

# SMPTE PUBLIC COMMITTEE DRAFT

## Interoperable Master Format — Application VC-5



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## Foreword

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## Introduction

This clause is entirely informative and does not form an integral part of this Engineering Document.

The VC-5 codec standardized in the SMPTE ST 2073 document suite is a mezzanine video compression format with very high visual quality and excellent encoding and decoding performance. This document specifies how to implement the VC-5 bitstream as specified in the SMPTE ST 2073-10 (Mapping VC-5 Video Essence into the MXF Generic Container) in the Interoperable Mastering Format (IMF).

IMF Application VC-5 targets images with a wide range of dimensions from below standard definition (SD), to UHDTV, and larger images as specified in the VC-5 standards suite. A VC-5 bitstream can represent RGB, YCbCr with subsampled color difference components, and Bayer (CFA) image formats.

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## 1 Scope

This document specifies an IMF Application for the VC-5 bitstream as specified in the SMPTE ST 2073-10 (Mapping VC-5 Video Essence into the MXF Generic Container).

## 2 Normative References

The following documents contain provisions that, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this engineering document are encouraged to investigate the possibility of applying the most recent edition of any undated reference.

SMPTE ST 379-2:2010, Material Exchange Format (MXF) — MXF Constrained Generic Container

SMPTE ST 2067-2:2020, Interoperable Master Format — Core Constraints

SMPTE ST 2067-5:2020, Interoperable Master Format — Essence Component

SMPTE ST 2067-21:2023, Interoperable Master Format — Application #2E

SMPTE ST 2067-205:20xx, Interoperable Master Format — Auxiliary Image Sequence Plug-in

SMPTE ST 2073-10:2017, Mapping VC-5 Video Essence into the MXF Generic Container

## 3 Terms and Definitions

For the purposes of this document, the terms and definitions given in SMPTE ST 2073-10, and the following terms and definitions apply.

### 3.1 VC-5 Standards Suite

SMPTE standards numbered 2073

## 4 VC-5 in IMF

### 4.1 General

This document is limited to the image essence track. All other aspects of an IMF composition shall comply with the provisions of SMPTE ST 2067-2.

The image essence shall be constrained as specified in SMPTE ST 2073-10 and further constrained as listed in Clause 5.5.

## 4.2 Image Formats

The operating points for progressively scanned images should be as listed in Table 1.

**Table 1. Recommended Operating Points**

Image Format	Bit Depth	Structure	Frame Rate	Reference
1920 x 1080	8, 10, 12	4:2:2 (Y'C <sub>B</sub> C <sub>R</sub> )	60, 50, 30, 25, 24	ST 274
1920 x 1080	8, 10, 12	4:4:4 (Y'C <sub>B</sub> C <sub>R</sub> )	60, 50, 30, 25, 24	ST 274
1920 x 1080	8, 10, 12	4:4:4 (R'G'B')	60, 50, 30, 25, 24	ST 274
1280 x 720	8, 10, 12	4:2:2 (Y'C <sub>B</sub> C <sub>R</sub> )	60, 50, 30, 25, 24	ST 296
1280 x 720	8, 10, 12	4:4:4 (Y'C <sub>B</sub> C <sub>R</sub> )	60, 50, 30, 25, 24	ST 296
1280 x 720	8, 10, 12	4:4:4 (R'G'B')	60, 50, 30, 25, 24	ST 296
3840 x 2160	8, 10, 12	4:2:2 (Y'C <sub>B</sub> C <sub>R</sub> )	120, 100, 60, 50, 30, 25, 24	ST 2036-1
3840 x 2160	8, 10, 12	4:4:4 (Y'C <sub>B</sub> C <sub>R</sub> )	120, 100, 60, 50, 30, 25, 24	ST 2036-1
3840 x 2160	8, 10, 12	4:4:4 (R'G'B')	120, 100, 60, 50, 30, 25, 24	ST 2036-1
4096 x 2160	8, 10, 12	4:4:4 (X'Y'Z')	24	ST 428-1
7680 x 4320	8, 10, 12	4:2:2 (Y'C <sub>B</sub> C <sub>R</sub> )	120, 100, 60, 50, 30, 25, 24	ST 2036-1
7680 x 4320	8, 10, 12	4:4:4 (Y'C <sub>B</sub> C <sub>R</sub> )	120, 100, 60, 50, 30, 25, 24	ST 2036-1
7680 x 4320	8, 10, 12	4:4:4 (R'G'B')	120, 100, 60, 50, 30, 25, 24	ST 2036-1
1280 x 720	8, 10, 12	4:4:4:4 (R, G, G, B)	60, 50, 30, 25, 24	ST 2073-3
1920 x 1080	8, 10, 12	4:4:4:4 (R, G, G, B)	60, 50, 30, 25, 24	ST 2073-3
3840 x 2160	8, 10, 12	4:4:4:4 (R, G, G, B)	120, 100, 60, 50, 30, 25, 24	ST 2073-3
4096 x 2160	8, 10, 12	4:4:4:4 (R, G, G, B)	24	ST 2073-3
7680 x 4320	8, 10, 12	4:4:4:4 (R, G, G, B)	120, 100, 60, 50, 30, 25, 24	ST 2073-3

**NOTE** Progressive frame rates for both the Frame Rate  $F$  listed in Table 1 and  $F/1.001$  are included for 24, 30, 60, and 120 frames per second.

An alpha channel shall be handled by the Auxiliary Image Sequence Plug-in as specified in SMPTE ST 2067-205 and shall not be obtained from the VC-5 bitstream while processing this IMF Application.

### 4.3 Shim Parameters

Track Files shall be associated with the shim parameter values specified Table 2.

**Table 2. Shim Parameter Values**

Shim Parameter	Value
shim_id	<a href="http://www.smpite-ra.org/ns/2067-72/202x">http://www.smpite-ra.org/ns/2067-72/202x</a>
gc_type	379-2-gc
picture_family	VC-5
picture_bitrate	ST 2067-72
picture_format	ST 2067-72
picture_custom_ANC	false
picture_render_ANC	false

## 5 Track Files

### 5.1 General

Track Files shall conform to SMPTE ST 379-2, SMPTE ST 2067-2, and SMPTE ST 2073-10.

### 5.2 Image Track File Essence

The image essence contained in image track files shall conform to Clause 4.

The image essence is constrained as specified in SMPTE ST 2073-10.

Image essence shall be frame wrapped as specified in SMPTE ST 2067-5.

### 5.3 Image Track File Format and Mapping

An image track file shall conform to SMPTE ST 2073-10 and the following constraints:

1. The edit rate and sample rate equal the image frame rate as defined in SMPTE ST 379-2.
2. Indexing is image frame-based, using index edit rates defined by the edit rates of the image essence track, as defined in SMPTE ST 377-1.

The top-level file package of the image track file shall reference either:

- A VC5CDCIPictureEssenceSubDescriptor as defined in SMPTE ST 2073-10 if the image essence uses  $Y'C'_B'C'_R(A)$  color components, or
- A VC5BayerPictureEssenceSubDescriptor as defined in SMPTE ST 2073-10 if the image essence is Bayer color format, or
- An RGBA Picture Essence Descriptor as defined in SMPTE ST 377-1 if the image essence uses  $R'G'B'(A)$  color components

## 5.4 Image Track File Descriptor

The status of Generic Picture Essence Descriptor items for this IMF Application shall be as listed in Table 3.

**Table 3. Generic Picture Essence Descriptor Items**

Item	Constraints	Status: SMPTE ST 377-1	Status: SMPTE ST 2067-2
Frame Layout	See Clause 5.5.2	B.Effort	-
StoredWidth	See Clause 5.5.3	B.Effort	-
StoredHeight	See Clause 5.5.4	B.Effort	-
StoredF2Offset	See Clause 5.5.5	Opt	-
SampledWidth	Shall be present. See Clause 5.5.6	Opt	-
SampledHeight	Shall be present. See Clause 5.5.7	Opt	-
SampledXOffset	Shall be present. See Clause 5.5.8	Opt	-
SampledYOffset	Shall be present. See Clause 5.5.9	Opt	-
DisplayWidth	Shall be present. See Clause 5.5.10	Opt	-
DisplayHeight	Shall be present. See Clause 5.5.11	Opt	-
DisplayXOffset	Shall be present. See Clause 5.5.12	Opt	-
DisplayYOffset	Shall be present. See Clause 5.5.13	Opt	-
DisplayF2Offset	Shall be present. See Clause 5.5.14	Opt	-
ActiveWidth	See Clause 5.5.15	-	Opt
ActiveHeight	See Clause 5.5.16	-	Opt
ActiveXOffset	See Clause 5.5.17	-	Opt
ActiveYOffset	See Clause 5.5.18	-	Opt
AspectRatio	See Clause 5.5.19	B.Effort	-
Video Line Map	See Clause 5.5.20	B.Effort	-
Transfer Characteristic	Shall be present. See Clause 5.5.21	Opt	-
Coding Equations	Shall be present. See Clause 5.5.21	Opt	-
Color Primaries	Shall be present. See Clause 5.5.21	Opt	-
Picture Essence Coding	Shall be present. See Clause 5.5.22	D/req	-
Alternative Center Cuts	See Clause 5.5.23	-	Opt



## 5.5 Image Track File Descriptor Items

### 5.5.1 Image Formats

The width and height dimensions shall be as specified in Table 4 for the corresponding image format and frame structure.

**Table 4. Dimensions for Image Format and Frame Structure**

Image Format	Frame Structure	Width	Height	Aspect Ratio
1280 x 720	Progressive	1280	720	16:9
1920 x 1080	Progressive	1920	1080	16:9
3840 x 2160	Progressive	3840	2160	16:9
7680 x 4320	Progressive	7680	4320	16:9

### 5.5.2 Frame Layout

The value of the Frame Layout item shall be equal to 0x00 (FULL\_FRAME).

NOTE Interlaced image structure, 0x01 (SEPARATE\_FIELDS), is not supported.

### 5.5.3 Stored Width

The value of StoredWidth shall be as listed in Table 4 for the corresponding image format and frame structure.

### 5.5.4 Stored Height

The value of StoredHeight shall be as listed in Table 4 for the corresponding image format and frame structure.

### 5.5.5 StoredF2Offset

The default value is 0.

### 5.5.6 Sampled Width

The value of SampledWidth shall be as listed in Table 4 for the corresponding image format and frame structure.

### 5.5.7 Sampled Height

The value of SampledHeight shall be as listed in Table 4 for the corresponding image format and frame structure.

### 5.5.8 SampledXOffset

The default value is 0.

### 5.5.9 SampledYOffset

The default value is 0.

#### **5.5.10 DisplayWidth**

The value of DisplayWidth shall be as listed in Table 4 for the corresponding image format and frame structure.

#### **5.5.11 Display Height**

The value of DisplayHeight shall be as listed in Table 4 for the corresponding image format and frame structure.

#### **5.5.12 DisplayXOffset**

The default value is 0.

#### **5.5.13 DisplayYOffset**

The default value is 0.

#### **5.5.14 DisplayF2Offset**

The default value is 0.

#### **5.5.15 Active Width**

The value of ActiveWidth is the number of horizontal pixels of the Active Area Rectangle, as defined in Annex G of SMPTE ST 2067-2:2020.

#### **5.5.16 Active Height**

The value of ActiveHeight is the number of vertical pixels of the Active Area Rectangle, as defined in Annex G of SMPTE ST 2067-2:2020.

#### **5.5.17 ActiveXOffset**

The value of ActiveYOffset is the vertical offset in Pixels of the Active Area Rectangle relative to the Display Rectangle, as defined in Annex G of SMPTE ST 2067-2:2020.

#### **5.5.18 ActiveYOffset**

The value of ActiveYOffset is the vertical offset in Pixels of the Active Area Rectangle relative to the Display Rectangle, as defined in Annex G of SMPTE ST 2067-2:2020.

#### **5.5.19 Aspect Ratio**

The aspect ratio shall be as listed in Table 4 for the corresponding image format and frame structure.

#### **5.5.20 Video Line Map**

The value of the Video Line Map item should be equal to:

- {42,0} if the image format is 1920x1080 and progressive.
- {26,0} if the image format is 1280x720 and progressive.
- {42,0} if the image format is 3840x2160 and progressive.
- {42,0} if the image format is 7680x4320 and progressive.

#### **5.5.21 Transfer Characteristic, Coding Equations, and Color Primaries**

Transfer Characteristic, Coding Equations and Color Primaries should be one of the combinations per Signal Formats of SMPTE ST 2067-21.

### 5.5.22 Picture Essence Coding

The Picture Essence Coding item is specified in SMPTE ST 2073-10.

### 5.5.23 Alternative Center Cuts

The Alternative Center Cuts item specifies the alternate aspect ratio subset(s) of the active area as specified in Annex F of SMPTE ST 2067-2:2020. Active area is defined in Annex G of SMPTE ST 2067-2:2020.

## 5.6 RGBA Picture Essence Descriptor

### 5.6.1 General

The RGBA Picture Essence Descriptor items are specified in Annex G of SMPTE ST 377-1:2019 and shall be further constrained as specified in this clause. Table 5 lists the items in the RGBA Picture Essence Descriptor that are specified as Optional in SMPTE ST 377-1 but are required for this IMF Application.

**Table 5. RGBA Picture Essence Descriptor Items**

RGBA Item	Constraints	Status: SMPTE ST 377-1
Component Max Ref	Shall be present. See Clause 5.6.2.	Opt
Component Min Ref	Shall be present. See Clause 5.6.2.	Opt
Pixel Layout	See Clause 5.6.3.	B.Effort

### 5.6.2 Color Range (Informative)

The unsigned 32-bit integer value of Component Max Ref specifies the R'G'B' sample value for the reference white level. Similarly, the unsigned 32-bit integer value of Component Min Ref specifies the R'G'B' sample value for the reference black level. Table 6 specifies the “narrow range” and “full range” signal representations from Recommendations ITU-R BT.601-7, ITU-R BT.709-6, and ITU-R BT.2100, as applicable for the listed bit depths.

**Table 6. Component Max Ref and Component Min Ref Values**

Property	Narrow Range			Full Range		
Bit Depth	8	10	12	8	10	12
Component Min Ref	16	64	256	0	0	0
Component Max Ref	235	940	3760	255	1023	4095

### 5.6.3 Pixel Layout (Informative)

The value of the Pixel Layout item shall be equal to {'G', x, 'B', x, 'R', x, 0, 0, 0, 0, 0, 0, 0, 0, 0} where x is equal to 8, 10 or 12 corresponding to 8-bit, 10-bit or 12-bit color components per Clause 4.1.

## 5.7 VC-5 CDCI Picture Essence SubDescriptor

### 5.7.1 General

The VC-5 CDCI Picture Essence SubDescriptor items are specified in SMPTE ST 2073-10 shall be further constrained as specified in this clause. Table 7 lists the items in the SubDescriptor that are specified as Optional in SMPTE ST 377-1 but are required for this IMF Application.

**Table 7. CDCI Picture Essence Descriptor items**

CDCI Item	Constraints	Status: SMPTE ST 377-1
Component Depth	See Clause 5.7.2.	B.Effort
Horizontal Subsampling	See Clause 5.7.3.	B.Effort
Vertical Subsampling	Shall be present. See Clause 5.7.4.	Opt
Color Siting	Shall be present. See Clause 5.7.5.	Opt
ReversedByteOrder	See Clause 5.7.6.	Opt
PaddingBits	See Clause 5.7.7.	Opt
Black Ref Level	Shall be present. See Clause 5.7.8.	Opt
White Ref level	Shall be present. See Clause 5.7.8.	Opt
Color Range	Shall be present. See Clause 5.7.8.	Opt

### 5.7.2 Component Depth

The value shall be equal to the bit-depth used.

### 5.7.3 Horizontal Subsampling

The value of Horizontal Subsampling item shall be equal to:

- 0x01 if 4:4:4 sampling per Clause 4.2.
- 0x02 if 4:2:2 or 4:2:0 sampling per Clause 4.2.

### 5.7.4 Vertical Subsampling

The value of Vertical Subsampling item shall be equal to:

- 0x01 if 4:4:4 or 4:2:2 sampling is used per Clause 4.2.
- 0x02 if 4:2:0 sampling is used per Clause 4.2.

### 5.7.5 Color Siting

The value shall be 0x00.

### 5.7.6 Reversed Byte Order

The default value is false.

### 5.7.7 Padding Bits

The default value is 0.

### 5.7.8 Color Range (Informative)

The values of the Black Ref Level, White Ref Level and Color Range items can be set according to the component bit depth used. Table 8 describes the “narrow range” and “full range” signal representations from Recommendations ITU-R BT.601-7, ITU-R BT.709-6, and ITU-R BT.2100, as applicable for the listed bit depths.

**Table 8. Black Ref Level, White Ref Level, and Color Range Values**

Property	Narrow range			Full range		
Bit Depth	8	10	12	8	10	12
Black Ref Level	16	64	256	0	0	0
White Ref Level	235	940	3760	255	1023	4095
Color Range	225	897	3585	256	1024	4096

**NOTE** The White Ref Level item applies only to the Y' component and the Color Range item to the C<sub>B</sub> and C<sub>R</sub> components.

## 5.8 Bayer Picture Essence SubDescriptor (Informative)

The Bayer Picture Essence Descriptor as described in SMPTE ST 2073-10 is present if the image format is Bayer.

# 6 Composition

## 6.1 General

Composition shall conform to SMPTE ST 2067-2.

## 6.2 Application Identification

The ApplicationIdentification element (see SMPTE ST 2067-2) shall be the value listed in Table 2.

## 6.3 Homogeneous Essence

Within a given a composition, the following shall remain constant:

1. The height and width of the image.
2. The pixel format of the image.

The color profile of the image.

## Bibliography

Recommendation ITU-R BT.601-7 (03/2011) Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios

Recommendation ITU-R BT.709-6 (06/2015), Parameter values for the HDTV standards for production and international programme exchange

Recommendation ITU-R BT.2100-2 (07/2018), Image parameter values for high dynamic range television for use in production and international programme exchange