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SMPTE 2019-4-2009

SMPTE STANDARD

Mapping VC-3 Coding Units into the MXF Generic Container

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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.

SMPTE ST 2019-4 was prepared by the 31FS Technology Committee.

Intellectual Property

SMPTE draws attention to the fact that it is claimed that compliance with this Standard may involve the use of one or more patents or other intellectual property rights (collectively, "IPR"). The Society takes no position concerning the evidence, validity, or scope of this IPR.

Each holder of claimed IPR has assured the Society that it is willing to License all IPR it owns, and any third party IPR it has the right to sublicense, that is essential to the implementation of this Standard to those (Members and non-Members alike) desiring to implement this Standard under reasonable terms and conditions, demonstrably free of discrimination. Each holder of claimed IPR has filed a statement to such effect with SMPTE. Information may be obtained from the Director, Standards & Engineering at SMPTE Headquarters.

Attention is also drawn to the possibility that elements of this Standard may be subject to IPR other than those identified above. The Society shall not be responsible for identifying any or all such IPR.

Introduction

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

This standard maps the coding units for each VC-3 (SMPTE ST 2019-1) coded frame or pair of fields into a MXF Generic Container. VC-3 is a picture-by-picture coding scheme where each picture is entirely independent and can be extracted as an independent entity. However, the coding units can be simply concatenated to form a sequence of compressed pictures.

This standard maps the VC-3 coding units as either frame-wrapped where each VC-3 Compressed Frame is individually mapped into a single MXF GC Picture Item or clip-wrapped where a sequence of VC-3 Compressed Frames is mapped into a single MXF GC Picture Item. This standard defines the KLV coding, the Essence Container and Compression Label values and the Essence Descriptor.

1 Scope

This standard specifies the mapping of VC-3 Coding Units as a Picture Element that may be used in the Picture Item of the MXF GC. The Picture Element may contain either individual VC-3 Compressed Frames using frame-wrapping or a sequence of VC-3 Compressed Frames using clip-wrapping. The MXF Generic Container (GC) is described in SMPTE ST 379-1. VC-3 Coding Units and Compressed Frames are described in SMPTE ST 2019-1.

This standard specifies the Key, the Length and the Value fields of the VC-3 Picture Element. This standard also defines the Essence Container and Compression Label values and the Essence Descriptor.

2 Conformance Notation

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 section 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.

3 Normative References

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 379-1:2009) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 379-1-2009). Documents with the same root number (e.g. 379-1) and publication year (e.g. 2009) are functionally identical.

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE ST 377-1:2011, Material Exchange Format (MXF) — File Format Specification

Amendment 1:2012 to SMPTE ST 377-1:2011

Amendment 2:2012 to SMPTE ST 377-1:2011

SMPTE ST 379-1:2009, Material Exchange Format (MXF) — MXF Generic Container

SMPTE ST 400:2012, SMPTE Labels Structure

SMPTE ST 2019-1:2014, VC-3 Picture Compression and Data Stream Format

4 Glossary of Acronyms, Terms and Data Types

The general glossary of acronyms, terms and data types used in the MXF specification is given in SMPTE ST 377-1 and is supplemented in SMPTE ST 379-1. These glossaries are not repeated here to avoid any divergence of meaning.

Definitions of terms, abbreviations and symbols relating to VC-3 are given in SMPTE ST 2019-1.

5 Mapping VC-3 into the MXF Generic Container

5.1 VC-3 Coding Summary (Informative)

VC-3 is a picture-by-picture coding scheme where each picture is entirely independent and can be extracted as an independent entity. However, the coding units can be simply concatenated to form a sequence of compressed pictures. VC-3 is defined by SMPTE ST 2019-1, VC-3 Picture Compression and Data Stream Format.

A VC-3 compressed bit stream is comprised of continuously concatenated Coding Units. A Coding Unit consists of a Header of 640 bytes, a Compressed Payload, and an End-Of-Frame (EOF) signature of 4 bytes.

VC-3 Coding Units are concatenated to form Compressed Frames. For progressive-scan video, a Compressed Frame consists of a single Coding Unit. For interlaced video, a Compressed Frame consists of a pair of Coding Units, one for each field.

Please refer to SMPTE ST 2019-1 for further details.

5.2 Frame Wrapping (Informative)

The "Frame Wrapping" methods for VC-3 are shown in Figure 1 and Figure 2.

Figure 1 shows a series of images each wrapped in a single Content Package with no other Generic Container Elements in the Container. Each Content Package has the duration of one VC-3 Compressed Frame.

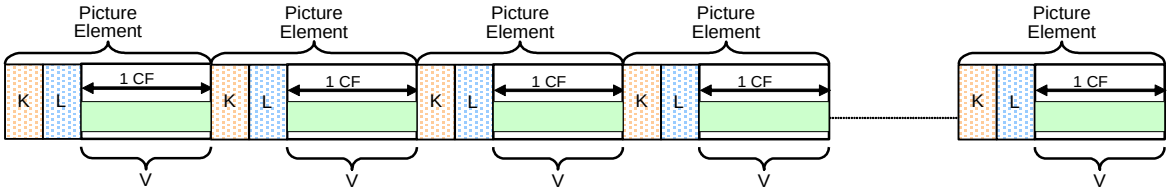

Figure 1 – Simple Representation of Frame Wrapping

The Frame Wrapping method enables Frame by Frame access by MXF applications which process at the KLV level. This can be particularly useful for applications which support multiple Generic Container mapping types, for example, MXF Operational Pattern OP-1A.

Sufficient Information is provided to allow individual Frames to be identified at the KLV level without an MXF decoder having to parse or decode the Essence Data. Each VC-3 Compressed Frame is KLV wrapped using a GC Picture Element Key.

In some applications, the Frame Wrapped VC-3 picture data will exist in Content Packages with other Elements such as Sound and Data Elements. An example Generic Container is shown in Figure 2 below.

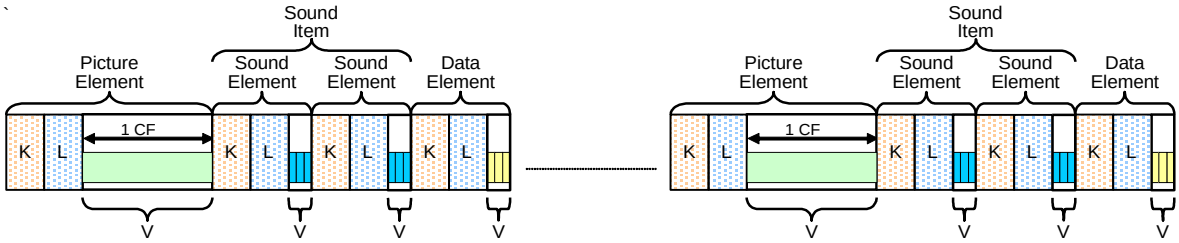

Figure 2 – Frame Wrapping with other GC Elements

The Generic Container Mapping Specifications for the Sound and Data Elements will detail the Key values and format of the data within the elements. In this wrapping mode, the Sound and Data Elements should follow the guidance given in SMPTE ST 379-1, Section 5.4 concerning placement of the synchronized samples in Essence Containers.

5.3 **Clip Wrapping** (Informative)

The "Clip Wrapping" methods for VC-3 are shown in Figure 3 and Figure 4.

In Clip wrapping, KLV encoding wraps the whole of the VC-3 stream that may contain a single frame or thousands of frames. Any other elements in the Generic Container should also be clip wrapped.

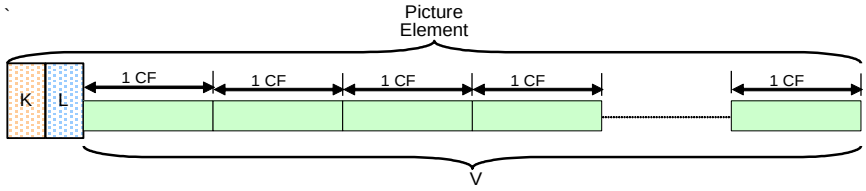

Figure 3 – Simple Representation of Clip Wrapping a Video Stream

The Clip Wrapping method is intended for applications which carry the VC-3 stream as a single large entity. This can be very useful in applications where it is desired to use the rich metadata structures of MXF as an annotation to VC-3 data and also in applications such as store and forward servers which process whole files.

The clip of VC-3 data is KLV wrapped using an appropriate key as detailed in Section 6. When VC-3 data is Clip wrapped, there should be only one clip per Generic Container. Single Clips can be wrapped as atomic MXF files, for example, using MXF Operational Pattern OP-Atom.

Multiple Clips can be concatenated and edited using the Operational Pattern mechanism detailed in the MXF format document. In some applications, the Clip Wrapped VC-3 data will exist in a Content Package with other Elements such as Sound and Data Elements. An example Generic Container is shown in Figure 4.

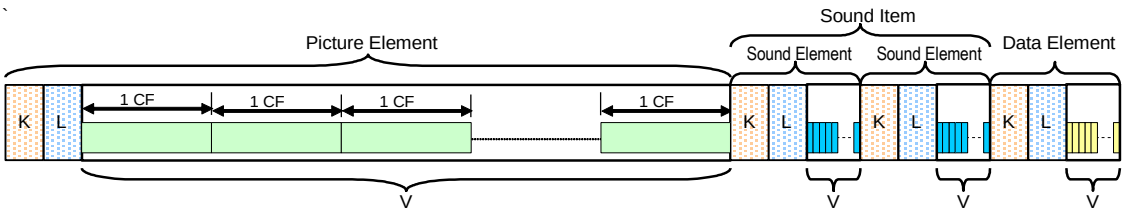

Figure 4 – Clip Wrapping with other GC Elements

The Generic Container Mapping Specifications for the Sound and Data Elements will detail the Key values and format of the data within the elements. Note that in this wrapping mode, the duration of Sound and Data Elements is intended to be that of the entire clip.

6 KLV Coding of VC-3 Coding Units

6.1 Essence Element Key

The values of the first 12 bytes of the essence element Key are defined in SMPTE ST 379-1. The values of the last four bytes of the Picture Element Key shall be as given in Table 1.

Table 1 – Key Value for the VC-3 Picture Element

Byte No.	Description	Value (hex)	Meaning
1~12	Defined in SMPTE ST 379-1		See SMPTE ST 379-1
13	Item Type Identifier	15h	GC Picture Item (as defined in SMPTE ST 379-1)
14	Essence Element Count	kkh	Count of Picture Elements in the Picture item
15	Essence Element Type	0Ch 0Dh	Frame-wrapped VC-3 Picture Element Clip-wrapped VC-3 Picture Element
16	Essence Element Number	nnh	The Number (used as an Index) of this Picture Element in the Picture Item

6.1.1 Essence Element Count – Byte 14

This shall be a count of the number of Picture Elements in the Picture Item of the Generic Container, typically 1.

6.1.2 Essence Element Type – Byte 15

The value of 0Ch identifies that each VC-3 Compressed Frame is frame-wrapped.

The value of 0Dh identifies that the sequence of VC-3 Compressed Frames are clip-wrapped.

6.1.3 Essence Element Number – Byte 16

This is a number used as an index to identify this instance of the Element Type within the Picture Item. Each Element within an Item shall have a unique value between 00h and 7Fh, as defined by SMPTE ST 379-1, which shall remain constant within the Generic Container.

6.2 Length

The length field should be 4 byte BER long-form encoded (i.e., 83h.xx.yy.zz) for frame-based wrapping and should be 8 byte BER long-form encoded (i.e., 87h.aa.bb.cc.dd.ee.ff.gg) for clip-based wrapping. Decoders shall conform to SMPTE ST 377-1.

The length field shall comply with SMPTE 379-1, Section 5.5.1.

6.3 Value

6.3.1 Frame-wrapped

The value field shall comprise a single VC-3 Compressed Frame as defined in SMPTE ST 2019-1.

6.3.2 Clip-wrapped

The value field shall comprise a sequence of one or more concatenated VC-3 Compressed Frames where each VC-3 Compressed Frame is as defined in SMPTE ST 2019-1.

7 SMPTE Label for VC-3 Essence Container Identification

The values for the Essence Container UL shall be as given in Table 2.

Table 2 – Specification of the Essence Container Label

Byte No.	Description	Value (hex)	Meaning
1-12	Defined by Generic Container	See SMPTE ST 379-1	As defined in SMPTE ST 379-1
13	Essence Container Kind	02h	MXF Generic Container
14	Mapping Kind	11h	VC-3 Picture Element (as listed in SMPTE RP 224)
15	Content Kind	01h 02h	Frame- wrapped Picture Element Clip- wrapped Picture Element
16	Reserved	00h	

The Essence Container UL is used within a batch of ULs in Partition Packs and the Preface set and on its own in the Essence Descriptor. These UL values are listed in the SMPTE Labels Registry, RP 224.

8 SMPTE Label for VC-3 Picture Essence Compression

The values for the Picture Essence Compression UL shall be as given in Table 3.

Table 3 – Specification of the Picture Essence Compression Label

Byte No.	Description	Value (hex)	Meaning
1-8	Registry Designator	See SMPTE ST 400M	Designator value is defined in SMPTE ST 400
9	Parametric	04h	Node used to define parametric data
10	Picture Essence	01h	Identifies picture essence coding
11	Picture Coding Characteristics	02h	Identifies picture coding characteristics
12	Specialized Compression Schemes	02h	Identifies specialized compression
13	VC-3 Picture Coding	71h	Identifies VC-3 picture coding
14	VC-3 Picture Coding Variant	xxh	Identifies VC-3 Compression ID according to SMPTE ST 2019-1. See Table 4
15	unused	00h	Unused
16	Unused	00h	Unused

The correspondence between Byte 14 in Table 3 and the VC-3 Compression ID described in SMPTE ST 2019-1 is as given in Table 4.

Table 4 – Picture Essence Compression UL Byte 14

Picture Essence Compression UL Byte 14	SMPTE ST 2019-1 Compression ID	Meaning
01h	1235	Progressive, 1920x1080, 10 bit, high rate
03h	1237	Progressive, 1920x1080, 8 bit, medium
04h	1238	Progressive, 1920x1080, 8 bit, high
07h	1241	Interlaced, 1920x1080, 10 bit, high
08h	1242	Interlaced, 1920x1080,8 bit, medium
09h	1243	Interlaced, 1920x1080, 8 bit, high
0Ah	1244	Interlaced, 1440x540, 8 bit, medium
10h	1250	Progressive, 1280x720, 10 bit, medium
11h	1251	Progressive, 1280x720, 8 bit, high
12h	1252	Progressive, 1280x720, 8 bit, medium
13h	1253	Progressive, 1920x1080, 8 bit, low
16h	1256	Progressive, 1920x1080, 10 bit, high
18h	1258	Progressive, 960x720, 8 bit, low
19h	1259	Progressive, 1440x1080, 8 bit, low
1Ah	1260	Interlaced, 1440x540, 8 bit, low

The Picture Essence Compression UL is used in the Generic Picture Essence Descriptor. This UL is listed in RP 224, SMPTE Labels Register.

9 Essence Descriptors for VC-3

The File Descriptor sets are those structural metadata sets in the Header Metadata that describe the essence and metadata elements defined in this document. The structure of these sets is defined in the MXF File Format Specification (SMPTE ST 377-1) and in some Generic Container mapping specifications. File Descriptor sets shall be present in the Header Metadata for each Essence Element.

The mapping of VC-3 uses the CDCI (Color Difference Component Image) Picture Essence Descriptor or RGBA (Red Green Blue Alpha) Picture Essence Descriptor as defined in SMPTE ST 377-1, Annex F.4. The meaning of the items in the CDCI Picture Essence Descriptor and RGBA Picture Essence Descriptor (and their superclasses) are defined in SMPTE ST 377-1, Annex G. The RGBA Picture Essence Descriptor shall only be used in conjunction with Compression ID 1256.

The values of the items defined in the CDCI Picture Essence Descriptor and the RGBA Picture Essence Descriptor are derived from values used in the VC-3 coding units. In the event of discrepancy between values, those in the VC-3 coding units shall take precedence and decoders shall use those values. The values in the CDCI Picture Essence Descriptor and the RGBA Picture Essence Descriptor should be updated.

The specific items whose values are derived are as follows, and their values should be as specified in Table 5, Table 6, and Table 7.

Table 5 – Generic Picture Essence Descriptor Values

Item Name.	Meaning	Source of derived data	Legal values
Frame Layout	Interlace or progressive layout	SMPTE ST 2019-1 Table 4, column: Source scan type	FULL_FRAME (0) for progressive SEPARATE_FIELDS (1) for interlaced
Stored Width	Horizontal Size of stored picture	SMPTE ST 2019-1 Table 4, column: Samples per line	1920, 1440, 1280 or 960
Sampled Width	Sampled width supplied to codec	same	same
Display Width	Displayed Width placed in Production Aperture	same	same
Stored Height	Vertical Field Size of stored picture	SMPTE ST 2019-1 Table 4, column: Active lines	1080 for 1080p 540 for 1080i 720 for 720p
Sampled Height	Sampled height supplied to codec	same	same
Display Height	Displayed Height placed in Production Aperture	same	same
Aspect Ratio	Specifies the horizontal to vertical aspect ratio of the whole image as it is to be presented	Constant	{16,9} by default; other values are possible
Video Line Map	First active line in each field	SMPTE ST 2019-1 Table 4, column: Active lines	{42,0} for 1080p {21,584} for 1080i {26,0} for 720p
Image Alignment Offset	Byte Boundary alignment required for Low Level Essence Storage	Constant	8192

Table 6 – CDCI Picture Essence Descriptor Values

Item Name.	Meaning	Source of derived data	Legal values
Component Depth	Number of active bits per sample	SMPTE ST 2019-1 Table 4, column: Sample bit depth	8 or 10
Horizontal Subsampling	The horizontal subsampling factor of the color difference samples relative to the luma samples in the Stored Rectangle	SMPTE ST 2019-1 Table 4, column: Channel Sub-sampling	1 for 4:4:4 2 for 4:2:2

Table 7 – RGBA Picture Essence Descriptor Values

Item Name.	Meaning	Source of derived data	Legal values
PixelLayout	Pixel quantization and order as a data structure	Constant	as defined in SMPTE ST 377-1 Annex G , for example { 'F', 2, 'B', 10, 'G', 10, 'R', 10,,0,0,0,0,0,0,0,0,0}

All other items use the default value as specified in SMPTE ST 377-1.

10 Application Issues

10.1 Alignment

As noted in SMPTE ST 377-1, Section 5.4.1, "it may be desirable to align certain KLV elements to specific byte boundaries. This can be achieved with the insertion of KLV Fill items to ensure the desired items are aligned."

For VC-3, MXF encoders should place the first byte of each VC-3 Coding Unit at a multiple of 8192 bytes into the file by insertion of KLV fill items in accordance with SMPTE ST 377-1, Section 5.4, as shown in Figure 6 of SMPTE ST 377-1.

Note: Such alignment can enable optimal MXF decoder operation

This alignment should be signaled by placing the value 8192 in the Image Alignment Offset property of the Picture Essence Descriptor, as shown above. For Frame Wrapping, the alignment should be achieved by inserting an initial KLV Fill before the first Frame-Wrapped GC Content Package, and ending each Frame-Wrapped GC Content Package with a KLV Fill. For Clip-Wrapping, only an initial KLV Fill is required, since all VC-3 Coding Units are a multiple of 8192 bytes in length. To avoid any requirement to insert unneeded KLV Fill items throughout the file, the mapping of VC-3 need not use KAG in the partition pack.

10.2 Index Tables

The VC-3 compressed data stream has a constant frame size and is an intra-frame codec. Therefore, each frame is a CBE element as defined in SMPTE ST 377-1. Wherever possible, it is recommend to create an index table with a "Constant Edit Unit Size" as per SMPTE ST 377-1, Section 11.1.9.

Annex A Bibliography (Informative)

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 298:2009) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 298-2009). Documents with the same root number (e.g. 298) and publication year (e.g. 2009) are functionally identical.

SMPTE ST 298:2009, Universal Labels for Unique Identification of Digital Data

SMPTE ST 336M:2007, Data Coding Protocol Using Key-Length-Value

SMPTE RP 224, SMPTE Labels Register

SMPTE EG 41:2004, Television — Material Exchange Format (MXF) — Engineering Guideline

Revision Notes

1. Corrected values for Byte 15 in Table 1, and in Section 6.1.2 (changed 05h to 0Ch and 06h to 0Dh).

2. Updated references in Section 3 (Normative References), Annex A (Bibliography), and throughout the text.

3. Updated Table 4 to include 5 new CIDs (1244, 1256, 1258, 1259, 1260). Updated Section 9 to include RGBA essence type. Split Table 5 into 3 new tables. Other small edits and template update for 2013.