

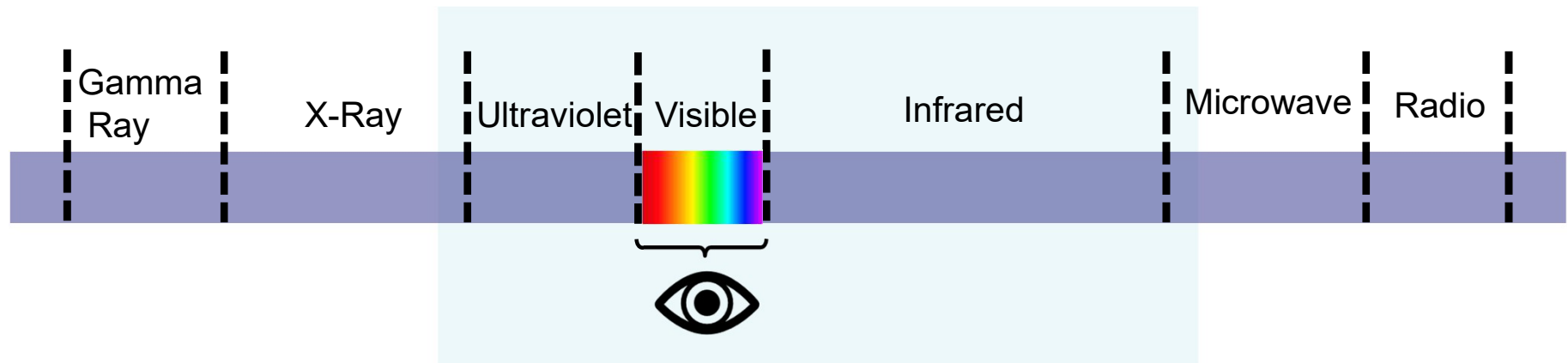
JVET-AG0077

## AHG9: On Picture Modality Information

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## Motivation

- Today's advanced image sensors, which operate across a variety of spectral ranges, are being integrated into cameras. These advanced image sensors are widely used in applications including autonomous vehicles, UAVs, industrial automation, and more.



**The decoded pictures may be from various spectrums and of different picture modality types.**

# Introduction

- In the 32<sup>nd</sup> JVET meeting, signaling the picture modality type in VUI parameters proposed in JVET-AF0147 was adopted into TuC for future extensions of VSEI [JVET-AF2032].

vui_parameters( payloadSize ) {	Descriptor
...	
if( more_data_in_payload( ) ) {	
if( payload_extension_present( ) ) {	
<b>vui_modality_info_present_flag</b>	u(1)
if( vui_modality_info_present_flag ) {	
<b>vui_modality_type</b>	u(8)
}	
}	
<b>vui_payload_bit_equal_to_one</b> /* equal to 1 */	f(1)
while( !byte_aligned( ) )	
<b>vui_payload_bit_equal_to_zero</b> /* equal to 0 */	f(1)
}	
}	

Table 4– Mapping of vui\_modality\_type to the type of picture modalities

vui_modality_type	type of picture modality
0	Unspecified
1	Visible Picture
2	Infrared Picture
3	Thermal Infrared Picture
4..255	Reserved for future use

- It was commented that infrared imaging has many applications, and signaling the source properties at a high level in VVC would be interesting. It was also suggested to signal the wavelength of the optical radiation during the JVET meeting.

# Introduction

- This contribution proposes the following items on the picture modality information:
  - ❖ Common Aspects:
    1. Signal **minimum and maximum wavelength**.
    2. Add **an extension mechanism** to picture modality information.
    3. Change the type of picture modalities from **thermal infrared picture** to **ultraviolet picture**.
    4. Add a constraint on **vui\_colour\_description\_present\_flag**.
  - ❖ Option 1 Aspect:
    5. Allow user to specify wavelength + Add predefined spectrum range table.
    6. Add constraints on the values in the spectrum range table.
  - ❖ Option 2 Aspect:
    7. Allow the user to specify wavelength.

# Common Aspect: item 1

- **Item 1:** signal **minimum and maximum wavelength**, wherein the **decimal floating points** of wavelength are represented using **mantissa** and **exponent**.

Table 1: The spectral bands for optics and photonics specified in **ISO 20473:2007**.

Designation of the radiation		Wavelength (nm)
Ultraviolet radiation	Extreme UV	1 to 100
	Vacuum UV	100 to 190
	Deep UV	190 to 280
	Mid UV	280 to 315
	Near UV	315 to 380
Visible radiation, light		380 to 780
Infrared radiation	Near IR	780 to 3 000
	Mid IR	3 000 to 50 000
	Far IR	50 000 to 10 <sup>6</sup>

Table 1 illustrates the spectral bands for optics and photonics specified in ISO 20473:2007, which cover the spectral range from ultraviolet light to infrared light.

# Common Aspect: item 1

For example:

MinWavelength =

$$\text{vui\_min\_wavelength\_mantissa} * 10^{\text{vui\_min\_wavelength\_exponent\_plus15-15}}$$

**vui\_min\_wavelength\_mantissa** specifies the mantissa part of the minimum wavelength. Since the wavelength has up to 3 significant digits, 10 bits are allocated to represent the mantissa part of the minimum wavelength.

**vui\_min\_wavelength\_exponent\_plus15** minus 15 specifies the exponent part of the minimum wavelength. 5 bits are allocated to represent the exponent part of the minimum wavelength. The units of wavelength are specified in meters. The actual exponent may be negative, hence, a bias of 15 is used for the exponent part. The actual exponent ranges from -15 to 16, which is sufficient to represent the entire spectrum range. The bias is calculated as  $2^{(k-1)}-1$ , wherein k represents the length in bits of the exponent.

vui parameters( payloadSize ) {	Descriptor
...	
if( more data in payload() ) {	
if( payload extension present() ) {	
<b>vui modality info present flag</b>	u(1)
if( vui modality info present flag ) {	
<b>vui modality type</b>	u(8)
<b>vui spectrum range present flag</b>	u(1)
if( vui spectrum range present flag == 1 ) {	
<b>vui min wavelength mantissa</b>	u(10)
<b>vui max wavelength mantissa</b>	u(10)
<b>vui min wavelength exponent plus15</b>	u(5)
<b>vui max wavelength exponent plus15</b>	u(5)
}	
<b>vui modality type extension bits</b>	ue(v)
if( vui modality type extension bits > 0 )	
<b>vui reserved modality type extension</b>	u(v)
}	
}	
<b>vui payload bit equal to one</b> /* equal to 1 */	f(1)
while( !byte aligned() )	
<b>vui payload bit equal to zero</b> /* equal to 0 */	f(1)
}	
}	
}	

# Common Aspect: item 2

▪ **Item 2:**  
add **vui\_modality\_type\_extension\_bits** and **vui\_reserved\_modality\_type\_extension** for future extension of picture modality information.

	Descriptor
vui_parameters( payloadSize ) {	
...	
if( more_data_in_payload() ) {	
if( payload_extension_present() ) {	
<b>vui_modality_info_present_flag</b>	u(1)
if( vui_modality_info_present_flag ) {	
<b>vui_modality_type</b>	u(8)
<b>vui_spectrum_range_present_flag</b>	u(1)
if( vui_spectrum_range_present_flag == 1 ) {	
<b>vui_min_wavelength_mantissa</b>	u(10)
<b>vui_max_wavelength_mantissa</b>	u(10)
<b>vui_min_wavelength_exponent_plus15</b>	u(5)
<b>vui_max_wavelength_exponent_plus15</b>	u(5)
}	
<b>vui_modality_type_extension_bits</b>	ue(v)
if( vui_modality_type_extension_bits > 0 )	
<b>vui_reserved_modality_type_extension</b>	u(v)
}	
}	
<b>vui_payload_bit_equal_to_one</b> /* equal to 1 */	f(1)
while( !byte_aligned() )	
<b>vui_payload_bit_equal_to_zero</b> /* equal to 0 */	f(1)
}	
}	

# Common Aspect: item 3

- **Item 3:**  
change the type of picture modalities from thermal infrared picture to ultraviolet picture, when vui\_modality\_type is equal to 3, as in Table 4.

Table 4– Mapping of vui\_modality\_type to the type of picture modalities

vui_modality_type	type of picture modality
0	Unspecified
1	Visible Picture
2	Infrared Picture
3	<del>Thermal Infrared Picture</del> Ultraviolet Picture
4..255	Reserved for future use

The thermal infrared picture is captured based on the thermal radiation emitted by objects, which is indeed a type of infrared light. Ultraviolet, along with visible and infrared radiation, falls under optical radiation. This spectrum is widely utilized in imaging to record light that objects emit or reflect.



# Common Aspect: item 4

- **Item 4:**  
add a constraint on vui\_colour\_description\_present\_flag

**vui\_colour\_description\_present\_flag** equal to 1 specifies that vui\_colour primaries, vui\_transfer\_characteristics, and vui\_matrix\_coeffs are present. vui\_colour\_description\_present\_flag equal to 0 specifies that vui\_colour primaries, vui\_transfer\_characteristics, and vui\_matrix\_coeffs are not present.

When vui\_modality\_type is equal to 2 or 3, vui\_colour\_description\_present\_flag shall be equal to 0.

Table 4– Mapping of vui\_modality\_type to the type of picture modalities

vui_modality_type	type of picture modality
0	Unspecified
1	Visible Picture
2	Infrared Picture
3	Ultraviolet Picture
4..255	Reserved for future use

# Option 1 Aspect: item 5

▪ **Item 5:**  
Add **vui\_spectrum\_range** to specify the spectrum band of the optical radiation wavelength represented by the pictures in the CLVS in a predefined spectrum range table.

	Descriptor
vui_parameters( payloadSize ) {	
...	
if( more_data_in_payload( ) ) {	
if( payload_extension_present( ) ) {	
<b>vui_modality_info_present_flag</b>	u(1)
if(vui_modality_info_present_flag) {	
<b>vui_modality_type</b>	u(8)
<b>vui_spectrum_range</b>	u(8)
if( vui_spectrum_range == 1 ) {	
<b>vui_min_wavelength_mantissa</b>	u(10)
<b>vui_max_wavelength_mantissa</b>	u(10)
<b>vui_min_wavelength_exponent_plus15</b>	u(5)
<b>vui_max_wavelength_exponent_plus15</b>	u(5)
}	
<b>vui_modality_type_extension_bits</b>	ue(v)
if(vui_modality_type_extension_bits > 0 )	
<b>vui_reserved_modality_type_extension</b>	u(v)
}	
}	
<b>vui_payload_bit_equal_to_one</b> /* equal to 1 */	f(1)
while( !byte_aligned( ) )	
<b>vui_payload_bit_equal_to_zero</b> /* equal to 0 */	f(1)
}	
}	

# Option 1 Aspect: item 6

## Item 6: Add constraints on vui\_spectrum\_range

When vui\_modality\_type is equal to 1, vui\_spectrum\_range should be 0, 1, or 7.

When vui\_modality\_type is equal to 2, vui\_spectrum\_range should be 0, 1, or in the range of 8 to 10.

When vui\_modality\_type is equal to 3, vui\_spectrum\_range should be 0, 1, or in the range of 2 to 6.

Table 4– Mapping of vui\_modality\_type to the type of picture modalities

vui_modality_type	type of picture modality
0	Unspecified
1	Visible Picture
2	Infrared Picture
3	Ultraviolet Picture
4..255	Reserved for future use

Table 5– Definition of vui\_spectrum\_range

Value	minimum wavelength (m)	maximum wavelength (m)	Informative remark
0	Unspecified		Image characteristics are unknown or are determined by the application.
1	User-defined		Image characteristics are defined by the user.
2	$1 \cdot 10^{-9}$	$1 \cdot 10^{-7}$	Extreme UV ISO 20473:2007
3	$1 \cdot 10^{-7}$	$19 \cdot 10^{-8}$	Vacuum UV ISO 20473:2007
4	$19 \cdot 10^{-8}$	$28 \cdot 10^{-8}$	Deep UV ISO 20473:2007
5	$28 \cdot 10^{-8}$	$315 \cdot 10^{-9}$	Mid UV ISO 20473:2007
6	$315 \cdot 10^{-9}$	$38 \cdot 10^{-8}$	Near UV ISO 20473:2007
7	$38 \cdot 10^{-8}$	$78 \cdot 10^{-8}$	Visible radiation, light ISO 20473:2007
8	$78 \cdot 10^{-8}$	$3 \cdot 10^{-6}$	Near IR ISO 20473:2007
9	$3 \cdot 10^{-6}$	$5 \cdot 10^{-5}$	Mid IR ISO 20473:2007
10	$5 \cdot 10^{-5}$	$1 \cdot 10^{-3}$	Far IR ISO 20473:2007
11..255	For future use by ITU-T   ISO/IEC		

# Option 2 Aspect: item 7

**Item 7:**  
add **vui\_spectrum\_range\_present\_flag** to enable signaling of the min and max wavelength directly, without a predefined spectrum range table.

**vui\_spectrum\_range\_present\_flag** equal to 1 specifies that the spectrum band of the optical radiation wavelength represented by the pictures in the CLVS is present in the VUI parameters. **vui\_spectrum\_range\_present\_flag** equal to 0 specifies that the spectrum band of the optical radiation wavelength represented by the pictures in the CLVS is not present in the VUI parameters.

	Descriptor
vui parameters( payloadSize ) {	
...	
if( more data in payload( ) ) {	
if( payload extension present( ) ) {	
<b>vui modality info present flag</b>	u(1)
if(vui modality info present flag) {	
<b>vui modality type</b>	u(8)
<b>vui spectrum range present flag</b>	u(1)
if( vui spectrum range present flag == 1 ) {	
<b>vui min wavelength mantissa</b>	u(10)
<b>vui max wavelength mantissa</b>	u(10)
<b>vui min wavelength exponent plus15</b>	u(5)
<b>vui max wavelength exponent plus15</b>	u(5)
}	
<b>vui modality type extension bits</b>	ue(v)
if(vui modality type extension bits > 0 )	
<b>vui reserved modality type extension</b>	u(v)
}	
}	
<b>vui payload bit equal to one</b> /* equal to 1 */	f(1)
while( !byte aligned( ) )	
<b>vui payload bit equal to zero</b> /* equal to 0 */	f(1)
}	
}	

## Conclusion

- It is proposed to add picture modality information which includes spectrum range in VUI parameters by implementing one of the following options:
  - ❑ *Option 1 Aspect* (items 5 and 6) + *Common Aspects* (items 1 to 4).
  - ❑ *Option 2 Aspect* (item 7) + *Common Aspects* (items 1 to 4).

**It is proposed to adopt common aspects and either option 1 aspect or option 2 aspect in VSEI.**

# Proposal: option 1 aspect + common aspects

**vui\_colour\_description\_present\_flag** equal to 1 specifies that **vui\_colour\_primaries**, **vui\_transfer\_characteristics**, and **vui\_matrix\_coeffs** are present. **vui\_colour\_description\_present\_flag** equal to 0 specifies that **vui\_colour\_primaries**, **vui\_transfer\_characteristics**, and **vui\_matrix\_coeffs** are not present.

When **vui\_modality\_type** is equal to 2 or 3, **vui\_colour\_description\_present\_flag** shall be equal to 0.

**vui\_modality\_info\_present\_flag** equal to 1 specifies that **vui\_modality\_type** is present in the VUI parameters. **vui\_modality\_info\_present\_flag** equal to 0 specifies that **vui\_modality\_type** is not present in the VUI parameters.

**vui\_modality\_type** indicates the type of modality of the decoded picture as specified in Table 4. When not present, the value of **vui\_modality\_type** is inferred to be equal to 0, denoting that the modality type of the picture is unknown or unspecified or determined by other means not specified in this Specification.

Table 4– Mapping of **vui\_modality\_type** to the type of picture modalities

vui_modality_type	type of picture modality
0	Unspecified
1	Visible Picture
2	Infrared Picture
3	Thermal Infrared Picture Ultraviolet Picture
4..255	Reserved for future use

vui_parameters( payloadSize ) {	Descriptor
...	
if( more_data_in_payload() ) {	
if( payload_extension_present() ) {	
<b>vui_modality_info_present_flag</b>	u(1)
if( vui_modality_info_present_flag ) {	
<b>vui_modality_type</b>	u(8)
<b>vui_spectrum_range</b>	u(8)
if( vui_spectrum_range == 1 ) {	
<b>vui_min_wavelength_mantissa</b>	u(10)
<b>vui_max_wavelength_mantissa</b>	u(10)
<b>vui_min_wavelength_exponent_plus15</b>	u(5)
<b>vui_max_wavelength_exponent_plus15</b>	u(5)
}	
<b>vui_modality_type_extension_bits</b>	ue(v)
if( vui_modality_type_extension_bits > 0 )	
<b>vui_reserved_modality_type_extension</b>	u(v)
}	
}	
<b>vui_payload_bit_equal_to_one</b> /* equal to 1 */	f(1)
while( !byte_aligned() )	
<b>vui_payload_bit_equal_to_zero</b> /* equal to 0 */	f(1)
}	
}	

# Proposal: option 1 aspect + common aspects

**Table 5– Definition of vui\_spectrum\_range**

Value	minimum wavelength (m)	maximum wavelength (m)	Informative remark
0	Unspecified		Image characteristics are unknown or are determined by the application.
1	User-defined		Image characteristics are defined by the user.
2	$1 \cdot 10^{-9}$	$1 \cdot 10^{-7}$	Extreme UV ISO 20473:2007
3	$1 \cdot 10^{-7}$	$19 \cdot 10^{-8}$	Vacuum UV ISO 20473:2007
4	$19 \cdot 10^{-8}$	$28 \cdot 10^{-8}$	Deep UV ISO 20473:2007
5	$28 \cdot 10^{-8}$	$315 \cdot 10^{-9}$	Mid UV ISO 20473:2007
6	$315 \cdot 10^{-9}$	$38 \cdot 10^{-8}$	Near UV ISO 20473:2007
7	$38 \cdot 10^{-8}$	$78 \cdot 10^{-8}$	Visible radiation, light ISO 20473:2007
8	$78 \cdot 10^{-8}$	$3 \cdot 10^{-6}$	Near IR ISO 20473:2007
9	$3 \cdot 10^{-6}$	$5 \cdot 10^{-5}$	Mid IR ISO 20473:2007
10	$5 \cdot 10^{-5}$	$1 \cdot 10^{-3}$	Far IR ISO 20473:2007
11..255	For future use by ITU-T   ISO/IEC		

# Proposal: option 1 aspect + common aspects

**vui\_min\_wavelength\_mantissa** specifies the mantissa part of the minimum wavelength indicating the spectral band of optical radiation represented by the pictures in the CLVS. When `vui_min_wavelength_mantissa` is equal to 0, the minimum wavelength indicating the spectral band of optical radiation represented by the pictures in the CLVS is unknown or unspecified or determined by other means not specified in this Specification

**vui\_max\_wavelength\_mantissa** specifies the mantissa part of the maximum wavelength indicating the spectral band of optical radiation represented by the pictures in the CLVS. When `vui_max_wavelength_mantissa` is equal to 0, the maximum wavelength indicating the spectral band of optical radiation represented by the pictures in the CLVS is unknown or unspecified or determined by other means not specified in this Specification.

**vui\_min\_wavelength\_exponent\_plus15** minus 15 specifies the exponent part of the minimum wavelength indicating the spectral band of optical radiation represented by the pictures in the CLVS. When `vui_min_wavelength_mantissa` is equal to 0, decoders shall ignore the value of `vui_min_wavelength_exponent_plus15`.

The value of the minimum wavelength indicating the spectral band of optical radiation represented by the pictures in the CLVS is derived as follows:

$$\text{MinWavelength} = \text{vui\_min\_wavelength\_mantissa} * 10^{\text{vui\_min\_wavelength\_exponent\_plus15}-15}$$

**vui\_max\_wavelength\_exponent\_plus15** minus 15 specifies the exponent part of the maximum wavelength indicating the spectral band of optical radiation represented by the pictures in the CLVS. When `vui_max_wavelength_mantissa` is equal to 0, decoders shall ignore the value of `vui_max_wavelength_exponent_plus15`.

The value of the maximum wavelength indicating the spectral band of optical radiation represented by the pictures in the CLVS is derived as follows:

$$\text{MaxWavelength} = \text{vui\_max\_wavelength\_mantissa} * 10^{\text{vui\_max\_wavelength\_exponent\_plus15}-15}$$

`MinWavelength` and `MaxWavelength` are in units of meters as specified in ISO/IEC 80000.



# Proposal: option 1 aspect + common aspects

**vui\_modality\_type\_extension\_bits** equal to 0 specifies that **vui\_reserved\_modality\_type\_extension** is not present. **vui\_modality\_type\_extension\_bits** greater than 0 specifies the length, in bits, of **vui\_reserved\_modality\_type\_extension**.

The value of **vui\_modality\_type\_extension\_bits** shall be in the range of 0 to 2 048, inclusive. Values in the range of 1 to 2 048, inclusive, for **vui\_modality\_type\_extension\_bits** are reserved for future use by ITU-T | ISO/IEC and shall not be present in bitstreams conforming to this version of this document. Decoders conforming to this version of this document shall allow any value of **vui\_modality\_type\_extension\_bits** in the range of 0 to 2 048, inclusive, to appear in the syntax.

**vui\_reserved\_modality\_type\_extension** shall not be present in bitstreams conforming to this version of this document. However, decoders conforming to this version of this document shall allow the presence of **vui\_reserved\_modality\_type\_extension** in the syntax, but ignore the value. When present, the length, in bits, of **vui\_reserved\_modality\_type\_extension** is equal to **vui\_modality\_type\_extension\_bits**.

**vui\_payload\_bit\_equal\_to\_one** shall be equal to 1.

**vui\_payload\_bit\_equal\_to\_zero** shall be equal to 0.

# Proposal: option 2 aspect + common aspects

**vui\_spectrum\_range\_present\_flag** equal to 1 specifies that the spectrum band of the optical radiation wavelength represented by the pictures in the CLVS is present in the VUI parameters.

**vui\_spectrum\_range\_present\_flag** equal to 0 specifies that the spectrum band of the optical radiation wavelength represented by the pictures in the CLVS is not present in the VUI parameters.

**vui\_min\_wavelength\_mantissa** specifies the mantissa part of the minimum wavelength indicating the spectral band of optical radiation represented by the pictures in the CLVS. When **vui\_min\_wavelength\_mantissa** is equal to 0 or is not present, the minimum wavelength indicating the spectral band of optical radiation represented by the pictures in the CLVS is unknown or unspecified or determined by other means not specified in this Specification

**vui\_max\_wavelength\_mantissa** specifies the mantissa part of the maximum wavelength indicating the spectral band of optical radiation represented by the pictures in the CLVS. When **vui\_max\_wavelength\_mantissa** is equal to 0 or is not present, the maximum wavelength indicating the spectral band of optical radiation represented by the pictures in the CLVS is unknown or unspecified or determined by other means not specified in this Specification.

vui parameters( payloadSize ) {	Descriptor
...	
if( more data in payload( ) ) {	
if( payload extension present( ) ) {	
<b>vui modality info present flag</b>	u(1)
if( vui modality info present flag ) {	
<b>vui modality type</b>	u(8)
<b>vui spectrum range present flag</b>	u(1)
if( vui spectrum range present flag == 1 ) {	
<b>vui min wavelength mantissa</b>	u(10)
<b>vui max wavelength mantissa</b>	u(10)
<b>vui min wavelength exponent plus15</b>	u(5)
<b>vui max wavelength exponent plus15</b>	u(5)
}	
<b>vui modality type extension bits</b>	ue(v)
if( vui modality type extension bits > 0 )	
<b>vui reserved modality type extension</b>	u(v)
}	
}	
<b>vui payload bit equal to one</b> /* equal to 1 */	f(1)
while( !byte aligned( ) )	
<b>vui payload bit equal to zero</b> /* equal to 0 */	f(1)
}	
}	