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SMPTE ST 390:2011
Revision of
SMPTE 390M-2004

SMPTE STANDARD

Material Exchange Format (MXF) — Specialized Operational Pattern "OP-Atom" (Simplified Representation of a Single Item)

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Approved
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Foreword

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SMPTE ST 390 was prepared by Technology Committee 31FS.

Intellectual Property

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Introduction

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

This standard defines MXF Operational Pattern "Atom". In the MXF file format specification (SMPTE ST 377-1), 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.

1 Scope

This standard defines the specialized Operational Pattern “OP-Atom” or OP-Atom for the storage and exchange of an MXF file with a tightly defined structure for a single item of essence described by a single Essence Track. It defines the operating restrictions, Structural Metadata objects and individual attributes applied to the MXF file format specification to achieve interoperability when exchanging a single item of audio-visual material.

Operational Pattern “OP-Atom” is intended to satisfy the demands of applications where there is a requirement for exchange of material and associated metadata together in a single file with an open and standardized format, yet also a demand for a simple, predictable, layout with minimum scope for variation. OP-Atom is specifically intended for applications where each Essence Track is held separately. Operational Pattern “OP-Atom” provides for a subset of MXF features.

The provisions of OP-Atom make it unsuitable for certain applications, in these cases a generalized Operational Pattern or a different specialized Operational Pattern is used. In all cases, the suitability of this pattern needs to be judged on a per-application basis. Some specific areas to consider are:

- OP-Atom is optimized for applications where the record (file creation) process is completed before a playout (file read) process is started. Therefore, it is unsuitable in applications where the record/playout (file creation/file reading) processes occur concurrently.

- This Operational Pattern places a full Index Table in the Footer Partition which, with VBR essence, makes it impossible to use as a streaming format where stream delivery requires advanced knowledge of frame boundaries. With VBR essence, it also requires the (possibly very large) Index Table to be stored separately until the file recording ends.

- Each OP-Atom file holds a single track of essence data therefore many applications will need an external mechanism to synchronize essence among multiple files. This standard does not define such a synchronization method; however, it does include an annex detailing a method of informatively recording synchronization among files created as a group.

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

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 377-1:2009) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 377-1-2009). Documents with the same root number (e.g. 377-1) and publication year (e.g. 2009) are functionally identical.

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 377-1:2009, Television — Material Exchange Format (MXF) — File Format Specification

4 Glossary of Acronyms, Terms and Data Types

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

5 Operational Pattern Overview

Specialized Operational Pattern “OP-Atom” adds the following constraints to the format defined in the MXF file format specification:

- There shall be one Top-Level File Package (which references the essence in the single Essence Container). There is no restriction on the number of Lower-Level Source Packages.
- There shall be only one Essence Track in the Top-Level File Package.
- There shall be exactly one Essence Container and it shall only contain essence from a single instance of an MXF essence mapping. This Essence Container shall be internal to the file.
- The value of the Primary Package Property of the Preface Set shall be set and shall reference the Top-Level File Package.
- The size of the run-in shall be zero bytes.
- The Header Partition shall be closed and complete. Open or incomplete Header Partitions shall not be used. Section 8.2.5 gives advice on this issue.
- There shall be an Index Table in the Footer Partition and it shall not be sparse.
- There shall only be Header Metadata in the Header Partition (there shall be no Header Metadata repetitions).
- Each Partition shall contain data from no more than one data stream.
- Each data stream shall be contained in a single Partition.

Note: Although each copy of an Index Table has the same stream ID, they are regarded as separate, alternate, data streams. An instance of an Index Table is not split between two or more Partitions, but other copies of the same Index Table (complete or sparse) can exist in different Partitions.

5.1 Material Package Complexity

The Top-Level File Package in OP-Atom is highly constrained; however, no constraints are placed on the Material Package. The Material Package stores informative data about the synchronization of the essence in this file to essence stored in other files. An example is where audio and video are captured together and written to two OP-Atom files. More detailed examples are given in Annex B.

In the simplest case, the Material Package stores no extra data and so contains a single Essence Track with a single Source Clip that references the whole of the essence in the Top-Level File Package. More complex Material Packages may have more than one Essence Track, more than one Source Clip per Essence Track, or both.

The Material Package complexity is indicated in the OP label (see Section 7.3).

Note: The complexity of the Material Package does not affect basic decoding of an OP-Atom file as the Primary Package property allows a simple decoder to jump directly to the Top-Level File Package when parsing.

6 Application

The specialized Operational Pattern defined in this standard describes the audio-visual item as a single playable Essence Container. This Essence Container may, for example, contain a single clip or a single item of program material. The Essence Container shall provide for the continuous decoding of contiguous Essence Elements with no additional processing for discontinuities.

This Operational Pattern is intended only for applications where it is desirable to have a simple overall file layout requiring minimum parsing to separate the essence and metadata. It is also specifically intended for applications where each Essence Track is held separately. OP-Atom provides for a subset of MXF features.

The minimum implementation of OP-Atom satisfies the requirement for the definition of a single clip with minimum metadata support.

6.1 Constraints

A list of general constraints for OP-Atom is given in Table 1.

Table 1 – Summary of Operational Pattern constraints

File Kind	MXF
“Operational Pattern”	OP-Atom
Role	Continuous Recording, exchange of a single audio-visual item.
Essence	Single Essence Container
Number of Essence Track	1
Primary Package	Top-Level File Package
Material Packages	1
Number of Material Package Source Clips per Essence Track	1 or more
Top-Level File Packages	1
Number of Essence Container Types	1
Lower-Level Source Packages	0 or more
Partition Limits	closed and complete Header Partition closed and complete Footer Partition Also see Section 9
Body Partitions	See Section 9
Index Tables	Required
Editing Support	None (but see informative Annex B)
Streaming Support	Depends solely on the Essence Container

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 with specific constraints and additions detailed below.

7.2 Constraints on the MXF Packages

- There shall be only one Top-Level File Package;
- The “Primary Package”, as indicated in the Preface, shall be the Top-Level File Package;
- The Primary Package shall have a single Essence Track;
- There shall be only one Material Package;
- Lower-Level Source Packages, when present, shall be used to define the historical context of editing.

7.3 Universal Label for Operational Pattern “OP-Atom”

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	–
13	Operational Pattern: Specialized Operational Pattern "OP-Atom"	10h
14	Material Package complexity	See Table 3
15-16	Reserved	00h

Note: The Universal Label for Operational Pattern "OP-Atom" was added to RP 224 at Registry Version 2. Therefore, the value of byte 8 (Registry Version Number) is 2.

Byte 13 uniquely identifies this Operational Pattern specification.

The Material Package complexity is indicated by the value of byte 14:

Table 3 – Material Package complexity value

Bit No.	Value
0	0 = Each Material Package Essence Track contains a single Source Clip 1 = One or more Material Package Essence Track contains more than one Source Clip
1	0 = The Material Package contains a single Essence Track 1 = The Material Package contains more than one Essence Track
2-7	Reserved (set to 0)

7.3.1 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 the specialized Operational Pattern defined by this standard has the following limits in reference to the MXF file format specification:

1 Preface Set, 1 or more Identification Sets, 1 Content Storage Set, and 1 Essence Container Data Set

One Top-Level File Package including:

- the sets for the single Essence Track as required by the Essence Container;
- the Essence Descriptor required to describe the essence.

One Material Package including:

- the sets for the time code track;
- the sets for the single Essence Track referencing the Essence Track in the Top-Level File Package.

The sets required for the Index Table.

Support for Descriptive Metadata is optional but at least one scheme should be included in order to get the best from an MXF file.

The annexes of the MXF file format specification give the properties of the sets which should be implemented. All required and Best Effort set properties shall be supported by MXF encoders that comply with this Operational Pattern.

8 MXF File Interchange: Essence Container Issues

8.1 Essence Container Identification

The value of the Essence Container Universal Label shall be defined by the appropriate Essence Container specification document. This value shall be recorded in the Essence Containers property of the Preface Set and all Partition Packs and in the Essence Container property of the appropriate Essence Descriptor set. As OP-Atom only permits a single Essence Track in the Top-Level File Package, the Essence Container batches shall each contain a single entry.

8.2 Essence Container Requirements

8.2.1 Continuity of Essence Elements

As stated in Section 6, the 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.

Essence Container tracks are described by an Essence Descriptor set which defines 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 Essence Track.

As only one Essence Track is permitted in the Top-Level File Package that package shall only contain a single Essence Descriptor which shall not be a Multiple Descriptor.

8.2.2 Number of Essence Tracks

The number of Essence Tracks in the Top-Level File Package shall be one.

Note: If the Essence Container contains multi-channel essence that can be described as a single multi-channel track by a single Essence Descriptor then this can be placed in a single Essence Track. An example is stereo audio essence.

8.2.3 Number of Essence Elements

Although only a single instance of an essence mapping may be used in the Essence Container some mappings may allow the Essence Container to contain more than one element of essence data. In these cases the Top-Level File Package shall still contain only one Essence Track and the unreferenced elements should constitute a minority of the Essence Container data bytes.

Note: Essence mappings using the Generic Container Compound item, such as DV-DIF, can be used for holding picture essence in an OP-Atom file even though some of the items could contain sound or data that does not link to any Essence Tracks in the Header Metadata.

8.2.4 Use of Index Tables

The essence shall be indexed and a complete (i.e., not sparse) Index Table shall be contained in the Footer Partition.

Note: If the Index Table is a variable bit rate table, it can be necessary to store index data calculated during creation of the Essence Container and then transfer it to the Footer Partition after all essence has been written.

To allow the Footer Partition to be easily located, an OP-Atom file with the value 0 in the Footer Partition property of the Header Partition Pack should contain a Random Index Pack.

8.2.5 Creating OP-Atom files with open headers (Informative)

OP-Atom files are constrained to have closed headers; however, it cannot always be possible to write a valid closed header until the body has been written. In these circumstances, and if it is possible for another device or application to read the file before it is complete, it is recommended that an open header for an applicable generalized Operational Pattern be written with sufficient spare space (in the form of a KLV fill item) to rewrite the header with an OP-Atom closed header later.

9 Recommended Partitioning of OP-Atom Files

9.1 Partitioning OP-Atom with CBR Index Tables

OP-Atom files with constant-bit-rate Index Tables should be partitioned as follows:

- Header Partition: Including closed and complete Header Metadata and an optional Index Table, no Essence Container data.
- Body Partition: Including the complete Essence Container.
- Footer Partition: Including a repeat of the Index Table, no Header Metadata.

Further Partitions may be included between the Header and Footer Partitions to support extensions to MXF standards. These should not contain the Header Metadata, Index Table Segments or Essence Container Data

9.2 Partitioning OP-Atom with VBR Index Tables

OP-Atom files with variable-bit-rate Index Tables should be partitioned as follows:

- Header Partition: Including closed and complete header and an optional sparse Index Table, no Essence Container data.
- Body Partition: Including the complete Essence Container.
- Footer Partition: Including the complete Index Table, no Header Metadata.

Further Partitions may be included between the Header and Footer Partitions to support extensions to MXF standards. These should not contain the Header Metadata, Index Table Segments or Essence Container Data.

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, Television — Universal Labels for Unique Identification of Digital Data

SMPTE ST 336:2007, Television — Data Encoding Protocol using Key-Length-Value

SMPTE 377M-2004, Television — Material Exchange Format (MXF) — File Format Specification (Standard)

Annex B Examples of using Material Package Tracks to Add Synchronization Data to OP-Atom Files (Informative)

B.1 Introduction

OP-Atom files can only contain a single track of essence data and so the Top-Level File Package can only contain a single Essence Track. However, no restriction is placed on the number of tracks or Source Clips in the Material Package. This allows synchronization metadata to be held in the Material Package where a number of OP-Atom files are generated as a group. The grouping is across the timeline (such as separate audio and video files generated from a synchronized audio-video source), along the timeline (such as where the entire essence will not fit on a single disc) or even both. This annex shows examples of the first two groupings.

Note: The only Top-Level File Package present within an OP-Atom file describes the internal essence in that file. Therefore, any external references from the Material Package to other Top-Level File Packages are by UMID as these File Packages will not be in the file.

B.2 Parallel OP-Atom files

Consider a synchronized audio-video stream captured into two OP-Atom files. Each of these files will have a single Essence Container containing a single track of essence data. Each must also contain a File Package referencing that essence and a Material Package with an Essence Track that references the whole of that File Package Essence Track. There is no requirement for the Material Package to contain references to any essence data other than that contained within each file; however, it is considerably more useful for the Material Package to record the synchronization of the two essence streams.

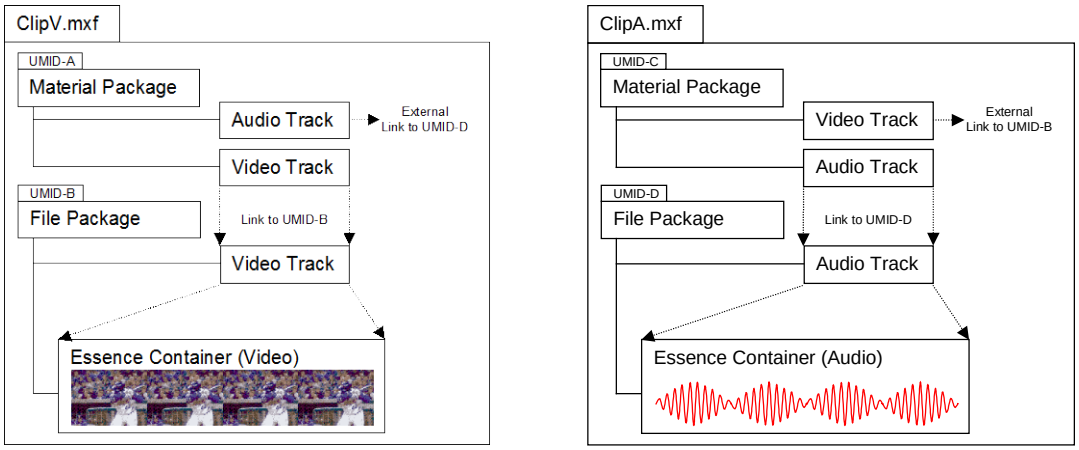

Figure B.1 – OP-Atom files showing a parallel relationship

Note: In MXF applications, UMID-C will typically equal UMID-A if the Material Packages are identical.

There is no need for a basic application to parse the Material Package as the Primary Package of the file is recorded as being the File Package. Therefore, simple parsing of an OP-Atom file can be achieved without the ability to read multiple Essence Tracks.

B.3 Sequence of OP-Atom files

A similar method can be used to show the relationship between a number of OP-Atom files that originate as part of a continuous sequence. An example is shown in Figure B.2.

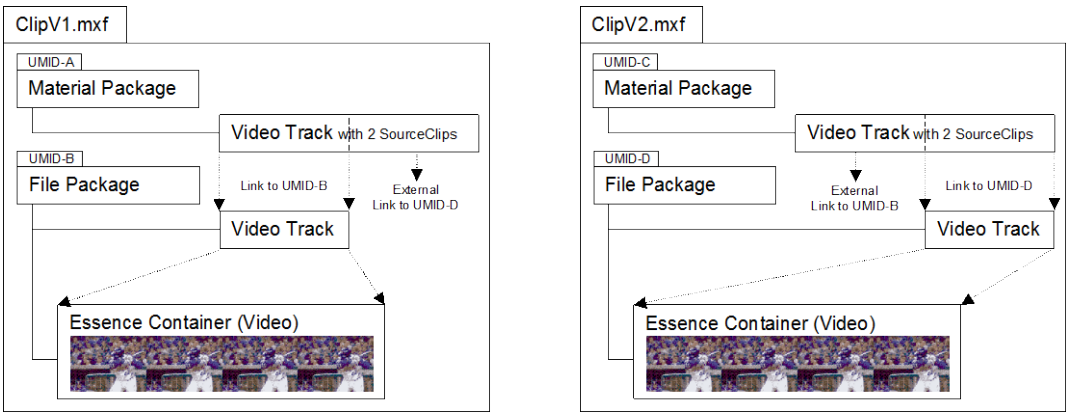

Figure B.2 – OP-Atom files showing a sequential relationship

Note: In MXF applications, UMID-C will typically equal UMID-A if the Material Packages are identical.

Again, there is no need for a basic application to parse the Material Package as the Primary Package of the file is recorded as being the File Package, therefore simple parsing of an OP-Atom file can be achieved without the ability to read multiple Source Clips.