SMPTE STANDARD

Low Latency Streaming MXF OP 1a

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Approved
April 24, 2012

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 Part XIII of its Operations Manual.

SMPTE ST 2049 was prepared by Technology Committee 31FS.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this standard. 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.

Introduction

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

This standard defines a proper subset of MXF using Op1a for an application where a camera or an audio/video signal source is converted to an MXF file, transported on a data network and converted back an audio/video signal in the shortest practical time; i.e. with the lowest latency. The standard does not prohibit the sending or receiving device from storing the MXF file so a broader range of applications can be addressed. It also includes design features that allow a receiver to "join" the MXF stream in progress and start playout in a limited number of frame times. The exact number of frame times depends on the architecture of the sender the MXF receiver as well as the underlying MXF stream or file format.

This standard's design goals were established for low latency applications like camera to IP network to playout for live events or audio/video stream transfers.

Sample use cases that could use this standard include the streaming of an existing MXF file over a network and the recording this stream as an MXF file at the receiver. Other use cases include systems that convert live signals into a MXF on-the-fly, streaming the file over a network and playing-back as real-time signals or recording as MXF files at the receiver.

1 Scope

This standard defines a sub-set of the Material Exchange Format (MXF) for low latency streaming applications that use Operating Pattern 1A. Latency is defined as the delay time between image/sound acquisition and the image/sound display. The design is intended to support both CBR and VBR essence types.

In this document, the terms “MXF file” and “MXF stream” are used in an interchangeable manner. For easier reading only the term “MXF file” is being used exclusively throughout the following sections.

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.

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; followed by formal languages; then figures; and then any other language forms.

3 Normative References

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 378:2004) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 378M-2004). Documents with the same root number (e.g. 378) and publication year (e.g. 2004) are functionally identical.

The following standards contain provisions which, through reference in this text, constitute provisions of this recommended practice. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this recommended practice 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

SMPTE ST 378:2004, Material Exchange Format (MXF) – Operational Pattern 1A (Single Item, Single Package)

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

4 Definition of Acronyms, Terms and Data Types

4.1
Latency
time difference between the image/sound capture at an MXF sender and the MXF receiver's image/sound display; this includes codec, network and other latencies of the system.

4.2
Partition Duration
the duration of Essence in one partition.

5 Partition Multiplex

The following constraints are defined regarding the partition multiplex of the MXF file:

- The MXF file shall not contain a Run-In.
- The MXF file shall contain one Header Partition and this Header Partition shall not contain any Essence and shall not contain any Index Table segments.
- The MXF file shall contain zero or more Body Partitions. All Body Partitions shall contain either Header Metadata or Essence Container data or one Index Table segment. If a Body Partition contains Essence Container data, the duration of this Partition shall follow the definitions given in Section 5.1.
- If the Body Partition contains an Index Table segment, this Index Table segment shall index the Essence Container data of the previous Partition containing essence.
- The order of Body Partitions shall be as follows:
    1. The 1st Body Partition shall contain Essence Container data only.

       Note: If the Essence Container duration exceeds the maximum duration of essence of one partition, more Body Partitions are needed. In this case the total count of Body Partitions is at least 4.

    2. The 2nd Body Partition shall contain one Index Table segment only.
    3. The 3rd Body Partition shall contain Header Metadata only.
    4. All following Body Partitions shall follow the pattern of numbers 1,2 and 3. This order shall not change.
- The last Body Partition shall only contain one Index Table segment.

- The MXF file shall contain one Footer Partition. The Footer Partition shall contain Header Metadata and may contain one or more Index Table Segments. This Index Table segment shall index the complete Essence Container.

- The MXF file may contain a Random Index Pack.

5.1 Partition Duration

If a Body Partition contains Essence Container data, the duration of this Partition shall be one of the values defined in Table 1. Essence containers may be field-wrapped or frame-wrapped (see Section 8).For field-wrapped essence, all body partitions with essence shall contain an even number of content packages, including the last body partition with essence.

Compliance with the partition duration values in Table 1 shall consider the product of the edit rate and partition duration. This product yields the number of content packages per partition. The number of content packages shall be calculated as follows:

Content packages per partition: Ceiling (EditRate) * Partition Duration

Where Ceiling(x) shall be defined as follows:

For field-wrapped essence: The smallest integer not less than x, which gives an integer number of frames.

For frame-wrapped essence: The smallest integer not less than x.

All Body Partitions which contain essence, except the last one, shall contain the calculated number of content packages. The last partition may contain fewer content packages, but shall not contain more.

Table 1 – Operating points of Partition durations

Operating Point ID	Partition Duration
1	1 second
10	10 seconds
20	20 seconds
30	30 seconds
60	60 seconds

Notes (Informative):

- The provisions for partition duration and the exact number of Content Packages (CPs) described above are intended to simplify the receiver's design and avoid problems with an odd number of field-wrapped CPs.

- Provisions in SMPTE ST 379-2 and SMPTE ST 377-1:2011 constrain the duration of each CP. Specifically, SMPTE ST 379-2, Section 8.4.1, *Frame Wrapping*, states that the duration of every CP is constant and matches the Edit Unit duration in the related File Package tracks. Since this standard allows only field-wrapping or frame-wrapping, the terms *Content Package* and *Edit Unit* are equivalent.

- If interlaced material is frame-wrapped, then every CP will contain two fields, because the duration of every CP is constant.

Using long GOP compression systems with this standard is allowed, but it is not encouraged. If long GOP compression is used with this standard, the body partitions will usually not start at the start of the GOP in the compressed video stream, hence, the I-frames fall where they may. Content Packages that are used for pre-charge or roll-out shall be counted to the sum of Contest Packages per Partition as any other Content Package.

6 Header Metadata

Each Body Partition which contains Header Metadata (see Section 5) and the Footer Partition shall include the same or an updated instance of the Header Metadata of the Header Partition and previous Body Partitions. The Header Partition and all Body Partitions shall be incomplete. The Footer Partition shall be closed and complete.

Note: The Header Partition and Body Partitions can be open or closed.

Note: When the duration of the stream is not known (e.g. in a Live use case) all values of Duration properties are to be set to -1. In cases where the duration of the stream is known (e.g. when a complete file will be streamed) the Duration properties are to be set to the correct value.

Descriptive Metadata may be present in Partitions that contain Header Metadata. In each Partition the maximum size of HeaderByteCount shall not exceed 64 kB.

7 Operational Pattern

The MXF file shall use Operational Pattern OP1a. At all occurrences the Operational Pattern Universal Label shall be set to the following rules:

Table 2 – Universal Label byte range for the Operational Pattern

Byte No.	Description	Value	Meaning
1-12	Defined in SMPTE ST 377-1	See SMPTE ST 377-1	
13	Operational Pattern: Item Complexity	See SMPTE ST 378	Item Complexity
14	Operational Pattern: Package Complexity	See SMPTE ST 378	Package Complexity
15	Operational Pattern Definition	See Table 3	Qualifier bits (see Table 3)
16	Operational Pattern Definition	See SMPTE ST 378	

Table 3 – Byte 15 values of the Operational Pattern UL

Bit number	Values and description
0	See SMPTE ST 377-1
1	Shall be set to 0 (internal Essence)
2	Shall be set to 0 (stream file)
3	See SMPTE ST 377-1
4-7	See SMPTE ST 377-1

Decoders shall ignore MXF files containing any other value of the Operational Pattern label.

8 Generic Container

The MXF file shall use internal essence only. The essence shall be frame-wrapped or field-wrapped defined by SMPTE ST 379-2. The KAG shall be 1.