

SMPTE STANDARD

Interoperable Master Format — Application SMPTE ST 2117-1 (VC-6)



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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU. SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual. This SMPTE Engineering Document was prepared by Technology Committee TC 35PM.

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

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

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

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

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

The keyword "reserved" indicates a provision that is not defined at this time, shall not be used, and may be defined in the future.

The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be defined in the future.

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

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

Introduction

SMPTE ST 2117-1 (VC-6) is a versatile intra-frame compression scheme. This document maps the VC-6 bitstream into the Interoperable Master Format.

Intellectual Property

At the time of publication, no notice had been received by SMPTE claiming patent rights essential to the implementation of this Engineering Document. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

1 Scope

This document specifies a new IMF Application as a specialization of the IMF Framework to no-proxy workflow using the hierarchical properties of VC-6 to create workflow efficiencies through layered storage and transport whilst retaining the auditing and versioning capabilities of IMF.

The new IMF Application targets UHDTV and larger images that are encoded using SMPTE ST 2117-1 with multiple echelons and bitrates that deliver visually lossless and mathematically lossless storage.

2 Normative References

The following SMPTE STANDARD contains provisions that, through reference in this text, constitute provisions of this standard. Dated references require that the specific edition cited shall be used as the reference. Undated citations refer to the edition of the referenced document (including any amendments) current at the date of publication of this document. All SMPTE standards 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 274:2008, *1920 x 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates*. <https://doi.org/10.5594/smpete.st274.2008>

SMPTE ST 296:2012, *1280 x 720 Progressive Image 4:2:2 and 4:4:4 Sample Structure – Analog and Digital Representation and Analog Interface*. <https://doi.org/10.5594/smpete.st296.2012>

SMPTE ST 377-1:2019, *Material Exchange Format (MXF) — File Format Specification*. <https://doi.org/10.5594/smpete.st377-1.2019>

SMPTE ST 428-1:2019, *D-Cinema Distribution Master — Image Characteristics*. <https://doi.org/10.5594/smpete.st428-1.2019>

SMPTE ST 2036-1:2014, *Image Parameter Values for Program Production*. <https://doi.org/10.5594/smpete.st2036-1.2014>

SMPTE ST 2067-2:2020, *Interoperable Master Format Core Constraints*. <https://doi.org/10.5594/smpete.st2067-2.2020>

SMPTE ST 2067-21:2023, *Interoperable Master Format Application #2e*. <https://doi.org/10.5594/smpete.st2067-21.2023>

SMPTE ST 2117-10:2024, *VC-6 Video Compression — Mapping VC-6 into the MXF Generic Container*. <https://doi.org/10.5594/SMPTE.ST2117-10.2024>

3 Terms and Definitions

For the purposes of this document, the terms and definitions given in SMPTE ST 377-1 and ST 2117-10 apply.

4 VC-6 in IMF

4.1 General

All provisions of SMPTE ST 2067-2 shall apply. This document deals with the Main Image Virtual Track that shall reference content that complies with ST 2117-10.

4.2 Shim Parameters

Track files shall be associated with the shim parameters in Table 1 in addition to those in SMPTE ST 2067-2.

Table 1 — Shim Parameter Value Definitions

Shim parameter	Value
shim_id	http://www.smpte-ra.org/ns/2067-71/2024
picture_format	See SMPTE 2067-5
picture_bitrate	See SMPTE 2067-5
gc_type	379-2-constrained-gc
picture_family	VC-6
picture_custom_ANC	false
picture_render_ANC	false

4.3 Layering

All Image Track Files shall have all echelons and planes for each image contained within a single MXF Essence Stream.

NOTE VC-6 IMF multi-resolution workflows are constrained in this document to having all the echelon resolutions in a single MXF stream in a single MXF file.

5 Image Essence

5.1 General

Image essence shall consist of image frames, each a rectangular pixel array. Track Files shall conform to SMPTE ST 2117-10 and SMPTE ST 2067-2.

5.2 Constraints

Each image frame shall have the same characteristics and should conform to one of the permitted combinations of image frame characteristics listed in Table 2.

Table 2 — Recommended Operating Points

Image Format	Bit Depth	Structure	Frame Rate [1]	Reference
1920 × 1080	10, 12	4:2:2 (Y'C _B C _R)	60 ¹ , 50, 30 ¹ , 25, 24 ¹	ST 274
1920 × 1080	10, 12	4:4:4 (Y'C _B C _R)	60 ¹ , 50, 30 ¹ , 25, 24 ¹	ST 274
1920 × 1080	10, 12	4:4:4 (R'G'B')	60 ¹ , 50, 30 ¹ , 25, 24 ¹	ST 274
1280 × 720	10, 12	4:2:2 (Y'C _B C _R)	60 ¹ , 50, 30 ¹ , 25, 24 ¹	ST 296
1280 × 720	10, 12	4:4:4 (Y'C _B C _R)	60 ¹ , 50, 30 ¹ , 25, 24 ¹	ST 296
1280 × 720	10, 12	4:4:4 (R'G'B')	60 ¹ , 50, 30 ¹ , 25, 24 ¹	ST 296
3840 × 2160	10, 12	4:2:2 (Y'C _B C _R)	120 ¹ , 100, 60 ¹ , 50, 30 ¹ , 25, 24 ¹	ST 2036-1
3840 × 2160	10, 12	4:4:4 (Y'C _B C _R)	120 ¹ , 100, 60 ¹ , 50, 30 ¹ , 25, 24 ¹	ST 2036-1
3840 × 2160	10, 12	4:4:4 (R'G'B')	120 ¹ , 100, 60 ¹ , 50, 30 ¹ , 25, 24 ¹	ST 2036-1
4096 × 2160	10, 12	4:4:4 (X'Y'Z')	24	ST 428-1
7680 × 4320	10, 12	4:2:2 (Y'C _B C _R)	120 ¹ , 100, 60 ¹ , 50, 30 ¹ , 25, 24 ¹	ST 2036-1
7680 × 4320	10, 12	4:4:4 (Y'C _B C _R)	120 ¹ , 100, 60 ¹ , 50, 30 ¹ , 25, 24 ¹	ST 2036-1
7680 × 4320	10, 12	4:4:4 (R'G'B')	120 ¹ , 100, 60 ¹ , 50, 30 ¹ , 25, 24 ¹	ST 2036-1

1 Progressive Frame Rates of both *F* and *F/1.001* are included.

6 Image Track Files

6.1 Image Track File Essence

The Image Essence contained in Image Track Files shall conform to Clause 5.

6.2 Image Track File Format and Mapping

An Image Track File shall conform to SMPTE ST 2117-10:

- The Edit Rate and Sample Rate are equal to the image frame rate as defined in SMPTE ST 379-2.
- Indexing is image frame-based, using Index Edit Rates defined by the Edit Rates of the Essence Track, as defined in SMPTE ST 377-1. The Top-Level File Package of Image Track File shall reference:
 - A CDCI Picture Essence Descriptor as defined in SMPTE ST 377-1 if the Image Essence uses Y'C_bC_R color components.
 - An RGBA Picture Essence Descriptor as defined in SMPTE ST 377-1 if the Image Essence uses R'G'B' color components.
- A VC6SubDescriptor as defined in SMPTE ST 2117-10 shall be present.

6.3 Image Track File Descriptor

The Generic Picture Essence Descriptor items shall be as specified in Annex G of SMPTE ST 377-1:2019 and Annexes F and G of SMPTE ST 2067-21:2020 and then further constrained as specified in this clause (6.3). Table 3 specifies the following items:

- Best Effort (B.Effort) items which are specified in SMPTE ST 377-1.
- Items which are further constrained, i.e., required items which are specified as Optional (Opt) or Decoder Required (D/req) in SMPTE ST 377-1 StoredF2offset, DisplayF2offset and FieldDominance.
- Optional (Opt) items which are specified in SMPTE ST 2067-2.

Table 3 — Generic Picture Essence Descriptor Items

Item	Constraints	Status: ST 377-1	Status: ST 2067-2
Frame Layout	See Clause 6.4.1	B.Effort	-
Stored Width	See Clause 6.4.2	B.Effort	-
Stored Height	See Clause 6.4.3	B.Effort	-
StoredF2Offset	Shall be present for Interlaced. See Clause 6.4.4	Opt	-
Sampled Width	Shall be present. See Clause 6.4.5	Opt	-
Sampled Height	Shall be present. See Clause 6.4.6	Opt	-
SampledXOffset	Shall be present. See Clause 6.4.7	Opt	-
SampledYOffset	Shall be present. See Clause 6.4.8	Opt	-
DisplayWidth	Shall be present. See Clause 6.4.9	Opt	-

Item	Constraints	Status: ST 377-1	Status: ST 2067-2
DisplayHeight	Shall be present. See Clause 6.4.10	Opt	-
DisplayXOffset	Shall be present. See Clause 6.4.11	Opt	-
DisplayYOffset	Shall be present. See Clause 6.4.12	Opt	-
DisplayF2Offset	Shall be present. See Clause 6.4.13	Opt	-
ActiveWidth	See Clause 6.4.14	-	Opt
ActiveHeight	See Clause 6.4.15	-	Opt
ActiveXOffset	See Clause 6.4.16	-	Opt
ActiveYOffset	See Clause 6.4.17	-	Opt
Aspect Ratio	See Clause 6.4.18	B.Effort	-
Video Line Map	See Clause 6.4.19	B.Effort	-
Transfer Characteristic	Shall be present. See Clause 6.4.20	Opt	-
Coding Equations	Shall be present. See Clause 6.4.20	Opt	-
Color Primaries	Shall be present. See Clause 6.4.20	Opt	-
Picture Essence Coding	Shall be present. See Clause 6.4.21	D/req	-
Alternative Center Cuts	See Clause 6.4.22	-	Opt

6.4 Image Track File Descriptor Items

6.4.1 Frame Layout

The value of the Frame Layout item is equal to:

- 0x00 (FULL_FRAME) if the image structure is progressive.
- 0x01 (SEPARATE_FIELDS) if the image structure is interlaced.

6.4.2 Stored Width

The value of the Stored Width item shall be equal to:

- 1920 if the image format is 1920 × 1080.
- 1280 if the image format is 1280 × 720.
- 3840 if the image format is 3840 × 2160.
- 7680 if the image format is 7680 × 4320.

6.4.3 Stored Height

The value of the Stored Height item shall be equal to:

- 1088 if the image format is 1920 × 1080 and progressive.
- 544 if the image format is 1920 × 1080 and interlaced.
- 720 if the image format is 1280 × 720 and progressive.
- 2160 if the image format is 3840 × 2160 and progressive.
- 4320 if the image format is 7680 × 4320 and progressive.

6.4.4 StoredF2Offset

The default value is 0.

6.4.5 Sampled Width

The value of the Sampled Width item shall be equal to:

- 1920 if the image format is 1920 × 1080.
- 1280 if the image format is 1280 × 720.
- 3840 if the image format is 3840 × 2160.
- 7680 if the image format is 7680 × 4320.

6.4.6 Sampled Height

The value of the Sampled Height item shall be equal to:

- 1080 if the image format is 1920 × 1080 and progressive.
- 540 if the image format is 1920 × 1080 and interlaced.
- 720 if the image format is 1280 × 720 and progressive.
- 2160 if the image format is 3840 × 2160 and progressive.
- 4320 if the image format is 7680 × 4320 and progressive.

6.4.7 SampledXOffset

The default value is 0.

6.4.8 SampledYOffset

The default value is 0.

6.4.9 DisplayWidth

- 1920 if the image format is 1920 × 1080.
- 1280 if the image format is 1280 × 720.
- 3840 if the image format is 3840 × 2160.
- 7680 if the image format is 7680 × 4320.

6.4.10 DisplayHeight

The value of the DisplayHeight item shall be equal to:

- 1080 if the image format is 1920 × 1080 and progressive.
- 540 if the image format is 1920 × 1080 and interlaced.
- 720 if the image format is 1280 × 720 and progressive.
- 2160 if the image format is 3840 × 2160 and progressive.
- 4320 if the image format is 7680 × 4320 and progressive.

6.4.11 DisplayXOffset

The default value is 0.

6.4.12 DisplayYOffset

The default value is 0.

6.4.13 DisplayF2Offset

The default value is 0.

6.4.14 ActiveWidth

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

6.4.15 ActiveHeight

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

6.4.16 ActiveXOffset

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

6.4.17 ActiveYOffset

The value of the 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.

6.4.18 Aspect Ratio

The value of the Aspect Ratio item shall be equal to:

- 16:9 if the image format is 1920 × 1080.
- 16:9 if the image format is 1280 × 720.
- 16:9 if the image format is 3840 × 2160.
- 16:9 if the image format is 7680 × 4320.

6.4.19 Video Line Map

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

- {42,0} if the image format is 1920 × 1080 and progressive.
- {21,584} if the image format is 1920 × 1080 and interlaced.
- {26,0} if the image format is 1280 × 720 and progressive.
- {42,0} if the image format is 3840 × 2160 and progressive.
- {42,0} if the image format is 7680 × 4320 and progressive.

6.4.20 Transfer Characteristic, Coding Equations and Color Primaries

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

6.4.21 Picture Essence Coding

The value of the Picture Essence Coding item shall be as specified in SMPTE ST 2117-10.

6.4.22 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.

6.5 Image Track File RGBA Descriptor

6.5.1 General

The RGBA Picture Essence Descriptor items shall be as specified in Annex G of SMPTE ST 377-1:2019 and then further constrained as specified in this clause (6.5). Table 4 specifies the following items:

- Best Effort (B.Effort) items which are specified in SMPTE ST 377-1.
- Items which are further constrained, i.e., required items which are specified as Optional in SMPTE ST 377-1.

Table 4 — RGBA Picture Essence Descriptor Items

RGBA Item	Constraints	Status: ST 377-1
Component Max Ref	Shall be present. See Clause 6.5.2.	Opt
Component Min Ref	Shall be present. See Clause 6.5.2.	Opt
PixelLayout	See Clause 6.5.3.	B.Effort

6.5.2 Component Max Ref and Component Min Ref

Component Max Ref is an item whose unsigned 32-bit integer value shall specify the R'G'B' sample value for reference white level. Similarly, Component Min Ref is an item whose unsigned 32-bit integer value shall specify the R'G'B' sample value for reference black level. Table 5 describes the “narrow range” and “full range” signal representations of Recommendation ITU-R BT.2100.

Table 5 — Component Max Ref and Component Min Ref values

Range	Narrow range		Full range	
Bit Depth	10	12	10	12
Component Min Ref	64	256	0	0
Component Max Ref	940	3760	1023	4095

6.5.3 PixelLayout

The value of the PixelLayout 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 10 or 12 if 10-bit or 12-bit color components are used per Clause 5.2.

6.6 CDCI Picture Essence Descriptor

6.6.1 General

The CDCI Picture Essence Descriptor items shall be as specified in Annex G of SMPTE ST 377-1:2019 and then further constrained as specified in this clause (6.6). Table 6 specifies the following items:

- Best Effort (B.Effort) items which are specified in SMPTE ST 377-1.
- Items which are further constrained, i.e., required items which are specified as Optional in SMPTE ST 377-1.

Table 6 — CDCI Picture Essence Descriptor items

CDCI Item	Constraints	Status: ST 377-1
Component Depth	See Clause 6.6.2.	B.Effort
Horizontal Subsampling	See Clause 6.6.3.	B.Effort
Vertical Subsampling	Shall be present. See Clause 6.6.4.	Opt
Color Siting	Shall be present. See Clause 6.6.5.	Opt
ReversedByteOrder	See Clause 6.6.6.	Opt
PaddingBits	See Clause 6.6.7.	Opt
Black Ref Level	Shall be present. See Clause 6.6.8.	Opt
White Ref level	Shall be present. See Clause 6.6.8.	Opt
Color Range	Shall be present. See Clause 6.6.8.	Opt

6.6.2 Component Depth

The value shall be equal to the Bit Depth used.

6.6.3 Horizontal Subsampling

The value of Horizontal Subsampling item shall be equal to:

- 0x01 if 4:4:4 sampling is used per Clause 5.2.
- 0x02 if 4:2:2 or 4:2:0 sampling is used per Clause 5.2.

6.6.4 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 5.2.
- 0x02 if 4:2:0 sampling is used per Clause 5.2.

6.6.5 Color Siting

The value shall be 0x00.

6.6.6 ReversedByteOrder

The default value is 0.

6.6.7 PaddingBits

The default value is 0.

6.6.8 Black Ref Level, White Ref Level and Color Range

The values of the Black Ref Level, White Ref Level and Color Range items shall be set according to the component Bit Depth used. Table 7 describes the “narrow range” and “full range” signal representations of Recommendation ITU-R BT.2100.

Table 7 — Black Ref Level, White Ref Level and Color Range values

Property	Narrow range		Full range	
	10	12	10	12
Black Ref Level	64	256	0	0
White Ref Level	940	3760	1023	4095
Color Range	897	3585	1023	4095

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

6.7 VC6SubDescriptor

The VC6SubDescriptor shall be present even if no optional properties are present in the data.

7 Composition

7.1 General

Composition shall conform to SMPTE ST 2067-2.

7.2 Application Identification

The `ApplicationIdentification` element (see SMPTE ST 2067-2) shall include the value listed in Table 8.

Table 8 — Application Identification

Application Identifier
http://www.smpte-ra.org/ns/2067-71/2024

7.3 Homogeneous Essence — Image

Within a given composition, the following shall remain constant:

- The width and height of the image.
- The color profile of the image.
- The number of echelons used to encode the image.

7.4 Segment Duration

The provisions of Clause 7.4 in ST 2067-21:2023 shall apply.

Bibliography

SMPTE ST 379-2:2010, *Television — Material Exchange Format (MXF) — MXF Constrained Generic Container*. <https://doi.org/10.5594/SMPTE.ST379-2.2010>