

SMPTE STANDARD

Material Exchange Format (MXF) — Operational Pattern 2a (Play-List Items, Single Package)



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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 Part XIII of its Operations Manual.

SMPTE ST 392 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.

1 Scope

This standard defines operational pattern 2a for the exchange of an MXF file with a play-list of playable essence containers, each comprising either a single essence element or interleaved essence elements. It defines the operating restrictions, structural metadata objects and individual attributes that must be applied to the MXF file format specification to achieve interoperability when exchanging an MXF file as a list of continuously playable items of audio-visual material.

Operational pattern 2a is intended to meet the requirements of acquisition, storage and interchange applications that are satisfied by a play-list of individual items of content packaged in two or more essence containers each of the same type. Operational pattern 2a requires the use of body partitions for internal essence containers. Subdivision of each essence container by using body partitions is optional.

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 Reference

The following standard contains provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the edition indicated was 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 standard indicated below.

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

4 Glossary of Acronyms, Terms and Data Types

The full glossary of acronyms, terms and data types is given in the MXF file format specification, SMPTE ST 377-1. It is not repeated here to avoid any divergence of meaning.

5 Introduction

This standard defines MXF operational pattern 2a. In SMPTE ST 377-1, the properties of all generalized operational patterns are defined. In the MXF engineering guideline, SMPTE EG 377-3, the concepts of operational patterns and the general conditions for audio-visual material interchange and interoperability are described in outline form. The introductory sections of these documents are not repeated here.

5.1 Operational Pattern 2a Definition

Generalized MXF operational patterns are defined as a combination of the two dimensions as defined in SMPTE 377-1. This operational pattern shall be defined as follows:

5.1.1 Item complexity

- Play-list items: The file contains two or more concatenated items. Each item shall be defined by a top-level file package. There shall be one material package having SourceClips each of which has a duration that is equal to the corresponding top-level file package.

5.1.2 Package complexity

- Single package: The material package can only access a single top-level file package at a time.

The two dimensions of operational patterns are illustrated in informative Figure 1.

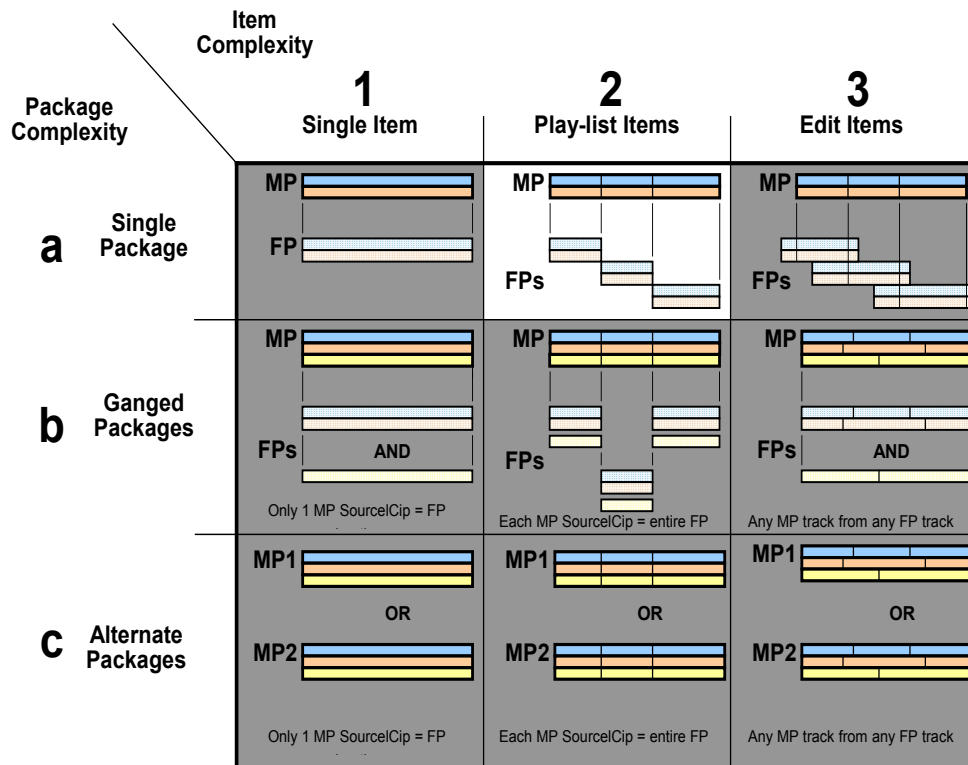


Figure 1 – Item and package complexity (Informative)

This operational pattern defines an MXF file as a single package of play-list items, as illustrated in the center-top box of Figure 1. All other standard operational patterns to the right or below this box are notionally a superset of the functionality of this operational pattern.

5.2 Material, File and Source Package Relationships

This operational pattern has multiple essence containers which shall be all of the same type, and may comprise either a single essence element or interleaved essence elements. The essence containers shall each comprise essence stream data that represents a continuous recording as illustrated in Figure 2.

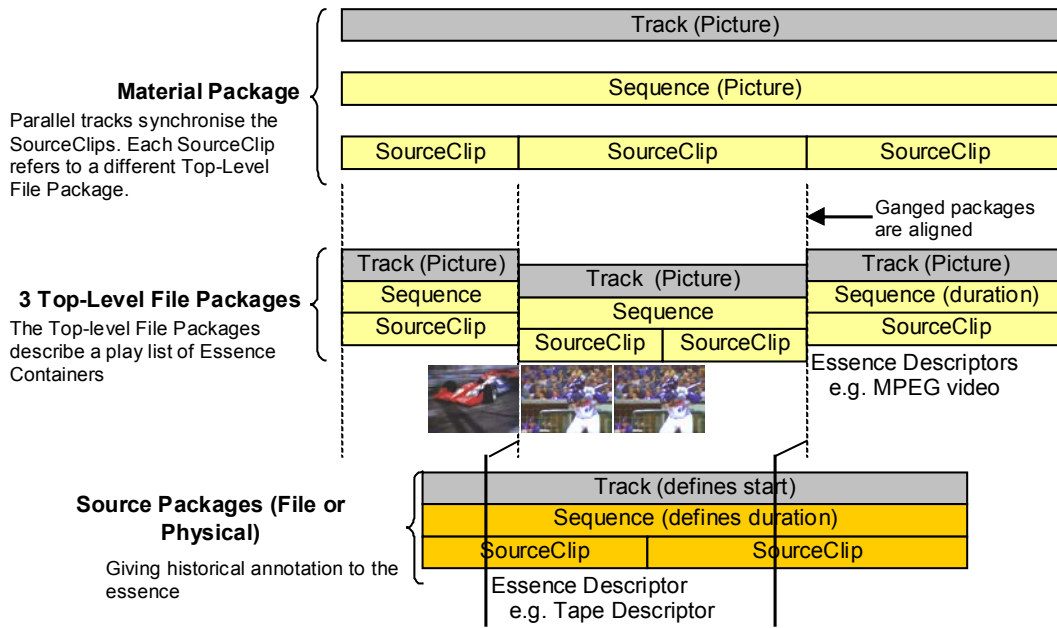


Figure 2 – Outline of operational pattern 2a (Informative)

6 Application

Operational pattern 2a represents a play-list of items as a contiguous sequence of playable essence containers. Each essence container may, for example, contain a single clip or a single item of program material. Each essence container shall be of the same type. The sequence of essence containers shall provide for the continuous decoding of contiguous essence elements.

Operational pattern 2a is intended to satisfy the requirements of simple cuts-only editing and finished program interchange applications.

The minimum implementation of operational pattern 2a will satisfy the requirement for a concatenation of multiple clips as a program, with metadata support for each clip as well as metadata support for the program as a whole.

6.1 Constraints

A list of general constraints for this operational pattern is given in Table 1.

Table 1 – General constraints for operational pattern 2a

File Kind	MXF
“Operational Pattern”	2a: (Play-list items, single package)
Role	Interchange of programs with simple edits.
Essence	Multiple essence containers of the same type. Operational pattern qualifiers apply (see MXF file format specification, SMPTE ST 377-1)
Material Packages	1
Number of Material Package SourceClips for each Essence Track	>1
Top-Level File Packages	Number of material package SourceClips per track
Number of Essence Container Types	1
Lower-Level Source Packages	0 or more
Partition limits	None
Body Partitions	Required. If there are N internal essence containers, a file shall have at least N-1 body partitions.
Index Tables	Optional, but recommended
Editing Support	Simple play-list output
Streaming Support	According to operational pattern qualifiers (see Section 6.4)

Notes:

1. The “number of material package SourceClips” in Table 1 refers only to essence tracks. Operational patterns are intended to constrain the essence handling of an MXF application. So in the case where the essence is continuous and only the metadata in a file has multiple SourceClips, it is likely that the file is an operational pattern lower than 2a.
2. The “1” essence container type is also subject to the continuity of essence condition in Section 8.3. When using the MXF generic container, it is possible that there will be several different essence container labels being signaled in a file (e.g., one for the audio; another for the video). Each and every track is subject to the continuity conditions in Section 8.3.

7 Header Metadata Specification

7.1 General

The structural metadata sets and the normative universal label used to identify this operational pattern are defined in the MXF file format specification document with specific constraints and additions detailed below.

7.2 Constraints on the MXF Packages

- The material package shall have more than one SourceClip per essence track.
- The material package SourceClips shall start and end synchronously for each and every material package essence track.
- The material package may define a different start time-code value to the first top-level file package to allow a change to the initial time-code on layout.
- Each top-level file package shall have one track for each utilized essence element in the associated essence container.
- Lower-level source packages, where present, shall be used to define the historical context of editing.

7.3 Universal Label for Operational Pattern 2a

The universal label value to define this operational pattern shall be as defined in Table 2.

Table 2 – Value of the MXF operational pattern identification Universal label

Byte No.	Description	Value (hex)
1-12	Defined in the MXF File Format Specification Operational Patterns Section	See SMPTE ST 377-1
13	Operational Pattern: Item Complexity	02h
14	Operational Pattern: Package Complexity	01h
15	Operational Pattern: Qualifiers (application dependent)	See SMPTE ST 377-1
16	Operational Pattern: OP2a qualifiers	See Table 3

The meanings of the bytes in this label are specified in the operational pattern section of the MXF file format specification (SMPTE ST 377-1). Bytes 13 and 14 uniquely identify this operational pattern specification and byte 15 contains generic qualifiers that are defined in the MXF file format specification.

7.4 Operational Pattern Qualifiers

This operational pattern shall support the qualifiers as specified in byte 15 of the operational pattern universal label. Each bit of byte 15 shall be correctly set, as defined by SMPTE ST 377-1, to reflect the status of the essence container.

7.4.1 Essence container location

The essence containers should be embedded in the file body for interchange applications.

The essence containers may be externally referenced for certain specialized applications. Example applications include shared-storage networks, archives and other applications where the access to an essence container is localized and the locator value (defined by a locator set in SMPTE ST 377-1) is persistent.

If all the essence containers are internal to the file, then bit 1 shall be set to zero. Guidance on using external essence is given in SMPTE EG 377-3.

7.4.2 Interleaving of multiple essence tracks

All essence containers used in this operational pattern should be streamable.

If all the essence containers are streamable, and have been multiplexed in a way that makes the overall file streamable, then bit 2 shall be set to zero. If the primary package references any external essence, then the file shall not be indicated as streamable. Guidance on streamability is given in SMPTE EG 377-3.

7.4.3 Number of essence tracks

This operational pattern supports multiple essence containers, each with one or more essence tracks. If all essence containers have a single essence track, then bit 3 shall be set to zero.

7.5 Qualifiers Specific to this Operational Pattern

Each bit of byte 16 shall be correctly set, as defined in Table 3 and in the subsections that follow.

Table 3 – Byte 16 of the operational pattern label

Bit number	Values and Descriptions
0-3	Reserved for future use, encoders should set to zero
4	<p>=0 no inter-SourceClip processing needed</p> <p>At the join of 2 Material Package SourceClips, No special processing is required. An essence decoder will be able to decode the stream which results from the data from the first SourceClip butted onto the second SourceClip.</p> <p>=1 no knowledge of the inter-SourceClip processing is available</p> <p>No assumptions can be made about the processing required to butt edit the essence streams. For example, a long GoP MPEG stream could require extra frames to pre-charge the decoder. Other essence types could require other processing.</p>
5-7	Reserved for future use, encoder should set to zero

Note: MPEG is used generically several times in this standard as an example of an inter-frame compression codec.

7.6 Minimum Implementation Recommendation

All constraints given in the MXF file format specification shall apply unless specifically overridden or extended in this standard. The minimum implementation of operational pattern 2a should have the following limits in reference to the MXF file format specification.

1 preface set, 1 or more identification sets, 1 content storage set and 2 or more essence container data sets.

One material package including:

1. the sets for the time code track;
2. the sets for each picture track as required by the essence container;
3. the sets for each sound track as required by the essence container;
4. the sets for each data track as required by the essence container.

Two or more top-level file packages each including:

1. the sets for each picture track as required by the essence container;
2. the sets for each sound track as required by the essence container;
3. the sets for each data track as required by the essence container.

The annexes of the MXF format specification give the properties of the sets which should be implemented. All required set properties should be supported by MXF encoders that comply with this operational pattern.

Notes:

1. This section is a recommendation because the exact structure of the sets depends on how many of the top-level file packages reference external data.
2. Support for descriptive metadata is optional but adding at least one scheme will help to get the best from an MXF file.

8 Essence Container Requirements in Operational Pattern 2a

8.1 Number of Essence Elements

There are no constraints on the number of essence elements in an individual essence container. It is possible that an operational pattern 2a file may contain descriptive metadata and no essence container. Although not encouraged, it is permitted.

8.2 Interleaving of Essence Elements

For operational pattern 2a, when supporting streaming capability for essence containers containing more than one essence element, the essence elements should be interleaved over a limited duration (typically 1 frame). Each essence element is encoded using KLV coding according to the rules in the essence container specification.

8.3 Continuity of Essence Elements

As stated in Section 6, each essence container shall provide for the continuous decoding of contiguous essence elements. The essence container or essence element specifications may add extra restrictions to this condition.

For each material package track, the boundary between essence containers shall provide for the continuous decoding of contiguous essence elements.

In the case of compression algorithms involving temporal prediction (for example, long GoP MPEG), it is likely that context information is needed at the start and end points of each SourceClip in order to pre-charge the essence decoder. Including this context information in an operational pattern 2a file is permitted. The number of extra frames included should be the minimum number required to represent the context information without breaking any of the normative requirements of the underlying essence type.

An important phrase in this specification is “continuous decoding of contiguous essence containers”. When this condition is not met at the junction of two material package SourceClips, bit 4 of byte 16 shall be set according to Table 3. An obvious example is when context information is required as described in the paragraph above. A more subtle example would be the case of butting together two closed GoP MPEG sequences. In principle, there is no context information required between the butting points, but unless the buffer conditions in each clip are matched, then processing will be required for continuous decoding of contiguous essence containers and so bit 4 of byte 16 in Table 3 shall be set to 1.

The audio tracks at essence container boundaries may be processed on the output decoder to prevent clicks and to reduce listener fatigue. The essence container or essence element specifications may add further restrictions.

The essence container specification contains essence descriptor sets which define the source coding and any compression coding. Each essence descriptor property value which could otherwise prevent continuous decoding shall be constant for the duration of the material package track.

Note: Examples of compression coding parameters which must remain continuous include any compression coding format parameters (i.e. no switching of the compression type in mid-stream) and picture sampling parameters.

8.4 Number of Essence Tracks

The number of picture, sound and data essence tracks shall be defined by the number of picture, sound and data essence elements in the essence container.

8.5 Use of Body Partitions

This operation pattern requires the use of at least one partition for each internal essence container. If there are N internal essence containers, there will be at least N-1 body partitions within this file.

Annex A MPEG Example of an Operational Pattern 2a File (Informative)

Figure A.1 shows a simple OP2a file with two SourceClips in the material package. Each of these SourceClips references a different top-level file package, which in turn describes some stored long GoP MPEG content. As described in Section 8.2.3, there can be some context information stored to allow correct switching between the stored essence containers.

As can be seen in Figure A.1, the stored content extends beyond the start and end points described by the metadata. The first clip is an entire 15 frame GoP (including a sequence header with picture dimension information). The second clip consists of two 15 frame GoPs.

Inspecting the diagram, it is obvious that the condition “continuous decoding of contiguous essence containers” is not met due to the extra “B” frame at the end of the first SourceClip and the extra “IBBPB” at the start of the second SourceClip. Bit 4 of byte 16 in Table 3 is set to 1 in this case.

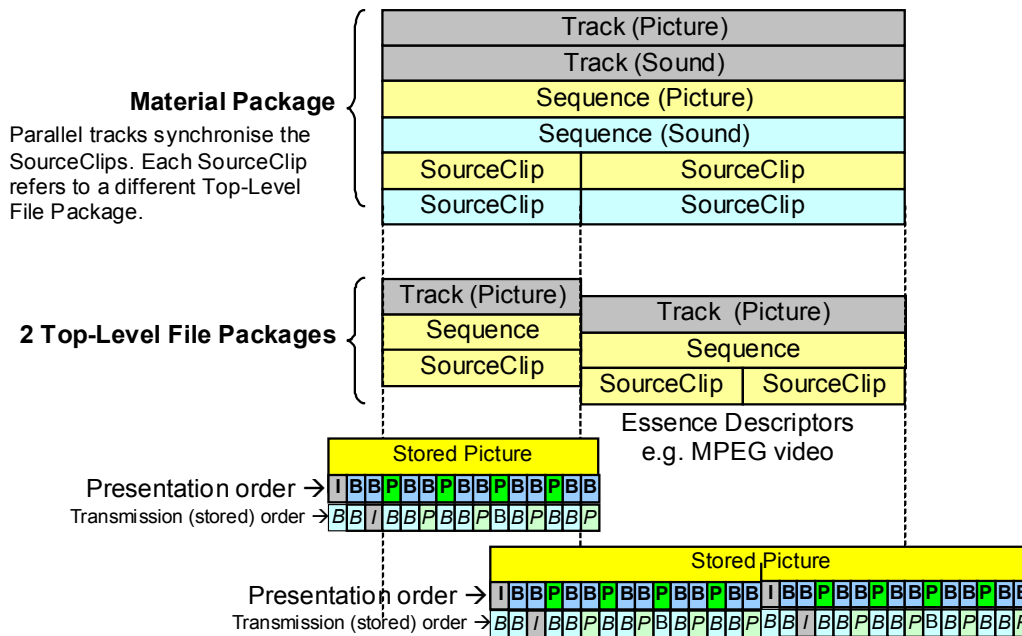


Figure A.1 – Operational pattern 2a file with 2 MPEG essence containers

Figure A.2 shows a processed version of the file in Figure A.1. The extra frames have been removed and the appropriate GoP and sequence headers replaced in the stored MPEG content so that both essence containers are still valid MPEG files. Inspecting Figure A.2, it now seems possible that the condition “continuous decoding of contiguous essence containers” can be met. Bit 4 of byte 16 in Table 3 needs to be set to 0 for Figure A.2, **only** when all MPEG splice conditions are appropriate for continuous decoding across the junction. These conditions include buffer occupancy and sequence header parameter continuity. Tutorials on MPEG splicing give more coverage on this topic than is appropriate for this operational pattern document.

Annex B 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 336:2007, Data Encoding Protocol Using Key-Length-Value

SMPTE RP 224, SMPTE Labels Register

SMPTE EG 377-3:2013, Material Exchange Format (MXF) — Engineering Guideline

ISO/IEC 13818-2:200, Information Technology — Generic Coding of Moving Pictures and Associated Audio Information: Video