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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 set 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\_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 set 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\_mcts\_sets\_minus1**[ i ] |  |
| for( j = 0; j <= num\_mcts\_sets\_minus1[ i ]; j++ ) { |  |
| **num\_mcts\_in\_set\_minus1**[ i ][ j ] | ue(v) |
| for( k = 0; k <= num\_mcts\_in\_set\_minus1[ i ][ j ]; k++ ) |  |
| **eis\_mctsid**[ i ][ j ][ k ] | ue(v) |
| if( num\_mcts\_in\_set\_minus1[ i ][ j ] > 0 ) { |  |
| **mcts\_set\_tier\_level\_idc\_present\_flag**[ i ][ j ] | u(1) | |
| if( mcts\_set\_tier\_level\_idc\_present\_flag[ i ][ j ] ) { |  | |
| **mcts\_set\_tier\_flag**[ i ][ j ] | u(1) | |
| **mcts\_set\_level\_idc**[ i ][ j ] | u(8) | |
| } |  | |
| } |  |
| } |  |
| **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\_byte**[ 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\_byte**[ 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\_byte**[ i ][ j ][ k ] | u(8) |
| } |  |
| } |  |

**D.2.44 Motion-constrained tile set nesting SEI message syntax**

|  |  |
| --- | --- |
| mcts\_nesting( ) { | **Descriptor** |
| **all\_mcts\_flag** | u(1) |
| if( !all\_mcts\_flag ) { |  |
| **num\_nesting\_mcts\_minus1** | ue(v) |
| for( i = 0; i <= num\_nesting\_mcts\_minus1; i++ ) |  |
| **nesting\_mctsid**[ i ] | ue(v) |
| } |  |
| **num\_sei\_messages\_nesting\_mcts\_minus1** | ue(v) |
| while( !byte\_aligned( ) ) |  |
| **nesting\_mcts\_zero\_bit** /\* equal to 0 \*/ | u(1) |
| for( i = 0; i  <=  num\_sei\_messages\_nesting\_mcts\_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 nested SEI messages. Each nested SEI message has the same persistence scope as if the SEI message was not nested |
| Motion-constrained tile set extraction information set | The access unit containing the SEI message and up to but not including the next access unit, in decoding order, that contains an SEI message of the same type |
| Motion-constrained tile set nesting | The access unit containing the SEI message |

*In D.3.30, remove the following paragraph:*

The number of temporal motion-constrained tile sets SEI messages applicable to the same nuh\_layer\_id value in each access unit shall not exceed 5.

*In D.3.30, add the following paragraph immediately before the semantics of mc\_all\_tiles\_exact\_sample\_value\_match\_flag:*

A slice segment that contains one or more tiles belonging to any particular MCTS mctsA shall not be a dependent slice segment of an independent slice segment that contains one or more tiles that do not belong to mctsA.

*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)

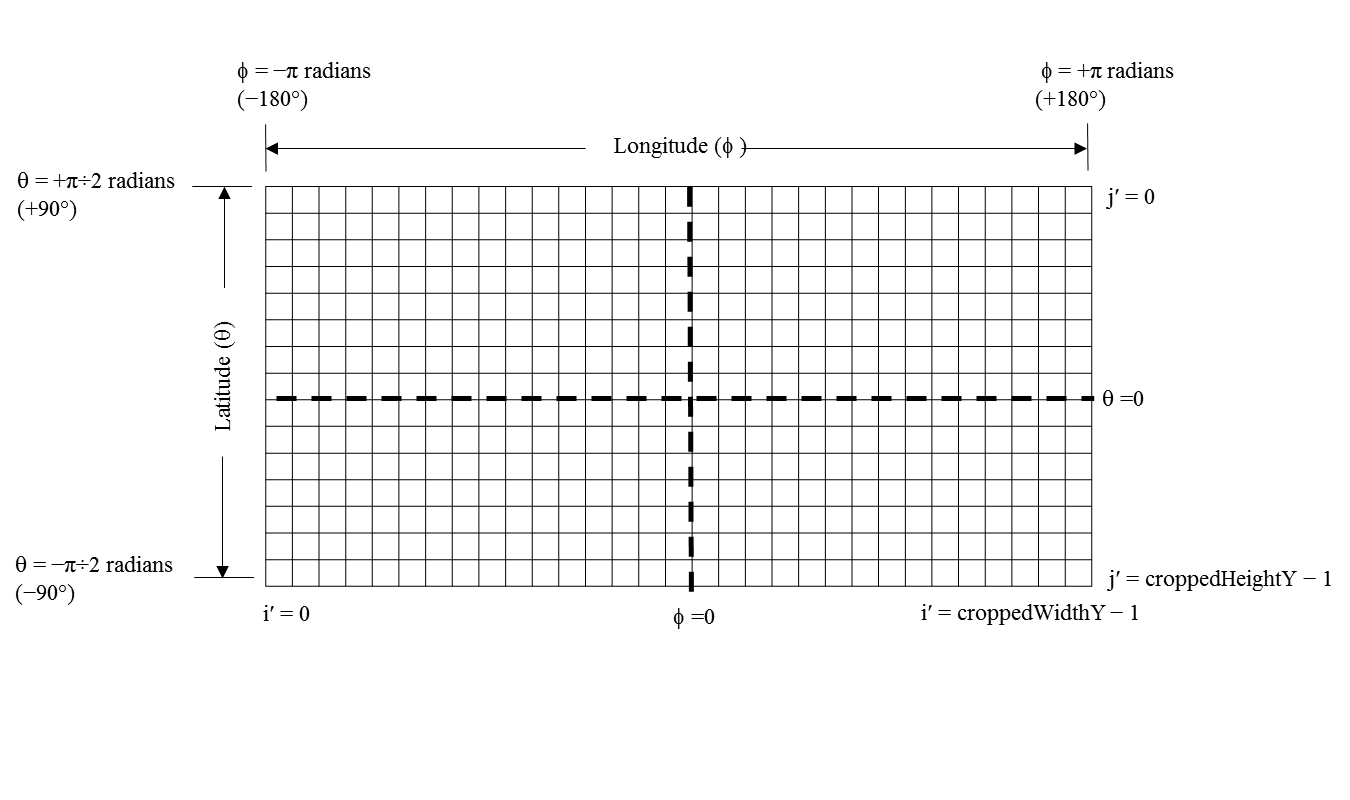
and CenterLeftOffsetC and CenterTopOffsetC are given by Table D.22 as a function of chroma\_format\_idc and ChromaLocType, which is set as follows:

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 nested in a regional nesting SEI message, the semantics of the nested SEI message are to be interpreted as to be applicable to each region identified in the SEI message.

The list listOfRegionNestableMessageTypes includes the following types of SEI messages:

– User data registered by Rec. ITU-T T.35 SEI message identified with a particular combination of country code, terminal provider code and terminal provider oriented code

– User data unregistered SEI message identified with a particular value of uuid\_iso\_iec\_11578

– 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 – Tone mapping information SEI messages with different values of tone\_map\_id are considered different types of SEI messages in the above list. The same applies to the knee function information SEI message, the colour remapping information SEI message, and the user data unregistered SEI message.

Each nested SEI message has the same persistence scope as if the SEI message were not nested.

When an SEI message with a particular value of payloadType is signalled with an associated film\_grain\_characteristics\_cancel\_flag, tone\_map\_cancel\_flag, knee\_function\_cancel\_flag, or colour\_remap\_cancel\_flag, equal to 1 and is nested in a regional nesting SEI message or is present without nesting, it cancels the persistence of all the SEI messages of the same value of payloadType that are nested in a regional nesting SEI message, regardless of their associated regions. When an SEI message with a particular value of payloadType is nested in a regional nesting SEI message with an associated film\_grain\_characteristics\_persistence\_flag, tone\_map\_persistence\_flag, knee\_function\_persistence\_flag, or colour\_remap\_persistence\_flag equal to 1, the persistence of the nested SEI message is determined by the semantics of the SEI message irrespective of which region it applies to.

It is a requirement of bitstream conformance that the following restrictions apply on the nesting of SEI messages in a regional nesting SEI message:

– The regional nesting SEI message shall not contain any SEI message that is not in listOfRegionNestableMessageTypes.

– When an SEI message of a type belonging to listOfRegionNestableMessageTypes that is not nested in a regional nesting SEI message is applicable to the current picture, there shall be no SEI message of the same type belonging to listOfRegionNestableMessageTypes that is nested in a regional nesting SEI message that is applicable to the current picture.

Decoders encountering an SEI message that is nested in a regional nesting SEI message that does not belong to listOfRegionNestableMessageTypes shall ignore the nested SEI message.

Unlike the scalable nesting SEI message, the SEI messages nested in the regional nesting SEI message should not be extracted and sent as a separate SEI message, as the values signalled in the 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 regional nesting SEI messages. 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 indicated by 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.

**regional\_nesting\_rect\_region\_id**[ i ] indicates an identifier for the i-th rectangular region specified in the regional nesting SEI message, for i in the range of 0 to regional\_nesting\_num\_rect\_regions − 1, inclusive.

Unless indicated otherwise by some means not specified in this document, when a sample belongs to more than one region for which more than one regional nested SEI messages of the same type in listOfRegionNestableMessageTypes are indicated, only one of these nested SEI messages applies to the sample; this nested SEI message is the one that is associated with the region that has the largest value of regional\_nesting\_rect\_region\_id[ ], and the rest of the regional nested SEI messages of that type that are associated with the region do not apply.

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 an SEI message of a particular type in listOfRegionNestableMessageTypes is present in one regional nesting SEI message and applies to a list of regions listA in the current picture and another SEI message of the same type in listOfRegionNestableMessageTypes is present in a regional nesting SEI message and applies to a list of regions listB in the current picture, it is a requirement of bitstream conformance that, for any pair or 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 and the two 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 in the SEI message. The offsets for the rectangular region are specified in units of luma sample positions. 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 nested SEI messages specified 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 nested SEI message is associated. When regional\_nesting\_num\_rect\_regions is greater than 1, 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 nested SEI message applies to all the regions specified in 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 nested SEI message signalled 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 set extraction information set SEI message semantics**

The motion-constrained tile set extraction information set (MCTS-EIS) SEI message provides supplemental information that can be used in motion-constrained tile set (MCTS) sub-bitstream extraction as specified below to generate a conforming bitstream for an MCTS set. The information consists of a number of extraction information sets, each containing RBSP bytes of the replacement VPSs, SPSs, and PPSs to be used during the MCTS sub-bitstream extraction process. Each extraction information set is shared by a number of MCTS sets, i.e., is used for extraction of any of these MCTS sets.

An MCTS-EIS SEI message shall not be present in an access unit unless there is a temporal MCTS SEI message present in the access unit. A temporal MCTS SEI message present in the same access unit as an MCTS-EIS SEI message is referred to as the associated temporal MCTS SEI message of the MCTS-EIS SEI message.

An MCTS-EIS SEI message applies to the same of pictures as the associated temporal MCTS SEI message, i.e., the associatedPicSet of the associated temporal MCTS SEI message of an MCTS-EIS SEI message applies to the MCTS-EIS SEI message.

When more than one MCTS-EIS SEI message is present for the pictures of associatedPicSet, they shall contain identical content.

NAL units that contain tiles belonging to any particular MCTS mctsA shall not contain tiles that do not belong to mctsA.

If the value of each\_tile\_one\_tile\_set\_flag of the associated temporal MCTS SEI message is equal to 0, the MCTS identifier of an MCTS of the current picture is the value of the index of the MCTS, where the index is the variable i within the loop of the num\_sets\_in\_message\_minus1 + 1 sets of MCTS information specified by the associated temporal MCTS SEI message. Otherwise, the MCTS identifier of each MCTS, which consists of one single tile, is the tile position of the single tile in the MCTS in tile raster scan order. [Ed. (YK): This paragraph may also be moved to the semantics of the temporal MCTS SEI message, with wording adjustment as needed for the right context, such that the specification of MCTS identifiers apply to all other places, including at least here and the MCTS nesting SEI message, and do not need to be repeated in different places.]

**num\_extraction\_info\_sets\_minus1** plus 1 specifies the number of extraction information sets contained in the MCTS-EIS SEI message The value of num\_extraction\_info\_sets\_minus1 shall be in the range of 0 to 2047, inclusive.

The i-th extraction information set is assigned an MCTS-EIS identifier value equal to i.

**num\_mcts\_sets\_minus1**[ i ] plus 1 specifies the number of MCTS sets that share the i-th extraction information set. The value of num\_mcts\_sets\_minus1[ i ] shall be in the range of 0 to 2047, inclusive.

**num\_mcts\_in\_set\_minus1**[ i ][ j ] plus 1 specifies the number of MCTSs in the j-th MCTS set that is associated with the i-th extraction information set. The value of num\_mcts\_in\_set\_minus1[ i ][ j ] shall be in the range of 0 to 255, inclusive.

**eis\_mctsid**[ i ][ j ][ k ] indicates the MCTS identifier of the k-th MCTS in the j-th MCTS set that is associated with the i-th extraction information set. The value of eis\_mctsid[ i ][ j ][ k ] shall be in the range of 0 to 255, inclusive.

It is a requirement of bitstream conformance that the tiles in each MCTS set, when placed together as follows, shall form a rectangular region:

* The tiles are placed in increasing order of their orders in tile scan of the picture.
* The tiles of the same tile row are still placed in the same tile row as follows: After placing one particular tile tileA of a particular tile row, when the next tile tileB of the same tile row in the MCTS set is not the next tile in the picture, both in tile scan order, i.e., tileA and tileB are not neighboring to each other, tileB is placed neighboring to tileA in the same tile row.
* The tiles of the same tile column are still placed in the same tile column as follows: After placing one particular tile tileC of a particular tile column, when the next tile tileD of the same tile column in the MCTS set is not the next tile in the same tile column in the picture, both in tile scan order, i.e., tileC and tileD are not neighboring to each other, tileC is placed neighboring to tileD in the same tile column.

**mcts\_set\_tier\_level\_idc\_present\_flag**[ i ][ j ] equal to 1 specifies that the mcts\_set\_tier\_flag[ i ][ j ] and mcts\_set\_level\_idc[ i ][ j ] syntax elements are present. mcts\_set\_tier\_level\_idc\_present\_flag[ i ][ j ] equal to 0 specifies that the mcts\_set\_tier\_flag[ i ][ j ] and mcts\_set\_level\_idc[ i ][ j ] syntax elements are not present.

**mcts\_set\_tier\_flag**[ i ][ j ] specifies the tier context for the interpretation of mcts\_set\_level\_idc[ i ][ j ] corresponding to the j-th MCTS set that is associated with the i-th extraction information set. mcts\_set\_tier\_flag[ i ][ j ] equal to 0 indicates conformance to the Main tier, and mcts\_set\_tier\_flag[ i ][ j ] equal to 1 indicates conformance to the High tier, according to the tier constraints specified in Table A.6 [Ed. (YK): Add x-ref when included into a new integrated edition]. mcts\_set\_tier\_flag[ i ][ j ] shall be equal to 0 when mcts\_set\_level\_idc[ i ][ j ] is less than 120. When not present, the value of mcts\_set\_tier\_flag[ i ][ j ] is inferred to be equal to general\_tier\_flag.

When present, the value of mcts\_set\_tier\_flag[ i ][ j ] shall be equal to the general\_tier\_flag of the replacement SPS RBSP in the i-th extraction information set that has the same value of sps\_seq\_parameter\_set\_id as the active SPS RBSP.

**mcts\_set\_level\_idc**[ i ][ j ] indicates a level to which j-th MCTS set that is associated with the i-th extraction information set conforms. The value of mcts\_set\_level\_idc[ i ][ j ] shall be less than or equal to the value of general\_level\_idc in the active SPS RBSP. When not present, the value of mcts\_set\_level\_idc[ i ][ j ] is inferred to be equal to general\_level\_idc.

When present, the value of mcts\_set\_level\_idc[ i ][ j ] shall be equal to the general\_level\_idc of the replacement SPS RBSP in the i-th extraction information set that has the same value of sps\_seq\_parameter\_set\_id as the active SPS RBSP.

**num\_vps\_in\_extraction\_info\_set\_minus1**[ i ] plus 1 specifies the number of replacement VPSs 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 ] specifies the number of RBSP data bytes of the j-th replacement VPS in the i-th extraction information set.

**num\_sps\_in\_extraction\_info\_set\_minus1**[ i ] plus 1 specifies the number of replacement SPSs 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 ] specifies the number of RBSP data bytes of the j-th replacement SPS in the i-th extraction information set.

**num\_pps\_in\_extraction\_info\_set\_minus1**[ i ] plus 1 specifies the number of replacement PPSs 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 ] minus 1 specifies the temporal identifier of the j-th replacement PPS in the i-th extraction information set.

**pps\_rbsp\_data\_length**[ i ][ j ] specifies the number of RBSP data bytes of the j-th replacement PPS in the i-th extraction information set.

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

**vps\_rbsp\_data\_byte**[ i ][ j ][ k ] contains the k-th byte of the RBSP data of the j-th replacement VPS in the i-th extraction information set.

**sps\_rbsp\_data\_byte**[ i ][ j ][ k ] contains the k-th byte of the RBSP data of the j-th replacement SPS in the i-th extraction information set.

**pps\_rbsp\_data\_byte**[ i ][ j ][ k ] contains the k-th byte of the RBSP data of the j-th replacement PPS in the i-th extraction information set.

The MCTS sub-bitstream extraction process is specified as follows:

– Let a bitstream inBitstream, a target MCTS Set index mctsSetIdxTarget, a target MCTS-EIS identifier mctsEisIdTarget and a target highest TemporalId value mctsTidTarget be the inputs to the MCTS sub-bitstream extraction process.

– The output of the MCTS sub-bitstream extraction process is a sub-bitstream outBitstream that 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 NAL units with nal\_unit\_type equal to VPS\_NUT, SPS\_NUT, or PPS\_NUT.

– Remove all SEI NAL units that contain non-MCTS-nested SEI messages.

NOTE – A "smart" bitstream extractor might include appropriate non-MCTS-nested SEI messages in the extracted sub-bitstream, provided that the SEI messages applicable to the sub-bitstream were present as MCTS-nested SEI messages in the original bitstream.

– Remove from outBitstream all of the following NAL units:

– VCL NAL units that contain tiles not belonging to any of the MCTSs with MCTS identifier equal to eis\_mctsid[ mctsEisIdTarget ][ mctsSetIdxTarget ][ k ] for each value of k in the range of 0 to num\_mcts\_in\_set\_minus1[ mctsEisIdTarget ][ mctsSetIdxTarget ], inclusive,

– Non-VCL NAL units with nal\_unit\_type equal to VPS\_NUT, SPS\_NUT, or PPS\_NUT.

– Insert into each access unit within the list ausWithVps num\_vps\_in\_extraction\_info\_minus1[ mctsEisIdTarget ] plus 1 VPS NAL units generated from the RBSP data of the list of replacement VPSs in the mctsEisIdTarget-th MCTS-EIS. For each VPS NAL unit that is generated the nuh\_layer\_id is set equal to 0 and nuh\_temporal\_id\_plus1 is set equal to 1.

– Insert into each access unit within the list ausWithSps num\_sps\_in\_extraction\_info\_minus1[ mctsEisIdTarget ] plus 1 SPS NAL units generated from the RBSP data of the list of replacement SPSs in the mctsEisIdTarget-th MCTS-EIS. For each SPS NAL unit that is generated the nuh\_layer\_id is set equal to 0 and nuh\_temporal\_id\_plus1 is set equal to 1.

– Insert into each access unit within the list ausWithPps PPS NAL units generated from the RBSP data of the replacement PPSs, in the mctsEisIdTarget-th MCTS-EIS, for which pps\_nuh\_temporal\_id\_plus1[ mctsEisIdTarget ][ j ] is less than or equal to mctsTidTarget. For each PPS NAL unit that is generated the nuh\_layer\_id is set equal to 0, and for the PPS NAL unit that is generated from the RBSP data of the j-th replacement PPS in the mctsEisIdTarget-th MCTS-EIS, nuh\_temporal\_id\_plus1 is set equal to pps\_nuh\_temporal\_id\_plus1[ mctsEisIdTarget ][ j ].

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

– Set the value of slice\_segment\_address, when present, according to the tile configuration parameters in the PPS with pps\_pic\_parameter\_set\_id equal to slice\_pic\_parameter\_set\_id.

It is a requirement of bitstream conformance for the input bitstream that any output sub-bitstream that is the output of the MCTS sub-bitstream extraction process as specified above shall be a conforming bitstream.

**D.3.44 Motion-constrained tile set nesting SEI message semantics**

The motion-constrained tile set (MCTS) nesting SEI message provides a mechanism to convey and associate SEI messages with bitstream subsets corresponding to one or MCTSs. An SEI message contained in an MCTS nesting SEI message is referred to as MCTS-nested or an MCTS-nested SEI message, and an SEI message that is not contained in an MCTS nesting SEI message is referred to as non-MCTS-nested or a non-MCTS-nested SEI message.

When a sub-bitstream is extracted for an MCTS, e.g., using the MCTS sub-bitstream extraction process as specified in D.3.44, the MCTS-nested SEI messages applicable to the MCTSs in an MCTS set in an access unit can be included in the corresponding access unit of the extracted sub-bitstream as non-MCTS-nested SEI messages.

An MCTS nesting SEI message shall not be present in an access unit unless there is an MCTS-EIS SEI message present in the access unit. A temporal MCTS SEI message present in the same access unit as an MCTS nesting SEI message is referred to as the associated temporal MCTS SEI message of the MCTS nesting SEI message.

An SEI NAL unit containing an MCTS nesting SEI message shall not contain any other SEI message that is not MCTS-nested in the MCTS-nesting SEI message.

If the value of each\_tile\_one\_tile\_set\_flag of the associated temporal MCTS SEI message is equal to 0, the MCTS identifier of an MCTS of the current picture is the value of the index of the MCTS, where the index is the variable i within the loop of the num\_sets\_in\_message\_minus1 + 1 sets of MCTS information specified by the associated temporal MCTS SEI message. Otherwise, the MCTS identifier of each MCTS, which consists of one single tile, is the tile position of the single tile in the MCTS in tile raster scan order. [Ed. (YK): This paragraph may also be moved to the semantics of the temporal MCTS SEI message, with wording adjustment as needed for the right context, such that the specification of MCTS identifiers apply to all other places, including at least here and the MCTS-EIS SEI message, and do not need to be repeated in different places.]

**all\_mcts\_flag** equal to 0 specifies that the list nesting\_mctsid is set to consist of all nesting\_mctsid[ i ] for i from 0 to num\_nesting\_mcts\_minus1, inclusive. all\_mcts\_flag equal to 1 specifies that the list nesting\_mctsid consists of the MCTS identifiers of all the MCTSs indicated by the temporal MCTS SEI messages present in the current access unit.

The MCTS-nested SEI messages apply to all MCTSs for which the MCTS identifiers are included in the list nesting\_mctsid.

**num\_nesting\_mcts\_minus1** plus 1 specifies the number of the following nesting\_mctsid[ i ] syntax elements. The value of num\_nesting\_mcts\_minus1[ i ] shall be in the range of 0 to 255, inclusive.

**nesting\_mctsid**[ i ] indicates the MCTS identifier of the i-th MCTS to which the following MCTS-nested SEI messages apply. The value of nesting\_mctsid[ i ] shall be in the range of 0 to 255, inclusive.

**num\_sei\_messages\_nesting\_mcts\_minus1** plus 1 specifies the number of the following MCTS-nested SEI messages.

**nesting\_mcts\_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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