pitch\_center should be inferred to be equal to 0.

**roll\_center** specifies the value of roll that corresponds to the center in the projection image, in increments of 0.01 degrees. The values of roll\_center shall be in the range of -18000 and 18000. When not present, the value of roll\_center should be inferred to be equal to 0.

**yaw\_range** specifies the range of values of yaw that are present in the projection image, in increments of 0.01 degrees. The values of yaw\_range shall be in the range of 1 and 36000. When not present, the value of yaw\_range should be inferred to be equal to 36000.

**pitch\_range** specifies the range of values of pitch that are present in the projection image, in increments of 0.01 degrees. The values of pitch\_range shall be in the range of 1 and 18000. When not present, the value of pitch range should be inferred to be equal to 18000.

When projection\_type is equal to 1, sub\_geometry\_flag is equal to 1, and geometry\_type is equal to 1, cropped output picture samples at locations (i, j) are indicated as corresponding to angular coordinates. For i equal to SubWidthC \* conf\_win\_left\_offset to SubWidthC \* conf\_win\_left\_offset + croppedWidthC − 1 and j equal to SubHeightC \* conf\_win\_top\_offset to SubHeightC \* conf\_win\_top\_offset − 1, the corresponding angular coordinates (φ, θ) for the luma sample locations, in radians, are given by the following equirectangular mapping equations:

φmin = ( yaw\_center − yaw\_range ÷ 2 ) \* 0.01 \* π ÷ 180 (D‑52)

φmax = ( yaw\_center + yaw\_range ÷ 2 ) \* 0.01 \* π ÷ 180 (D‑56)

θmin = ( pitch\_center − pitch\_range ÷ 2 ) \* 0.01 \* π ÷ 180 (D‑57)

θmax = ( pitch\_center + pitch\_range ÷ 2 ) \* 0.01 \* π ÷ 180 (D‑58)

α = ( i′ + 0.5 ) \* ( φmax − φmin ) ÷ croppedWidthY + φmin (D‑59)

β = ( j′ + 0.5 ) \* ( θmin − θmax ) ÷ croppedHeightY − θmin (D‑60)

φ = Cos( ω ) \* α + Sin( ω ) \* β (D‑61)

θ = Sin( ω ) \* α − Cos( ω ) \* β (D‑62)

where

i′ = i − SubWidthC \* conf\_win\_left\_offset (D‑63)

j′ = j − SubHeightC \* conf\_win\_top\_offset (D‑64)

ω = roll\_center \* 0.01 \* π ÷ 180 (D‑65)

When chroma\_format\_idc is not equal to 0 (monochrome), for i equal to conf\_win\_left\_offset to conf\_win\_left\_offset + croppedWidthC − 1 and j equal to conf\_win\_top\_offset to conf\_win\_top\_offset + croppedHeightC − 1, the corresponding angular coordinates (φ, θ) for the chroma sample locations, in radians, are given by

α′ = ( i′ + CenterLeftOffsetC ) \* ( φmax − φmin ) ÷ croppedWidthC + φmin (D‑66)

β′ = ( j′ + CenterTopOffsetC ) \* ( θmin − θmax ) ÷ croppedHeightC − θmin (D‑67)

φ′ = Cos( ω ) \* α′ + Sin( ω ) \* β′ (D‑68)

θ′ = Sin( ω ) \* α′ − Cos( ω ) \* β′ (D‑69)

where

i′ = i − conf\_win\_left\_offset (D‑70)

j′ = j − conf\_win\_top\_offset (D‑71)

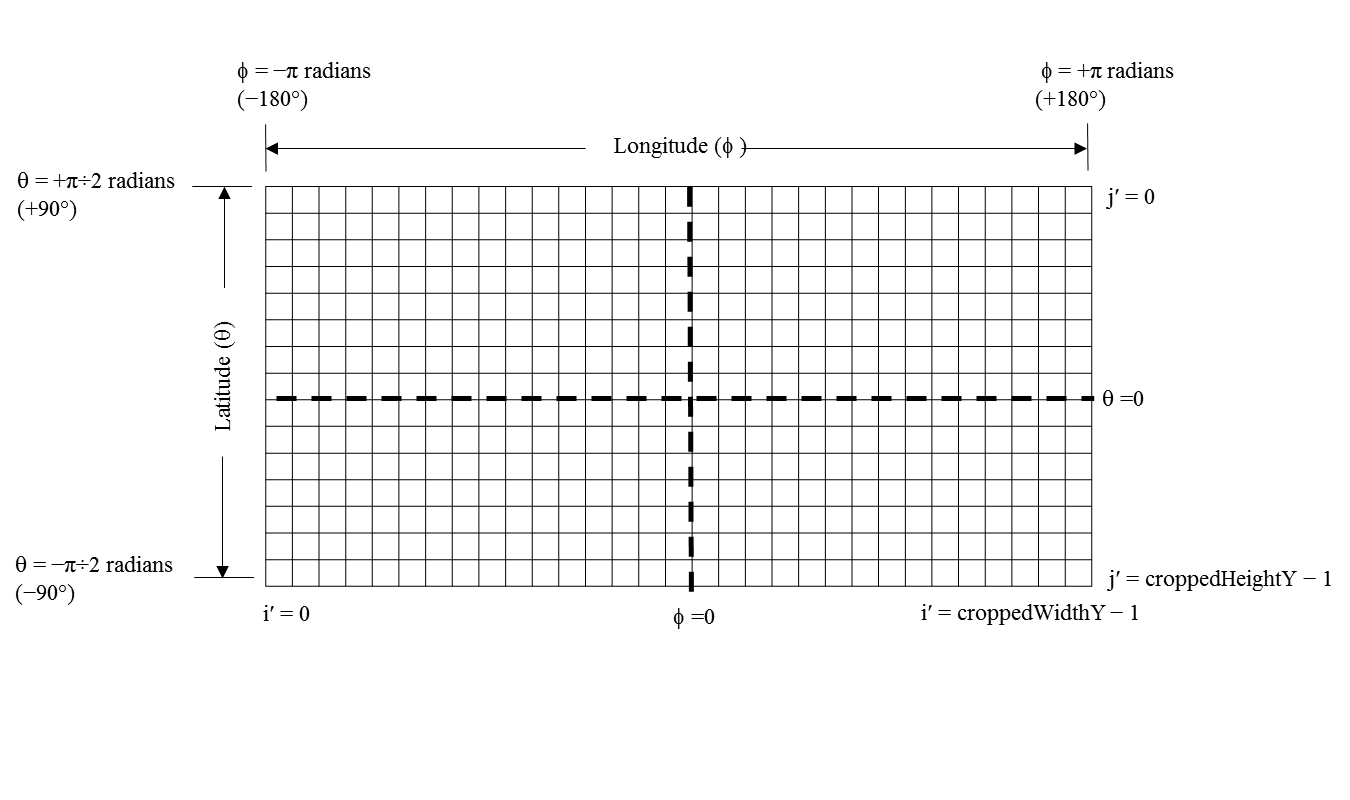
and CenterLeftOffsetC and CenterTopOffsetC are given by Table D.22 as a function of chroma\_format\_idc and ChromaLocType, which is set as follows:

1. If j % 2 is equal to 0, ChromaLocType is equal to chroma\_sample\_loc\_type\_top\_field
2. Otherwise, ChromaLocType is equal to chroma\_sample\_loc\_type\_bottom\_field

**Table D.22 – Derivation of CenterLeftOffsetC and CenterTopOffsetC**

|  |  |  |  |
| --- | --- | --- | --- |
| chroma\_format\_idc | ChromaLocType | CenterLeftOffsetC | CenterTopOffsetC |
| 1 (4:2:0) | 0 | 0.125 | 0.25 |
| 1 (4:2:0) | 1 | 0.25 | 0.25 |
| 1 (4:2:0) | 2 | 0.125 | 0.125 |
| 1 (4:2:0) | 3 | 0.25 | 0.125 |
| 1 (4:2:0) | 4 | 0.125 | 0.375 |
| 1 (4:2:0) | 5 | 0.25 | 0.375 |
| 2 (4:2:2) | – | 0.125 | 0.5 |
| 3 (4:4:4) | – | 0.5 | 0.5 |

When an omnidirectional projection indication SEI message is present for any picture of a CLVS of a particular layer and projection\_type is equal to 1 and geometry\_type is equal to 1, no frame packing arrangement SEI messages and segmented rectangular frame packing arrangement SEI messages shall be present in the CLVS.



**Figure D.14 Equirectangular mapping between cropped output picture luma samples and spherical coordinates**

**D.3.42 Regional nesting SEI message semantics**

The regional nesting SEI message provides a mechanism to associate SEI messages with regions of the picture. The associated SEI messages are conveyed within the regional nesting SEI message.

A regional nesting SEI message contains one or more SEI messages. When an SEI message is contained in a regional nesting SEI message, the contained SEI message is referred to as a region-nested SEI message. When an SEI message is not contained in a regional nesting SEI message, the SEI message is referred to as a non-region-nested SEI message.

For each region-nested SEI message in a regional nesting SEI message, one or more regions are specified in the regional nesting SEI message, and the semantics of the region-nested SEI message are to be interpreted as applying to each of these regions.

The list listOfRegionNestableMessageTypes includes the following types of SEI messages:

– Film grain characteristics SEI message

– Post filter hint SEI message

– Tone mapping information SEI message identified with a particular value of tone\_map\_id

– Chroma resampling filter hint SEI message

– Knee function information SEI message identified with a particular value of knee\_function\_id

– Colour remapping information SEI message identified with a particular value of colour\_remap\_id

– Content colour volume SEI message

NOTE 1 – SEI messages of each of the following are considered different types of SEI messages: 1) tone mapping information SEI messages with different values of tone\_map\_id, 2) knee function information SEI messages with different values of knee\_function\_id, and 3) colour remapping information SEI messages with different values of colour\_remap\_id.

When an SEI message of a particular type in listOfRegionNestableMessageTypes has film\_grain\_characteristics\_cancel\_flag, tone\_map\_cancel\_flag, knee\_function\_cancel\_flag, or colour\_remap\_cancel\_flag equal to 1, regardless of whether it is region-nested or non-region-nested, it cancels the persistence of all the region-nested SEI messages of the type, regardless of their associated regions. When an SEI message of a particular type having film\_grain\_characteristics\_persistence\_flag, tone\_map\_persistence\_flag, knee\_function\_persistence\_flag, or colour\_remap\_persistence\_flag equal to 1 is region-nested, the persistence of the SEI message is determined by the semantics of the SEI message irrespective of which region it applies to.

NOTE 2 – A region-nested SEI message has the same persistence scope as if the SEI message was non-region-nested.

NOTE 3 – A region-nested SEI message does not cancel the persistence of a non-region-nested SEI message of the same type.

The list listOfAllowedRegionalNestableMessageTypes includes the user data registered by Rec. ITU-T T.35 SEI message, user data unregistered SEI message and all the entries in the list listOfRegionNestableMessageTypes.

In bitstreams conforming to this version of this document, the regional nesting SEI message shall not contain any SEI message that is not in listOfAllowedRegionNestableMessageTypes. Decoders encountering a region-nested SEI message that does not belong to listOfAllowedRegionNestableMessageTypes shall ignore the region-nested SEI message.

When an access unit contains both region-nested SEI messages of a particular type belonging to listOfRegionNestableMessageTypes and non-region-nested SEI messages of the same type, decoders shall ignore either all the region-nested SEI message of that type or all the non-region-nested SEI messages of that type. Unless indicated otherwise by some means not specified in this document, when an access unit contains both region-nested SEI messages of a particular type belonging to listOfRegionNestableMessageTypes and non-region-nested SEI messages of the same type, the region-nested SEI messages should be preferred to be considered as applicable to the access unit.

A region-nested SEI message should not be extracted and sent as a non-region-nested SEI message, as the values signalled in the region-nested SEI message may not be applicable outside the indicated regions.

**regional\_nesting\_id** contains an identifying number that may be used to identify the purpose of the one or more SEI messages that are region-nested in the regional nesting SEI message. The value of regional\_nesting\_id shall be in the range of 0 to 216 − 1, inclusive.

Values of regional\_nesting\_id from 0 to 255 and from 512 to 215 − 1 may be used as determined by the application. Values of regional\_nesting\_id from 256 to 511 and from 215 to 216 − 1 are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of regional\_nesting\_id in the range of 256 to 511, inclusive, or in the range of 215 to 216 − 1, inclusive, shall ignore it.

**regional\_nesting\_num\_rect\_regions** specifies the number of rectangular regions specified in the regional nesting SEI message. The value of regional\_nesting\_num\_rect\_regions shall be in the range of 1 to 255, inclusive. The value of regional\_nesting\_num\_rect\_regions equal to 0 is reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore regional nesting SEI messages with regional\_nesting\_num\_rect\_regions equal to 0.

**regional\_nesting\_rect\_region\_id**[ i ] specifies the identifier for the i-th rectangular region specified by the regional nesting SEI message.

Unless indicated otherwise by some means not specified in this document, when a sample belongs to more than one region indicated as applying to more than one region-nested SEI message of a particular type in listOfRegionNestableMessageTypes, among these region-nested SEI messages, only those that are associated with the region that has the greatest value of regional\_nesting\_rect\_region\_id[ ] are considered as applying to the sample, while the rest of these region-nested SEI messages are considered as not applying to the sample.

NOTE 4 – When there are more than one of these region-nested SEI messages associated with the region that has the greatest value of regional\_nesting\_rect\_region\_id[ ], they are identical per other expressed constraints.

It is a requirement of bitstream conformance that the value of regional\_nesting\_rect\_region\_id[ i ] shall not be the same for any two different values of i in the range of 0 to regional\_nesting\_num\_rect\_regions − 1, inclusive, in the regional nesting SEI message.

When a region-nested SEI message of a particular type in listOfRegionNestableMessageTypes is indicated as applying to a list of regions listA in the current picture and another region-nested SEI message of the same type is indicated as applying to another list of regions listB in the current picture, it is a requirement of bitstream conformance that, for any pair of regions formed by choosing one from listA and the other from listB, the value of regional\_nesting\_rect\_region\_id[ ] of the two regions shall not be the same unless the two regions are identical (i.e., both position and size are the same) and the two region-nested SEI messages are identical.

**regional\_nesting\_rect\_left\_offset**[ i ], **regional\_nesting\_rect\_right\_offset**[ i ], **regional\_nesting\_rect\_**‌**top\_offset**[ i ] and **regional\_nesting\_rect\_bottom\_offset**[ i ] specify the coordinates of the i-th rectangular region specified by the SEI message. The offsets for the rectangular region are specified in units of luma samples. The i-th rectangular region contains the luma samples with horizontal picture coordinates from SubWidthC \* regional\_nesting\_‌rect\_left\_offset[ i ] to pic\_width\_‌in\_luma\_samples − ( SubWidthC \* regional\_nesting\_‌rect\_right\_offset[ i ] + 1 ), inclusive, and vertical picture coordinates from SubHeightC \* regional\_nesting\_‌rect\_top\_offset[ i ] to pic\_height\_‌in\_luma\_samples − ( SubHeightC \* regional\_nesting\_‌rect\_bottom\_offset[ i ] + 1 ), inclusive.

The value of SubWidthC \* ( regional\_nesting\_‌rect\_left\_offset[ i ] + regional\_nesting\_‌rect\_right\_offset[ i ] ) shall be less than pic\_width\_‌in\_luma\_samples and the value of SubHeightC \* ( regional\_nesting\_‌rect\_top\_offset[ i ] + regional\_nesting\_‌rect\_bottom\_offset[ i ] ) shall be less than pic\_height\_in\_luma\_samples.

**num\_sei\_messages\_in\_regional\_nesting\_minus1** plus 1 specifies the number of region-nested SEI messages in the regional nesting SEI message. The value of num\_sei\_messages\_in\_regional\_nesting\_minus1 shall be in the range of 0 to 255, inclusive.

**num\_regions\_for\_sei\_message**[ i ] specifies the number of regions to which the i-th region-nested SEI message is associated. When regional\_nesting\_num\_rect\_regions is greater than 0, the value of num\_regions\_for\_sei\_message[ i ] shall be in the range of 0 to regional\_nesting\_num\_rect\_regions, inclusive. When num\_regions\_for\_sei\_message[ i ] is equal to 0, the i-th region-nested SEI message applies to all the regions specified by the regional nesting SEI message.

**regional\_nesting\_sei\_region\_idx**[ i ][ j ] specifies the index, into the list of regions specified in the regional nesting SEI message, of the j-th region to which the i-th region-nested SEI message in the regional nesting SEI message is associated. The value of regional\_nesting\_sei\_region\_idx[ i ][ j ] shall be in the range of 0 to regional\_nesting\_num\_rect\_region − 1, inclusive.

**D.3.43 Motion-constrained tile sets extraction information set SEI message semantics**

A motion-constrained tile sets extraction information set SEI message provides supplemental information to carry out sub-bitstream motion-constrained tile sets extraction as specified below to derive a conforming bitstream from a motion-constrained tile set. The information consists of a number of extraction information sets, each containing identifiers of the motion-constrained tile sets to which the extraction information set applies. Each extraction information set contains RBSP bytes of replacement video parameter sets, sequence parameter sets and picture parameter sets to be used during the sub-bitstream motion-constrained tile sets extraction process.

Let a set of pictures associatedPicSet be the pictures from the access unit containing the motion-constrained tile sets extraction information set SEI message, inclusive, up to but not including the first of any of the following in decoding order:

– The next access unit, in decoding order, that contains a motion-constrained tile sets extraction information set SEI message.

– The next IRAP picture with NoRaslOutputFlag equal to 1, in decoding order.

– The next IRAP access unit, in decoding order, with NoClrasOutputFlag equal to 1.

The scope of the motion-constrained tile sets extraction information set SEI message is the set of pictures associatedPicSet.

When a motion-constrained tile sets extraction information set tile sets SEI message is present for any picture in associatedPicSet, a temporal motion-constrained tile set SEI message shall be present for the first picture of associatedPicSet in decoding order and may also be present for other pictures of associatedPicSet. The temporal motion-constrained tile sets SEI message shall have with mcts\_id[ ] equal to mcts\_identifer[ ] for all pictures in associatedPicSet.

When a motion-constrained tile sets extraction information set tile sets SEI message is present for any picture in associatedPicSet, a motion-constrained tile sets extraction information set SEI message shall be present for the first picture of associatedPicSet in decoding order and may also be present for other pictures of associatedPicSet.

The motion-constrained tile sets extraction information set SEI message shall not be present for any picture in associatedPicSet when tiles\_enabled\_flag is equal to 0 for any PPS that is active for any picture in associatedPicSet.

The motion-constrained tile sets extraction information set SEI message shall not be present for any picture in associatedPicSet unless every PPS that is active for any picture in associatedPicSet has the same values of the syntax elements num\_tile\_columns\_minus1, num\_tile\_rows\_minus1, uniform\_spacing\_flag, column\_width\_minus1[ i ], and row\_height\_minus1[ i ].

NOTE 1 – This constraint is similar to the constraint associated with tiles\_fixed\_structure\_flag equal to 1, and it may be desirable for tiles\_fixed\_structure\_flag to be equal to 1 when the motion-constrained tile sets extraction information set SEI message is present (although this is not required).

When more than one motion-constrained tile sets extraction information set SEI message is present for the pictures of associatedPicSet, they shall contain identical content.

NAL units that contain tiles belonging to tile set tileSetA shall not contain tiles that do not belong to tile set tileSetA.

The number of motion-constrained tile sets extraction information set SEI messages in each access unit shall not exceed 5.

**num\_extraction\_info\_sets\_minus1** plus 1 indicates the number of extraction information sets contained in the motion-constrained tile sets extraction information set SEI message to be applied in the mcts extraction process. The value of num\_extraction\_info\_sets\_minus1 shall be in the range of 0 to 232 − 2, inclusive.

The i-th extraction information is assigned a motion-constrained tile sets extraction information set identifier value equal to i.

**num\_associated\_tile\_set\_identifiers\_minus1**[ i ] plus 1 indicates the number of values of mcts\_id of the tile sets in the i-th extraction information set. The value of num\_extraction\_info\_sets\_minus1[ i ] shall be in the range of 0 to 232 − 2, inclusive.

**mcts\_identifier**[ i ][ j ] identifies the j-th tile set with mcts\_id equal to mcts\_identifier[ i ][ k ] associated to the i-th extraction information set. The value of mcts\_identifier[ i ][ j ] shall be in the range of 0 to 232 − 2, inclusive.

**num\_vps\_in\_extraction\_info\_set\_minus1**[ i ] plus 1 indicates the number of replacement video parameter sets in the i-th extraction information set. The value of num\_vps\_in\_extraction\_info\_set\_minus1[ i ] shall be in the range of 0 to 15, inclusive.

**vps\_rbsp\_data\_length**[ i ][ j ] indicates the number of bytes vps\_rbsp\_data\_bytes[ i ][ j ][ k ] of the following j-th replacement video parameter set in the i-th extraction information set.

**num\_sps\_in\_extraction\_info\_set\_minus1**[ i ] plus 1 indicates the number of replacement sequence parameter sets in the i-th extraction information set. The value of num\_sps\_in\_extraction\_info\_set\_minus1[ i ] shall be in the range of 0 to 15, inclusive.

**sps\_rbsp\_data\_length**[ i ][ j ] indicates the number of bytes sps\_rbsp\_data\_bytes[ i ][ j ][ k ] of the following j-th replacement sequence parameter set in the i-th extraction information set.

**num\_pps\_in\_extraction\_info\_set\_minus1**[ i ] plus 1 indicates the number of replacement picture parameter sets in the i-th extraction information set. The value of num\_pps\_in\_extraction\_info\_set\_minus1[ i ] shall be in the range of 0 to 63, inclusive.

**pps\_nuh\_temporal\_id\_plus1**[ i ][ j ] specifies a temporal identifier for generating PPS NAL unit associated with PPS data specified in PPS RBSP specified by pps\_rbsp\_data\_bytes[ i ][ j ][ k ] for the j-th replacement picture parameter set for the i-th extraction information set.

**pps\_rbsp\_data\_length**[ i ][ j ] indicates the number of bytes pps\_rbsp\_data\_bytes[ i ][ j ][ k ] of the following j-th replacement picture parameter set in the i-th extraction information set.

**mcts\_alignment\_bit\_equal\_to\_zero** shall be equal to 0.

**vps\_rbsp\_data\_bytes**[ i ][ j ][ k ] contains the k-th byte of the RBSP of the following j-th replacement video parameter set in the i-th extraction information set.

**sps\_rbsp\_data\_bytes**[ i ][ j ][ k ] contains the k-th byte of the RBSP of the following j-th replacement sequence parameter set in the i-th extraction information set.

**pps\_rbsp\_data\_bytes**[ i ][ j ][ k ] contains the k-th byte of the RBSP of the following j-th replacement picture parameter set in the i-th extraction information set.

The sub-bitstream motion-constrained tile sets extraction process is applied as follows:

Let a bitstream inBitstream, a target motion-constrained tile sets identifier mctsIdTarget, target motion-constrained tile sets extraction information set identifier mctsEISIdTarget and a target highest TemporalId value mctsTIdTarget be the inputs to the sub-bitstream motion-constrained tile sets extraction process.

The output of the sub-bitstream motion-constrained tile sets extraction process is a sub-bitstream outBitstream.

It is a requirement of bitstream conformance for the input bitstream that any output sub-bitstream that is the output of the process specified in this clause with the bitstream shall be a conforming bitstream.

The output sub-bitstream is derived as follows:

– The bitstream outBitstream is set to be identical to the bitstream inBitstream.

– The lists ausWithVPS, ausWithSPS and ausWithPPS are set to consist of all access units within outBitstream containing VCL NAL units with types VPS\_NUT, SPS\_NUT and PPS\_NUT.

– Remove all SEI NAL units that have nuh\_layer\_id equal to 0 and that contain non-nested SEI messages.

NOTE 2 – A "smart" bitstream extractor might include appropriate non-nested SEI messages in the extracted sub-bitstream, provided that the SEI messages applicable to the sub-bitstream were present as nested SEI messages in the mcts\_extraction\_info\_nesting ( ) in the original bitstream.

– Remove from outBitstream all NAL units with types:

– VCL NAL units that contain tiles not belonging to the tile set with mcts\_id[ i ] equal to mctsIdTarget,

– non-VCL NAL units with types VPS\_NUT, SPS\_NUT or PPS\_NUT.

– Insert into all access units within the list ausWithVPS in outBitstream num\_vps\_in\_extraction\_info\_minus1[ mctsEISIdTarget ] plus 1 NAL units with type VPS\_NUT generated from the VPS RBSP data in the mctsEISIdTarget-th motion-constrained tile sets extraction information set, i.e. vps\_rbsp\_data\_bytes[ mctsEISIdTarget ][ j ][ ] for all values of j in the range of 0 to num\_vps\_in\_extraction\_info\_minus1[ mctsEISIdTarget ], inclusive. For each VPS\_NUT that is generated the nuh\_layer\_id is set equal to 0 and nuh\_temporal\_id\_plus1 is set equal to 1.

– Insert into all access units within the list ausWithSPS in outBitstream num\_sps\_in\_extraction\_info\_minus1[ mctsEISIdTarget ] plus 1 NAL units with type SPS\_NUT generated from the SPS RBSP data in the mctsEISIdTarget-th motion-constrained tile sets extraction information set, i.e. sps\_rbsp\_data\_bytes[ mctsEISIdTarget ][ j ][ ] for all values of j in the range of 0 to num\_sps\_in\_extraction\_info\_minus1[ mctsEISIdTarget ], inclusive. For each SPS\_NUT that is generated the nuh\_layer\_id is set equal to 0 and nuh\_temporal\_id\_plus1 is set equal to 1.

– Insert into all access units within the list ausWithPPS in outBitstream NAL units with type PPS\_NUT generated from the PPS RBSP data in the mctsEISIdTarget-th motion-constrained tile sets extraction information set, i.e. pps\_rbsp\_data\_bytes[ mctsEISIdTarget ][ j ][ ] for all values of j in the range of 0 to num\_pps\_in\_extraction\_info\_minus1[ mctsEISIdTarget ], inclusive, for which pps\_nuh\_temporal\_id\_plus1[ mctsEISIdTarget ][ j ] is less than or equal to mctsTIdTarget. For each PPS\_NUT that is generated the nuh\_layer\_id is set equal to 0 and nuh\_temporal\_id\_plus1 is set equal to pps\_nuh\_temporal\_id\_plus1[ mctsEISIdTarget ][ j ] for all values of j in the range of 0 to num\_pps\_in\_extraction\_info\_minus1[ mctsEISIdTarget ], inclusive for which pps\_nuh\_temporal\_id\_plus1[ mctsEISIdTarget ][ j ] is less than or equal to mctsTIdTarget.

– Remove from outBitstream all NAL units with TemporalId greater than mctsTIdTarget.

– For each remaining VCL NAL units in outBitstream, adjust the slice segment header as follows:

– For the first VCL NAL unit within each access unit, set the value of first\_slice\_segment\_in\_pic\_flag equal to 1, otherwise 0.

– Set the value of slice\_segment\_address according to the tile setup defined in the PPS with pps\_pic\_parameter\_set\_id equal to slice\_pic\_parameter\_set\_id.

**D.3.44 Motion-constrained tile sets extraction information nesting SEI message semantics**

The motion-constrained tile sets extraction information nesting SEI message provides a mechanism to carry nested SEI messages and associate the nested SEI messages with bitstream subsets corresponding to one or more motion-constrained tile set.

In the sub-bitstream motion-constrained tile sets extraction process as specified in the semantics of the motion-constrained tile sets extraction information set SEI message, the nested SEI messages contained in the motion-constrained tile sets extraction information nesting SEI message can be used to replace the non-nested SEI messages in the access unit that contains the motion-constrained tile sets extraction information nesting SEI message.

**all\_tile\_sets\_flag** equal to 0 specifies that the mcts\_identifier list is set to consist of mcts\_identifier[ i ]. all\_tile\_sets\_flag equal to 1 specifies that the list mcts\_identifier[ i ] consists of all values of mcts\_id[ ] of the temporal\_motion\_constrained\_tile\_sets SEI messages present in the current access unit.

**num\_associated\_mcts\_identifiers\_minus1** plus 1 specifies the number of following mcts\_identifier. The value of num\_associated\_mcts\_identifiers\_minus1[ i ] shall be in the range of 0 to 232 − 2, inclusive.

**mcts\_identifier**[ i ] identifies the tile set with mcts\_id equal to mcts\_identifier[ i ] associated to the following nested SEI messages. The value of mcts\_identifier[ i ] shall be in the range of 0 to 232 − 2, inclusive.

**num\_sei\_messages\_in\_mcts\_extraction\_nesting\_minus1** plus 1 indicates the number of the following nested SEI messages.

**mcts\_nesting\_zero\_bit** shall be equal to 0.

*In E.3.1, after the paragraphs specifying the semantics of chroma\_sample\_loc\_type\_top\_field and chroma\_sample\_loc\_type\_bottom\_field, add the following paragraph:*

When chroma\_format\_idc is equal to 1 and the decoded video content is intended for interpretation according to Rec. ITU-R BT.2020 or Rec. ITU-R BT.2100, chroma\_loc\_info\_present\_flag should be equal to 1 and chroma\_sample\_loc\_type\_top\_field and chroma\_sample\_loc\_type\_bottom\_field should be equal to 2.

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