SMPTE STANDARD

VC-6 Video Compression — Mapping VC-6 into the MXF Generic Container

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Foreword

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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

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

SMPTE ST 2117-1 (VC-6) is a versatile intra-frame compression scheme. This document maps the VC-6 bitstream into the MXF Generic Container. The use of this mapping to synchronize with other components such as audio and video is outside the scope of this document.

The MXF Generic Container is a streamable Essence Container that can be placed on any suitable transport and stored. SMPTE ST 379-2 defines the MXF Constrained Generic Container.

Other MXF mapping documents such as SMPTE ST 382 define how audio can be mapped and synchronized with the video stream in the MXF Generic Container.

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 Standard specifies the MXF mapping of SMPTE ST 2117-1 into the MXF Generic Container or MXF Constrained Generic Container.

2 Normative References

The following 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 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 377-1:2019, *Material Exchange Format (MXF) — File Format Specification*. https://doi.org/10.5594/smpte.st377-1.2019

SMPTE ST 379-2:2010, *Television — Material Exchange Format (MXF) — MXF Constrained Generic Container*. https://doi.org/10.5594/smpte.st379-2.2010

SMPTE ST 2117-1:2023, *VC-6 Multiplanar Picture Format — Part 1. Elementary Bitstream*. https://doi.org/10.5594/smpte.st2117-1.2023

3 Terms and Definitions

For the purposes of this document, the terms and definitions given in SMPTE ST 377-1 and SMPTE ST 379-2 apply.

4 MXF File Structure and Mapping

4.1 General

SMPTE ST 2117-10 MXF files specified by this document shall comply with SMPTE ST 377-1 and shall have one of the two structures illustrated in Figure 1 and Figure 2 respectively.

Key for Figure 1 and Figure 2
HPP: Header Partition Pack BPP: Body Partition Pack FPP: Footer Partition Pack RIP: Random Index Pack

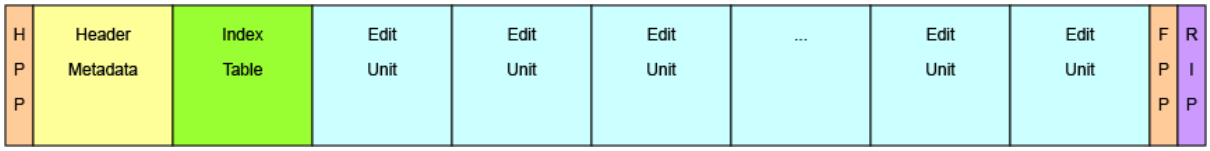

Figure 1 — Single Essence Location Style

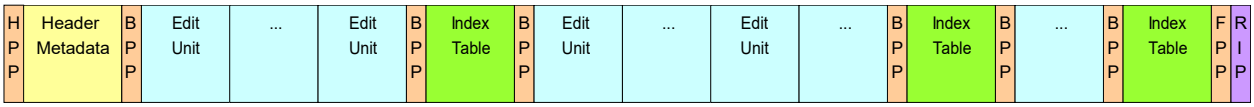

Figure 2 — Multiple Essence Location Style

4.2 Single Essence Location Style

As shown in Figure 1, this style comprises a Header Partition, a Footer Partition, and a Random Index Pack.

The Index Table is placed prior to the Essence Container.

Characteristics of this style include:

- It is easy to handle due to a simple structure.
- It is easy to edit during file transfer.
- It is easy to select an extract, or a “Partial file.”

The following Index Layout Properties shall be set according to SMPTE ST 377-1.

- Index Table Segment::Single Index Location TRUE (Single Location)
- Index Table Segment::Single Location TRUE (Single Location)
- Index Table Segment::Forward Index Direction TRUE (Forward)
- Preface:: is RIP present TRUE

4.3 Multiple Essence Location Style

As shown in Figure 2, this style comprises a Header Partition, segmented Body Partition(s), a Footer Partition, and a Random Index Pack. Each Body Partition carrying VC-6 data shall be followed by one Index Table Segment that carries the Index Entries for the Edit Units of that Body Partition.

Characteristics of this style include:

- One Index Table Segment for each Body Partition period on the sender side.
- It is easy to perform the function “Play while receiving file” on the receiver side.
- It is easy to select an extract, or a “Partial file.”

The following Index Layout Properties shall be set according to SMPTE ST 377-1.

- Index Table Segment::Single Index Location FALSE (Distributed Location)
- Index Table Segment::Single Essence Location FALSE (Distributed Location)
- Index Table Segment::Forward Index Direction FALSE (Backward)
- Preface:: is RIP present TRUE
- Essence Container Data:: Following Index Table TRUE (A Complete Index Table follows all Essence)

5 Mapping VC-6 Bitstream into the MXF Generic Container

VC-6 streams shall be mapped using the MXF Generic Container using frame wrapping as defined in SMPTE ST 379-2.

Figure 3 shows the SMPTE ST 2117-10 picture element. The bitstream for each frame shall comply with SMPTE ST 2117-1.

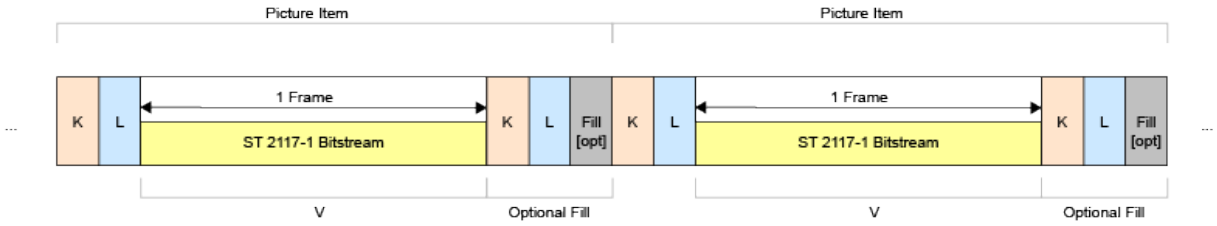

Figure 3 — Mapping of ST 2117-10 Picture Item Element

6 Key Length Value Encoding

6.1 SMPTE ST 2117-10 Picture Element Key

Table 1 defines the Picture Element Key.

Table 1 — Picture Element Keys

Symbol	Kind	Item UL
FrameWrappedVC6PictureElement	LEAF	urn:smpte:ul:060e2b34.01020101.0d010301.157f1f7f

NOTE The table shows the Item UL in the SMPTE Metadata registers where the value 7f in bytes 14 and 16 are placeholders for the Essence element count and Essence element number of the Element within the Picture Item as defined in SMPTE ST 379-2.

FrameWrappedVC6PictureElement key bytes 1-13 are defined in SMPTE ST 379-2.

FrameWrappedVC6PictureElement key bytes 14 and 16 shall be set to 1 in this version of the standard.

6.2 SMPTE ST 2117-10 Picture Element Length (informative)

The length field of the KLV coded Element complies with SMPTE ST 379-2.

6.3 SMPTE ST 2117-10 Picture Element Value (informative)

Each Picture Element value complies with the bitstream specification for a single image compliant with SMPTE ST 2117-1.

7 MXF Labels

7.1 Essence Container Label

The Essence Container Label is carried in the Essence Containers Properties of the Partition Packs, Preface Set and File Descriptor as defined in SMPTE ST 377-1.

The values of the Essence Container Label for VC-6 bitstreams in MXF shall be one of the values in Table 2.

Table 2 — Essence Container Label Values for VC-6

Symbol	Kind	Item UL
MXFGCVC6BitstreamContainerLabels	NODE	urn:smpte:ul:060e2b34.0401010d.0d010301.02240000
MXFGCVC6FrameWrappedGenericBitstream	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.02240100
MXFGCVC6FrameWrappedProgressivePictures	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.02240200
MXFGCVC6FrameWrappedInterlacedPictures	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.02240300

The VC6FrameWrappedGenericbitstream shall only be used in cases where neither VC6FrameWrappedProgressivePictures nor VC6FrameWrappedInterlacedPictures describe the Pictures that are VC-6 encoded.

7.2 Picture Essence Coding Label

Labels intended for use as values for the Picture Essence Coding item of the Generic Picture Essence Descriptor, specified in SMPTE ST 377-1, are given in Table 3.

Table 3 — Picture Essence Coding Label Values for VC-6

Symbol	Kind	Item UL
VC6BitstreamCoding	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01470000
VC6UnrestrictedBitstream	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01470100

NOTE The Picture Essence Coding item of the Generic Picture Essence Descriptor is intended to allow a decoder to fast-fail when processing the MXF file.

8 VC6SubDescriptor

A VC6SubDescriptor should be present for VC-6 content in MXF, even if all the optional properties are omitted. The VC6SubDescriptor is strongly referenced from a CDCI Descriptor or RGBA Descriptor and has the properties shown in Table 4, Table 5, Table 6 and Table 7.

Table 4 — VC6SubDescriptor ULs

Symbol	Register.Kind	Item UL
VC6Parameters	Elements.NODE	urn:smpte:ul:060e2b34.0101010e.0401060d.00000000
VC6SubDescriptor	Groups.LEAF	urn:smpte:ul:060e2b34.027f0101.0d010101.01018104
VC6GCUpsamplersBatch	Elements.LEAF	urn:smpte:ul:060e2b34.0101010e.0401060d.01000000
VC6ShortcutBitvectorBatch	Elements.LEAF	urn:smpte:ul:060e2b34.0101010e.0401060d.02000000
VC6Lossless	Elements.LEAF	urn:smpte:ul:060e2b34.0101010e.0401060d.03000000
VC6CBR	Elements.LEAF	urn:smpte:ul:060e2b34.0101010e.0401060d.04000000
VC6Bitrate	Elements.LEAF	urn:smpte:ul:060e2b34.0101010e.0401060d.05000000
VC6CompressedFrameMax	Elements.LEAF	urn:smpte:ul:060e2b34.0101010e.0401060d.06000000
VC6CompressedFrameAvg	Elements.LEAF	urn:smpte:ul:060e2b34.0101010e.0401060d.07000000
VC6MaxNoOfEchelons	Elements.LEAF	urn:smpte:ul:060e2b34.0101010e.0401060d.08000000
VC6EchelonsArray	Elements.LEAF	urn:smpte:ul:060e2b34.0101010e.0401060d.09000000

NOTE 1 VC6SubDescriptor is a child of SubDescriptor as specified in SMPTE ST 377-1:2019, Annex B.3, and includes properties of the parent.

Table 5 — Elements in the VC6SubDescriptor Set

Symbol	type	Len	Req?	Meaning
VC6SubDescriptor	Set UL	16	Req	VC-6 Sub-Descriptor
Length	BER Length	4	Req	Set Length
VC6GCUpsamplersBatch	UInt8Array	8 + 16n	Opt	Unordered Batch of UInt8 Upsampler Indices used in the Generic Container
VC6ShortcutBitvectorBatch	UInt16Array	8 + 16n	Opt	Unordered Batch of unique UInt16 ShortcutBitvector values used in the Generic Container
VC6Lossless	UInt8	1	Opt	Non-zero if the encoder created a lossless bitstream
VC6CBR	UInt8	1	Opt	Non-zero if the encoder intended a constant bitrate stream
VC6Bitrate	UInt64	8	Opt	Target CBR bitrate or Maximum VBR bitrate in bits per second
VC6CompressedFrameMax	UInt64	8	Opt	Maximum Size in bits of a Compressed Frame in the Generic Container
VC6CompressedFrameAvg	UInt64	8	Opt	Average Size in bits of a Compressed Frame in the Generic Container
VC6MaxNoOfEchelons	UInt8	1	Opt	Maximum Number of Echelons in any Frame in the Generic Container
VC6EchelonsArray	VC6EchelonPropertiesStrongReferenceArray	8 + 16n	Opt	An ordered set (lowest to highest resolution) of Strong references to VC6EchelonProperties sets

A zero value of VC6CBR shall indicate that VC6Bitrate represents the target CBR bitrate. A non-zero value shall indicate that VC6Bitrate represents the maximum bitrate value in bits per second for one frame period.

NOTE 2 VC6ShortcutVectorsBatch contains only unique values. In theory, there are 65536 different permutations of ShortcutVector. In practice only a few are actually created by an encoder. This property can be used by a decoder to help determine the resources required for decoding the generic container.

Table 6 — `VC6EchelonProperties` ULs

Symbol	Register.Kind	Item UL
`VC6EchelonProperties`	Groups.LEAF	urn:smpte:ul:060e2b34.027f0101.0d010101.01018105
`VC6EchelonIndex`	Elements.LEAF	urn:smpte:ul:060e2b34.0101010e.0401060d.0a000000
`VC6SampledHeight`	Elements.LEAF	urn:smpte:ul:060e2b34.0101010e.0401060d.0b000000
`VC6SampledWidth`	Elements.LEAF	urn:smpte:ul:060e2b34.0101010e.0401060d.0c000000

NOTE 3 `VC6EchelonProperties` is a child of `InterchangeObject` as specified in SMPTE ST 377-1 and includes properties of the parent.

Table 7 — Elements in the `VC6EchelonProperties` Set

Symbol	type	Len	Req?	Meaning
`VC6EchelonProperties`	Set UL	16	Req	Properties that describe an Echelon in a VC-6 bitstream
`Length`	BER Length	4	Req	Set Length
`VC6EchelonIndex`	UInt32	4	Req	Signed Index of this Echelon as identified in ST 2117-1:2023 §4.8.9
`VC6SampledHeight`	UInt32	4	Req	Sampled Height of the reconstructed pixel grid for the echelon
`VC6SampledWidth`	UInt32	4	Req	Sampled Width of the reconstructed pixel grid for the echelon

9 Application Issues

9.1 Application of the KAG (informative)

MXF encoders and decoders comply with the KAG rules defined in SMPTE ST 377-1. The default value of the KAG is 1. Other KAG values might be used within the range defined by SMPTE ST 377-1.

9.2 Index Tables and the Fill Item

VC-6 coding is frame-based and the KLV fill item can be used to maintain a constant edit unit size for all frames.

Where the application defines a constant edit unit size, an index table shall be used. This includes the cases where the VC-6 Essence element is the sole Essence component and where it is interleaved with other Essence components.

For applications employing a variable edit unit size, an index table should be used. SMPTE EG 377-3 illustrates the use of index tables for both mono and multi-Essence mappings and for both constant and variable length edit unit sizes.

9.3 Operational Pattern Usage

The ST 2117-10 Essence mapping may be used with any generalized operation pattern or specialized operational patterns that do not otherwise conflict with the use of this mapping.

NOTE This does not preclude the use of specialized operational patterns.

9.4 Mapping Track Numbers to Generic Container Elements

Each track number value for an Essence element defined in this standard shall be derived as described in the MXF Constrained Generic Container specification (SMPTE ST 379-2).

9.5 Essence Container Partitions

Frame wrapping maintains each content package of the generic container as a separate editable unit with the contents of the system, picture, sound and data items in synchronism. If a frame-wrapped Essence container is partitioned, then individual content packages should not be fragmented by the partitioning process.

NOTE SMPTE ST 377-1:2019, Clause 6.2.2 (Partition Rules Summary) summarizes the use of partitions in MXF files.

9.6 MXF Header Metadata Property Values

The following restrictions in Table 8 below apply to a Picture Stream wrapped with this standard.

Table 8 — MXF Header Metadata Property Restrictions

Property	Progressive Pictures	Interlaced Pictures
Bitstreams per KLV Element	1	2
Frame Layout (ST 377-1:2019 §G.2.1)	0 (full_frame)	1 (separate_fields) or 4 (segmented_frame)
Sample Rate (ST 377-1:2019 §G.2.2)	Frame	Frame
Edit Rate (ST 377-1:2019 §B.12)	Frame	Frame
Index Edit Rate (ST 377-1:2019 §11.2.3)	Frame	Frame
Aspect Ratio (ST 377-1:2019 §G.2.4)	Frame	Frame

Bibliography (informative)

SMPTE EG 377-3, *Material Exchange Format (MXF) — Engineering Guideline (Informative)*. https://doi.org/10.5594/SMPTE.EG377-3.2013

SMPTE ST 382, *Material Exchange Format — Mapping AES3 and Broadcast Wave Audio into the MXF Generic Container*. https://doi.org/10.5594/SMPTE.ST382.2023