SMPTE ST 2067-50:2018

SMPTE STANDARD

Interoperable Master Format – Application #5 ACES

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Approved February 12, 2018

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. This SMPTE Engineering Document was prepared by Technology Committee 35PM.

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 document specifies Compositions for IMF Application #5. It is a specialization of the IMF Framework.

Application #5 targets archival applications where a TV or movie title is to be archived as a single, high-quality set of master files from which one or more content versions can be derived.

It features SMPTE ST 2065-1 (ACES) image essence of arbitrary spatial and temporal resolution with individual frames encoded as ACES images.

The transformation of Application #5 Compositions to the output formats appropriate for different distribution channels is specified in other documents and outside the scope of this document. To facilitate Output Profile List processing, Annex A defines Pixel Color Schemes , as specified in SMPTE ST 2067-101, for the use with IMF Application #5.

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

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.

IEEE Std 754-2008, IEEE Standard for Floating-Point Arithmetic

IEC 61996-2-1:1999 Multimedia systems and equipment - Colour measurement and management - Part 2-1: Colour management; Default RGB colour space, sRGB

ISO/IEC 646:1991 Information technology — ISO 7-bit coded character set for information interchange

ISO/IEC 12639:2004 Graphic Technology — Prepress Digital Data Exchange — Tag Image File Format for Image Technology (TIFF/IT)

ISO/IEC 15948:2004, Information technology — Computer graphics and image processing — Portable Network Graphics (PNG): Functional specification

Internet Engineering Task Force (IETF) RFC 2045 (January 2001), Multipurpose Internet Mail Extensions (MIME) Part One: Format of Internet Message Bodies

Internet Engineering Task Force (IETF) RFC 2302 (March 1998), Tag Image File Format (TIFF) - image/tiff MIME Sub-type Registration

Internet Engineering Task Force (IETF) RFC 4122 (July 2005). A Universally Unique IDentifier (UUID) URN Namespace

Recommendation ITU-R BT.2100-1 (06/2017) Image parameter values for high dynamic range television for use in production and international exchange

SMPTE RP 431-2:2011, D-Cinema Quality — Reference Projector and Environment

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

SMPTE ST 429-5:2009, D-Cinema Packaging — Timed Text Track File

SMPTE ST 2065-1:2012, Academy Color Encoding Specification (ACES)

SMPTE ST 2065-4:2013, ACES Image Container File Layout

SMPTE ST 2065-5:2016, Material Exchange Format — Mapping ACES Image Sequences into the MXF Generic Container

SMPTE ST 2067-2:2016, Interoperable Master Format – Core Constraints

SMPTE ST 2067-3:2016, Interoperable Master Format – Composition Playlist

SMPTE ST 2067-21:2016, Interoperable Master Format – Application #2E

SMPTE ST 2067-101:2014, Interoperable Master Format — Output Profile List — Common Image Definitions and Macros

SMPTE ST 2067-102:2014, Interoperable Master Format — Common Image Pixel Color Schemes

SMPTE ST 2080-3:2017, Reference Viewing Environment for Evaluation of HDTV Images

World Wide Web Consortium (W3C) (28 October 2004). XML Schema Part 1: Structures (Second Edition)

World Wide Web Consortium (W3C) (28 October 2004). XML Schema Part 2: Datatypes (Second Edition)

4 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

4.1 ACES image

ACES image container file as defined in SMPTE ST 2065-4.

4.2 Target Frame

A single frame of the Image Essence rendered in a display-referred color space.

5 Overall

5.1 General

All provisions of SMPTE ST 2067-2 shall apply.

5.2 Format

An Image Track File shall conform to SMPTE ST 2065-5.

5.3 Shim Parameters

Track Files shall be associated with the shim parameter values specified in Table 1.

Table 1. Shim Parameter Values Definitions.

Shim Parameter	Value
shim_id	http://www.smpte-ra.org/ns/2067-50/2017
gc_type	379-2-gc
picture_family	ACES
picture_bitrate	ST 2067-50
picture_format	ST 2067-50
picture_custom_ANC	false
picture_render_ANC	false

6 Image Essence

6.1 General

Image essence shall consist of image frames. All image characteristics shall comply with SMPTE ST 2065-4.

6.2 Constraints (Informative)

Table 2 lists the combinations of characteristics allowed for Image frames.

Table 2. Image Characteristics.

Element	Reference	Value / Range	
Image Frame Width	§6.3.1	$1..2^{32}-1$	
Image Frame Height	§6.3.1	$1..2^{32}-1$	
Pixel Encoding	§6.3.5	16 bit half-float	
Frame Structure	§6.3.2	Progressive	
Stereoscopy	§6.3.8	Stereoscopic Monoscopic	
Frame Rate	§6.3.3	Any, see 6.3.3	
Sampling	§6.3.7	4:4:4:4	4:4:4
Color Components	§6.3.4	R G B A	R G B
Colorimetry	§6.3.6	COLOR.APP5.AP0, see 6.3.6	

6.3 Characteristics

6.3.1 Frame Dimensions (Informative)

The width and height of the frame are defined as the number of horizontal and vertical pixel elements, respectively.

The Image Frame Width is further constrained by the maximum value of pixel data size, as defined in SMPTE ST 2065-4.

6.3.2 Frame Structure (Informative)

Image frames are of progressive structure only.

An image frame with progressive structure consists of a complete image frame, scanned progressively from left to right and from top to bottom.

6.3.3 Frame Rate

The frame rate shall be specified in frames per second. The frame rate shall be a rational number; *n*/*d*. *n* and *d* shall both be UInt32 values greater than zero. The UInt32 data type is defined in SMPTE ST 377-1.

6.3.4 Color Components (Informative)

Image frames are sampled using linear RGB color component triplets plus an optional Alpha channel.

6.3.5 Pixel Values (Informative)

Each color component of each pixel is represented by a half float value according to SMPTE ST 2065-4.

6.3.6 Colorimetry

The values of the RGB component signals shall be mapped to ACES tristimulus values according to SMPTE ST 2065-1 (see Table 3).

Table 3. Colorimetry System.

System	Description
COLOR.APP5.AP0	Mapped as specified in SMPTE ST 2065-1

6.3.7 Sampling (Informative)

Sampling is 4:4:4 for RGB components and sampling is 4:4:4:4 for RGBA components.

In both 4:4:4 and 4:4:4:4 sampling, each component is sampled once at each image frame pixel.

6.3.8 Stereoscopic and Monoscopic Image Essence (Informative)

Monoscopic essence consists of a sequence of single image frames.

Stereoscopic essence, as defined in SMPTE ST 2067-2, consists of a sequence of pairs of image frames, a left eye frame and a right eye frame, for stereoscopic viewing. The two images of a pair are coincident in time.

Stereoscopic essence is wrapped into two Track Files, each consisting of monoscopic essence as defined in SMPTE ST 2067-2.

6.4 Encoding (Informative)

Each frame is encoded as a single ACES image according to SMPTE ST 2065-4. The component ordering is defined in SMPTE ST 2065-4.

7 Target Frames

7.1 General

The ACES Image Essence may be accompanied by Target Frames. Target Frames are individual, display-referred images as displayed on a Mastering Display. Each Target Frame is associated with a specific image of the ACES Image Essence. Target Frames are carried in the same Track File as the ACES Image Essence – see section 8.2.1

NOTE 1: Target Frames are intended to assist users in calibrating an Output Transform workflow by comparing the Target Frames to the result of the Output Transform workflow applied to the ACES Image Essence. See informative Annex D for further information.

NOTE 2: The position indicated by the Target Frame Index might or might not be part of the Virtual Image Track defined in the CPL. In particular, specific artificial test images could be provided covering the intended dynamic range and color space. Artificial test images are usually not part of the visible timeline (i.e. the Virtual Image Track).

NOTE 3: The number of Target Frames is expected to be representative, e.g. one frame per clip of a movie. The number of Target Frames is limited by the size of the header metadata.

7.2 File format

If present, Target Frames shall be either encoded in Tag Image File Format (TIFF), as defined in Annex C, or in Portable Network Graphics (PNG) format, as defined in Annex B.

8 Image Track File

8.1 Essence

An Image Track File shall contain image essence conforming to Section 6.

8.2 Wrapping

8.2.1 General

The image essence shall be Frame-wrapped as specified in SMPTE ST 2065-5.

Each Image Track File may contain one or more Target Frames (as defined in Section 7). The associated ACES Image within the Image Essence of a particular Image Track File shall be specified by a Target Frame Index, as defined in section 8.2.5.6.

There shall be no more than 500 Target Frames per Image Track File.

Each Target Frame shall be an Ancillary Resource in its own Generic Stream Partition, using Ancillary Resource Wrapping as defined in SMPTE ST 429-5.

Each Ancillary Resource shall be referenced by one Target Frame SubDescriptor, as defined in section 8.2.5.

The Top-Level File Package of an Image Track File shall reference an RGBA Picture Essence Descriptor as defined in SMPTE ST 377-1.

8.2.2 Generic Picture Essence Descriptor

8.2.2.1 General (Informative)

The Generic Picture Essence Descriptor items (including those specified in SMPTE ST 2067-2) are constrained as specified in SMPTE ST 2065-5.

8.2.3 RGBA Picture Essence Descriptor (Informative)

The RGBA Picture Essence Descriptor items are constrained as specified in SMPTE ST 2065-5.

8.2.4 ACES Picture SubDescriptor

8.2.4.1 General

One or more ACES Picture SubDescriptors may be strongly referenced by the RGBA picture essence descriptor, as specified in SMPTE ST 377-1. The ACES Picture SubDescriptor shall be a subclass of SubDescriptor, as defined in SMPTE ST 377-1.

Each ACES Picture SubDescriptor provides information about a particular authoring workflow for a Mastering Display.

The ACES Mastering Display metadata items, as defined in 8.2.4.5, 8.2.4.6, 8.2.4.7 and 8.2.4.8, shall specify the characteristics of the Mastering Display. Either all or none of the items specified in 8.2.4.5, 8.2.4.6, 8.2.4.7 and 8.2.4.8 shall be present.

NOTE: In current practice, an ACES Image Sequence is authored for one display-referred representation. This standard provides an option for multiple display-referred representations, using a specific authoring workflow per display-referred representation. In case no specific authoring workflow information is to be provided, e.g. for ungraded ACES image sequences, the ACES Picture SubDescriptor can be omitted.

Essence tracks that use the ACES essence mapping may use the values of the ACES Picture SubDescriptor as defined in Table 5. The ACES Picture SubDescriptor is encoded as a local set using 2-byte tag values and 2-byte length values consistent with all MXF descriptors.

NOTE: Annex C.6 of SMPTE ST 2067-21:2016 contains selected example values for Mastering Display Color Volume Metadata. Other values, not specified in these examples, are also permitted.

8.2.4.2 Key

The set key of the ACES Picture SubDescriptor shall be as defined in Table 4.

Table 4. ACES Picture SubDescriptor key.

Name	ACES Picture SubDescriptor
Symbol	ACESPictureSubDescriptor
Namespace	http://www.smpte-ra.org/reg/395/2014/13/1/aaf
Item UL	urn:smpte:060e2b34.027f0101.0d010101.01017900
Definition	ACES Picture SubDescriptor

8.2.4.3 Value

If present, the ACES Picture SubDescriptor may contain the item listed in Table 5.

Table 5. Specification of the values of the ACES Picture SubDescriptor.

Item Name	Type	Length	Local Tag	Item UL	Req ?	Meaning	Default
ACES Authoring Information	UTF-16 string	Var	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.0a 01.00.00.00	Opt	See 8.2.4.4	
ACES Mastering Display Primaries	ThreeColorPrimaries	12	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.0a 02.00.00.00	Opt	See 8.2.4.5	
ACES Mastering Display White Point Chromaticity	ColorPrimary	4	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.0a 03.00.00.00	Opt	See 8.2.4.6	
ACES Mastering Display Maximum Luminance	UInt32	4	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.0a 04.00.00.00	Opt	See 8.2.4.7	
ACES Mastering Display Minimum Luminance	UInt32	4	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.0a 05.00.00.00	Opt	See 8.2.4.8	

NOTE: The value of the Symbol for each item is equal to the value of the Item Name without white spaces.

8.2.4.4 ACES Authoring Information

If present, this field shall contain human readable information on the system used to author the ACES image essence contained in the track file. The syntax and semantics of this field are out of scope of this document.

NOTE: Values can be chosen according to Specification S-2014-002, published by the Academy of Motion Pictures, Arts and Sciences. An example value for a TransformID would be `ODT.Academy.P3D60_ST2084_1000nits.a1.0.3`

8.2.4.5 ACES Mastering Display Primaries

Syntax and semantics of this item shall be according to the syntax and semantics of the Mastering Display Primaries item, as defined in SMPTE ST 2067-21.

8.2.4.6 ACES Mastering Display White Point Chromaticity

Syntax and semantics of this item shall be according to the syntax and semantics of the Mastering Display White Point Chromaticity item, as defined in SMPTE ST 2067-21.

8.2.4.7 ACES Mastering Display Maximum Luminance

Syntax and semantics of this item shall be according to the syntax and semantics of the Mastering Display Maximum Luminance item, as defined in SMPTE ST 2067-21.

8.2.4.8 ACES Mastering Display Minimum Luminance

Syntax and semantics of this item shall be according to the syntax and semantics of the Mastering Display Minimum Luminance item, as defined in SMPTE ST 2067-21.

8.2.5 Target Frame SubDescriptor

8.2.5.1 General

One or more Target Frame SubDescriptors may be strongly referenced by the RGBA picture essence descriptor, as specified in SMPTE ST 377-1. The Target Frame SubDescriptor shall be a subclass of SubDescriptor, as defined in SMPTE ST 377-1.

If the Essence Track File contains one or more Target Frame Ancillary Resources, the RGBA Picture Essence Descriptor shall contain the same number of strong references to Target Frame SubDescriptors. There shall be one Target Frame SubDescriptor for each Target Frame Ancillary Resource.

The values of the Target Frame SubDescriptor shall be as defined in Table 7. The Target Frame SubDescriptor is encoded as a local set using 2-byte tag values and 2-byte length values consistent with all MXF descriptors.

NOTE: The elements of the Target Frame SubDescriptor are meant to specify the encoding characteristics of a Target Frame in terms of color primaries, white point, OETF and code range. Precise knowledge of the encoding characteristics is essential for correctly interpreting the Target Frames.

8.2.5.2 Key

The set key of the ACES Picture SubDescriptor shall be as defined in Table 6.

Table 6. Target Frame SubDescriptor key.

Name	Target Frame SubDescriptor
Symbol	TargetFrameSubDescriptor
Namespace	http://www.smpte-ra.org/reg/395/2014/13/1/aaf
Item UL	urn:smpte:ul:060e2b34.027f0101.0d010101.01017a00
Definition	Target Frame SubDescriptor

8.2.5.3 Value

If present, the Target Frame SubDescriptor shall contain the items listed in **Table 7**.

Table 7. Specification of the values of the Target Frame SubDescriptor.

Item Name	Type	Length	Local Tag	Item UL	Req ?	Meaning	De-fault
Target Frame Ancillary ResourceID	UUID	16	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.09 01.00.00.00	Req	See 8.2.5.4	
Media Type	UTF-16 string	Var	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.09 02.00.00.00	Req	See 8.2.5.5	
Target Frame Index	UInt64	8	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.09 03.00.00.00	Req	See 8.2.5.6	
Target Frame Transfer Characteristic	TransferCharacteristicType	16	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.09 04.00.00.00	Req	See 8.2.5.7	
Target Frame Color Primaries	ColorPrimariesType	16	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.09 05.00.00.00	Req	See 8.2.5.8	
Target Frame Component Max Ref	UInt32	4	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.09 06.00.00.00	Req	Maximum value for RGB components of the corresponding Target Frame, e.g. 60160 or 65535 (16 bits).	

Target Frame Component Min Ref	UInt32	4	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.09 07.00.00.00	Req	Minimum value for RGB components of the corresponding Target Frame, e.g. 0 or 4096 (16 bits).	
Target Frame Essence StreamID	UInt32	4	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.09 08.00.00.00	Req	The BodySID of the partition that contains the resource data	
ACES Picture SubDescriptor Instance ID	UUID	16	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.09 09.00.00.00	Opt	See 8.2.5.9	
Target Frame Viewing Environment	ViewingEnvironmentType	16	Dyn	06.0e.2b.34 01.01.01.0e 04.01.06.09 0a.00.00.00	Opt	See 8.2.5.10	

NOTE: The value of the Symbol for each item is equal to the value of the Item Name without white spaces.

8.2.5.4 Ancillary Resource ID

The Ancillary Resource ID shall be a Version 5 UUID as specified in IETF RFC 4122, using (i) the SHA-1 hash of the entire asset as the Type 5 UUID Name, (ii) SHA-1 as the Type 5 UUID Hash Algorithm, and (iii) `urn:uuid:bba41561-c505-4c9c-ab5a-71c68c2d70ea` as the Type 5 UUID Name Space ID.

NOTE: The UUID value `bba41561-c505-4c9c-ab5a-71c68c2d70ea` was chosen randomly.

8.2.5.5 Media Type

This field shall contain a Media Type identifier in notation “type/subtype”, see Content-Type Header Field, as defined in IETF RFC 2045. The value shall be one of the values listed in Table 8.

Table 8. Ancillary Resource Media Type.

Media Type value	Meaning
image/tiff	Tagged Image File Format Media Type, as defined in IETF RFC 2302
image/png	Portable Network Graphics Media Type, as defined in ISO 15948

8.2.5.6 Target Frame Index

The Target Frame Index field shall contain the index of the corresponding frame in the image essence, expressed in Edit Units, as defined in SMPTE ST 377-1. The index of the corresponding frame shall be counted starting with zero from the Zero Point on the output timeline of the Material Package of the Image Track File. The output timeline is defined in SMPTE ST 377-1.

8.2.5.7 Target Frame Transfer Characteristic

The value of the Target Frame Transfer Characteristic item shall be a Universal Label specifying the opto-electric transfer function applied to the associated Target Frame. Values are listed in the SMPTE Register.

Table 9 and Table 10 define additional values for the Target Frame Transfer Characteristic item.

The Gamma 2.6 Transfer Characteristic label, as defined in Table 9, shall identify the transfer function

$$E' = 1.0\ E^{(1/2.6)}$$

where E is a color component R, G, or B normalized to its respective maximum value. E' is the corresponding nonlinear component R', G' or B'. Input and Output of the transfer function are floating point numbers that range from 0.0 to 1.0.

Table 9. Gamma 2.6 Transfer Characteristic.

Name	Gamma 2.6 Transfer Characteristic
Symbol	TransferCharacteristic_Gamma_2_6
Namespace	http://www.smpte-ra.org/reg/400/2012
Item UL	urn:smpte:ul:060e2b34.0401010d.04010101.010c0000
Definition	Opto electric transfer function using a power function with an exponent of 1/2.6 and a scaling factor of 1.0.

Table 10. sRGB Transfer Characteristic.

Name	sRGB Transfer Characteristic
Symbol	TransferCharacteristic_sRGB
Namespace	http://www.smpte-ra.org/reg/400/2012
Item UL	urn:smpte:ul:060e2b34.0401010d.04010101.010d0000
Definition	Opto electric transfer function using a power function as defined in IEC 61966-2-1

8.2.5.8 Target Frame Color Primaries

The value of the Color Primaries item shall be a 16 byte Universal Label specifying the encoding color primaries and the white point of the associated Target Frame. Values are listed in the SMPTE Register.

8.2.5.9 ACES Picture SubDescriptor Instance ID

If present, the ACES Picture SubDescriptor Instance ID item shall be the Instance ID of an ACES Picture SubDescriptor.

The presence of this item indicates that the Target Frame was processed according to the ACES Authoring Information provided in the ACES Picture Essence SubDescriptor with the given Instance UUID.

8.2.5.10 Viewing Environment

If present, the value shall be the UL defined in Table 12, Table 13 or Table 14. Table 11 to Table 14 define Label Registry Entries for the Viewing Environment labels.

Table 11. Viewing Environment label node.

Name	Viewing Environment
Symbol	ViewingEnvironment
Namespace	http://www.smpte-ra.org/reg/400/2012
Item UL	urn:smpte:ul:060e2b34.0401010d.04100101.01000000
Definition	Viewing Environment Labels

Table 12. Label for Theatrical Viewing Environment.

Name	Theatrical Viewing Environment
Symbol	TheatricalViewingEnvironment
Namespace	http://www.smpte-ra.org/reg/400/2012
Item UL	urn:smpte:ul:060e2b34.0401010d.04100101.01010000
Definition	Theatrical Viewing Environment as defined in SMPTE RP 431-2

Table 13. Label for SDR HDTV Reference Viewing Environment.

Name	HDTV Reference Viewing Environment
Symbol	HDTVReferenceViewingEnvironment
Namespace	http://www.smpte-ra.org/reg/400/2012
Item UL	urn:smpte:ul:060e2b34.0401010d.04100101.01020000
Definition	Reference Viewing Environment for Evaluation of HDTV Images, as defined in SMPTE ST 2080-3

Table 14. HDR Reference Viewing Environment.

Name	HDR Reference Viewing Environment
Symbol	HDRReferenceViewingEnvironment
Namespace	http://www.smpte-ra.org/reg/400/2012
Item UL	urn:smpte:ul:060e2b34.0401010d.04100101.01030000
Definition	Reference Viewing Environment for Evaluation of HDR Images, as defined in ITU-R BT.2100-1

9 Composition

9.1 Application Identification

The ApplicationIdentification element (see SMPTE ST 2067-2) shall include the value listed in Table 15.

Table 15. Application Identification.

http://www.smpte-ra.org/ns/2067-50/2017

9.2 Homogenous Image Essence

Within a given composition all image essence characteristics specified in Section 6.2 shall remain constant.

9.3 Main Image Virtual Track

All Image Track Files referenced by Resource elements of type StereoImageTrackFileResourceType and type TrackFileResourceType shall conform to Section 8.1.

9.4 Segment Duration

If the average number of audio samples per Composition Edit Unit is not an integer, the duration of each Segment shall be chosen such that the number of audio samples per segment is an integer.

NOTE: In case the Composition Edit Unit Rate is 30 * 1000/1001, 60 * 1000/1001 or 120 * 1000/1001, the Segment duration has to be an integer multiple of 5/Composition Edit Rate.

10 Pixel Color Schemes

Annex A defines Pixel Color Schemes, as specified in SMPTE ST 2067-101, for the use with IMF Application #5.

NOTE: Annex A is for the sole purpose of enabling Output Profile List (OPL) processing of Application #5 IMF packages.

Annex A Pixel Color Schemes Definition (Normative)

A.1 XML Schema Definition

This section shall apply whenever a data structure is specified using XML schema definitions as specified in W3C XML Schema Part 1: Structures and W3C XML Schema Part 2: Datatypes.

In order to avoid duplication between text and schema, the cardinality and default values of elements are specified in the schema definitions only.

In the event of a conflict between schema definitions and the prose, the prose shall take precedence. The XML schema root element shall be as defined in Table 16.

Table 16. XML Schema root element definition.

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema targetNamespace="http://www.smpte-ra.org/ns/2067-50/2017/opl-color-scheme"
  xmlns:oplcs="http://www.smpte-ra.org/schemas/2067-101/2014/color-schemes"
  xmlns:acesc="http://www.smpte-ra.org/ns/2067-50/2017/opl-color-scheme"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  elementFormDefault="qualified" attributeFormDefault="unqualified">
  <xs:import namespace="http://www.smpte-ra.org/schemas/2067-101/2014/color-
                  schemes"/>
<!-- schema definitions found in Annex A of this document -->
</xs:schema>
```

A.2 Type Definitions

A.2.1 HalfFloatType

`HalfFloatType` represents floating-point numbers within the valid color component value range, as specified in SMPTE ST 2065-1. It shall be as specified in Table 17.

Table 17. HalfFloatType definition.

```
<xs:simpleType name="HalfFloatType">
  <xs:restriction base="xs:float">
    <xs:minInclusive value="-65504.0"/>
    <xs:maxInclusive value="65504.0"/>
  </xs:restriction>
</xs:simpleType>
```

A.2.2 HalfFloatTripletType

`HalfFloatTripletType` represents a triplet of ACES values, as specified in SMPTE ST 2065-1. It shall be as specified in Table 18.

Table 18. HalfFloatTripletType definition.

```
<xs:simpleType name="HalfFloatTripletType">
  <xs:restriction>
    <xs:simpleType>
      <xs:list itemType="acesc:HalfFloatType"/>
    </xs:simpleType>
    <xs:length value="3"/>
  </xs:restriction>
</xs:simpleType>
```

A.2.3 HalfFloatQuadrupletType

`HalfFloatQuadrupletType` represents a quadruplet of ACES values, as specified in SMPTE ST 2065-1. It shall be as specified in Table 19.

Table 19. HalfFloatQuadrupletType definition.

```
<xs:simpleType name="HalfFloatQuadrupletType">
  <xs:restriction>
    <xs:simpleType>
      <xs:list itemType="acesc:HalfFloatType"/>
    </xs:simpleType>
    <xs:length value="4"/>
  </xs:restriction>
</xs:simpleType>
```

A.3 ACES-RGB-Float-16

The ACES-RGB-Float-16 representation of a single pixel shall be as specified in Table 20.

Table 20. ACES-RGB-Float-16 Representation.

Name	ACES-RGB-Float-16
URI	`http://www.smpte-ra.org/ns/2067-50/2017#ACES-RGB-Float-16`
Description	Linear R, G and B components in the ACES color space, as specified in SMPTE ST 2065-1.
Mapping from Reference Image Pixel	R = clamp(-65504.0, 65504.0, P_1) G = clamp(-65504.0, 65504.0, P_2) B = clamp(-65504.0, 65504.0, P_3) The clamp function is specified in SMPTE ST 2067-102. R, G and B values shall be rounded to the closest `binary16` representation. The `binary16` format is specified in IEEE 754. The `roundToNearest` method with `roundTiesToEven` handling shall be applied, as specified in IEEE 754.
Mapping to Reference Image Pixel	P_1 = R P_2 = G P_3 = B

Pixel Encoding Type	`<xs:complexType name="ACES-RGB-Float-16">`
	`  <xs:simpleContent>`
	`  <xs:restriction base="oplcs:ColorEncodingType">`
	`  <xs:simpleType>`
	`  <xs:restriction base="acesc:HalfFloatTripletType"/>`
	`  </xs:simpleType>`
	`  </xs:restriction>`
	`  </xs:simpleContent>`
	`</xs:complexType>`

A.4 ACES-RGBA-Float-16

The ACES-RGBA-Float-16 representation of a single pixel shall be as specified in Table 21.

Table 21. ACES-RGBA-Float-16 Color Scheme.

Name	ACES-RGBA-Float-16
URI	`http://www.smpte-ra.org/ns/2067-50/2017#ACES-RGBA-Float-16`
Description	Linear R, G, B and A components. The R, G and B components are specified in SMPTE ST 2065-1, the A (Alpha) component is specified in SMPTE ST 2065-4.
Mapping from Reference Image Pixel	R = clamp(-65504.0, 65504.0, P_1) G = clamp(-65504.0, 65504.0, P_2) B = clamp(-65504.0, 65504.0, P_3) A = clamp(0.0, 1.0, P_4) The clamp function is specified in SMPTE ST 2067-102. R, G, B and A values shall be rounded to the closest `binary16` representation. The `binary16` format is specified in IEEE 754. The `roundToNearest` method with `roundTiesToEven` handling shall be applied, as specified in IEEE 754.
Mapping to Reference Image Pixel	P_1 = R P_2 = G P_3 = B P_4 = A

Pixel Encoding Type	`<xs:complexType name="ACES-RGBA-Float-16">`
	`  <xs:simpleContent>`
	`  <xs:restriction base="oplcs:ColorEncodingType">`
	`  <xs:simpleType>`
	`  <xs:restriction base="acesc:HalfFloatQuadrupletType"/>`
	`  </xs:simpleType>`
	`  </xs:restriction>`
	`  </xs:simpleContent>`
	`</xs:complexType>`

A.5 Consolidated Schema (Informative)

This specification is accompanied by the following element, which is an XML schema document as specified in W3C XML Schema Part 1: Structures.

st2067-50a-2018.xsd

This element collects the XML schema definitions defined in this specification. It is informative and, in case of conflict, this specification takes precedence.

Annex B Constrained PNG File Format (Normative)

B.1 General

Target Frames in PNG File Format shall be mapped as defined in ISO 15948:2004, and as constrained in this engineering document.

B.2 Constraints on PNG chunks

PNG chunks, as defined in ISO 15948:2004, shall be constrained as defined in Table 22.

Table 22. PNG chunks, as defined in ISO 15948, and constraints.

PNG chunk	PNG chunk name	Field	Width	Value constraint(s)
IHDR	Image Header	Bit depth	1 byte	16
IHDR	Image Header	Colour Type	1 byte	2 (Truecolor) or 6 (Truecolor with alpha)
IHDR	Image Header	Interlace method	1 byte	0 (no interlace)
PLTE	Palette			Shall not be present
cHRM	Primary chromaticities and white point			Shall be ignored by the decoder
gAMA	Image gamma			Shall not be present
iCCP	Embedded ICC profile			Shall not be present
sRGB	Standard RGB colour space			Shall not be present

NOTE: The Target Frame SubDescriptor provides the equivalent information of the items flagged to be ignored or not present.

Annex C Constrained TIFF File Format (Normative)

C.1 General

Target Frames in Tag Image File Format shall be mapped as full color images, as defined in ISO 12639:2004, Subclause 7.1, Structure of TIFF/IT file, and as constrained in this engineering document. Where requirements of this engineering document and ISO 12639:2004 are in conflict, this engineering document shall take precedence.

The Byte Order used within a compliant file shall be from the most significant to the least significant. This is called big-endian byte order. Bytes 0 – 1 of the image file header at the beginning of the file shall have the values “MM” or 4D4D.h. For reference, see ISO 12639:2004, Subclause 7.1.2, Header.

A compliant file shall convey only main image data in one image subfile, with one Image File Directory (IFD). For reference, see ISO 12639:2004, Subclause 7.1.3, Image subfiles.

C.2 Constrained TIFF Tags

The TIFF fields listed in Table 23 shall be included in the IFD (Image File Directory) of a compliant Target Frame image file. Field values that do not depend on image size shall be set to the indicated values. The fields ImageWidth, ImageLength, RowsPerStrip, and StripByteCounts depend on image size. Additional TIFF fields are allowed, as long as they do not affect the Target Frame interpretation.

For reference, see ISO 12639:2004, Subclause 7.1.4, IFD (Image File Directory), and Subclause 7.1.5, IFD entry.

All numeric values are expressed in decimal notation.

The field types used in Table 23 are as follows:

– LONG a 32-bit unsigned binary integer

– SHORT a 16-bit unsigned binary integer.

Table 23. Mandatory Fields.

TIFF Tag #	TIFF Field Name (Informative)	Field Type (Informative)	Field Value Constraints	Field Contents or Interpretation (Informative)
256	ImageWidth	SHORT or LONG	$< 2^{32}$	Image width in pixels
257	ImageLength	SHORT or LONG	$< 2^{32}$	Image height in pixels
258	BitsPerSample	SHORT (repeated SamplesPerPixel times)	16	Bits per Channel for RGB and RGBA images
259	Compression	SHORT	1	None
262	PhotometricInterpretation	SHORT	2	RGB samples
274	Orientation	SHORT	1	The 0th row represents the visual top of the image, and the 0th column represents the visual left-hand side.
277	SamplesPerPixel	SHORT	3 or 4	Color channels per pixel
278	RowsPerStrip	SHORT or LONG	Same as Image Length	The entire image (all image rows) packaged into one single strip
279	StripByteCounts	SHORT or LONG	ImageWidth x ImageLength x 2 x SamplesPerPixel	The number of bytes in the single strip = ImageWidth * ImageLength * bytes per pixel
284	PlanarConfiguration	SHORT	1	Chunky format, single image plane. The component values for each pixel are stored contiguously. For RGB data, the data is stored as RGBRGBRGB.. For RGBA data, the data is stored as RGBARGBARGBA...

Annex D Target Frame Workflow (Informative)

D.1 Processing model

Target Frames are provided for the purpose of enabling the consumer of IMF App#5 packages to calibrate their particular ACES Output Transform workflow to match the ACES Output Transform workflow used during mastering.

ACES images cannot be directly viewed for image evaluation. Therefore, ACES Image sequences are usually converted by an ACES Output Transform for being displayed on real-world displays. The ACES Output Transform converts ACES image data to display code values.

The ACES Output Transform includes tone-mapping operations and transformation into a display-referred color space representation.

In this Annex, it is assumed that, during mastering, one ACES Output Transform was applied to the ACES Image Sequence contained in the IMF App#5 package.

User-defined metadata, identifying the ACES Output Transform applied, can be carried in the ACES Authoring Information field of the ACES Picture SubDescriptor.

A Target Frame is an image that was processed by the Output Transform workflow applied during mastering, as shown in Figure 1. Zero to n Target Frames can exist.

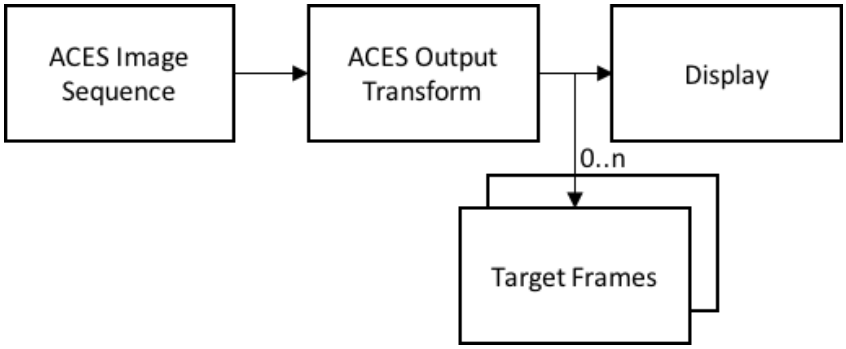

Figure 1: ACES Target Frame workflow.

If the Target Frames visually or mathematically match the rendered images obtained from a particular workflow, it gives a hint that the particular Output Transform workflow recreates the artistic intent applied during the mastering process of the original ACES Image sequence.

Hints for picking Target Frames: It is recommendable to use Target Frames that cover the color space and dynamic range of the intended display device. For example, a low dynamic range image with desaturated colors (i.e. a black frame in the worst case) might not be useful as Target Frame.

D.2 Example

For this example, it assumed that the ACES Image Essence contained in the IMF App #5 package was mastered using an AMPAS-published ODT for Rec. 2020 color space and a peak luminance of 1,000 cd/m^2. It is further assumed that the Mastering Display was a monitor with P3 primaries.

The ACES Image Essence consists of 6048 frames, therefore the frame count in Edit Units runs from 0 to 6047.

A Target Frame was rendered in TIFF format for frame no. 110 (frame no. = frame count in Edit Units, starting with zero) of the ACES Image Essence and is included in the Image Track File.

Figure 2 depicts the Duration of the Image Essence and the chosen Target Frame Index (see 8.2.5.6) of the Target Frame on the timeline.

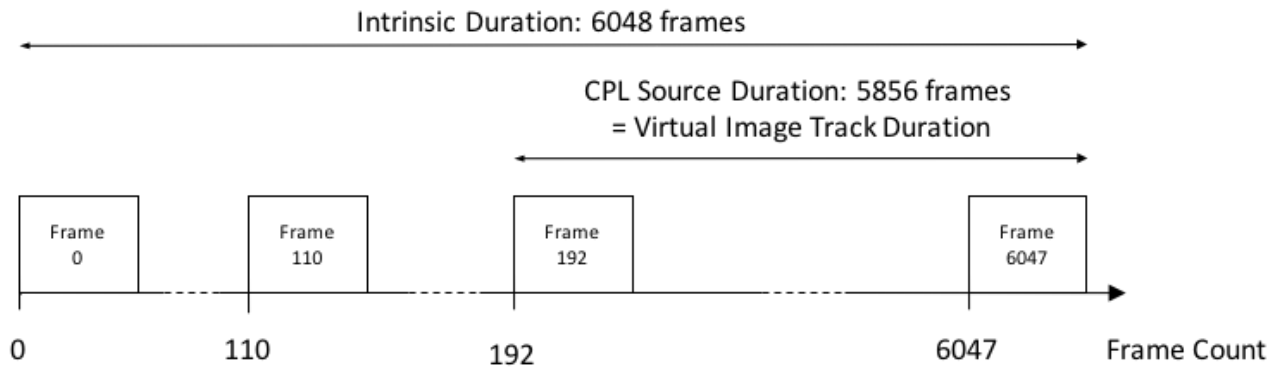

Figure 2: ACES Image Essence Timeline (not to scale).

This document is accompanied by the following element, which is a a sample Composition Playlist:

st2067-50b-2018-sample-cpl.xml

NOTE: For simplicity, it is assumed the sample Composition contains a Monaural Virtual Audio Track only.

Annex E Illustration of the MXF Descriptor Hierarchy (Informative)

Figure 3 shows the inheritance relationships between the MXF Descriptors and the strong reference from the RGBA Picture Essence Descriptor to zero or more ACES Picture SubDescriptors and to zero or more Target Frame SubDescriptors.

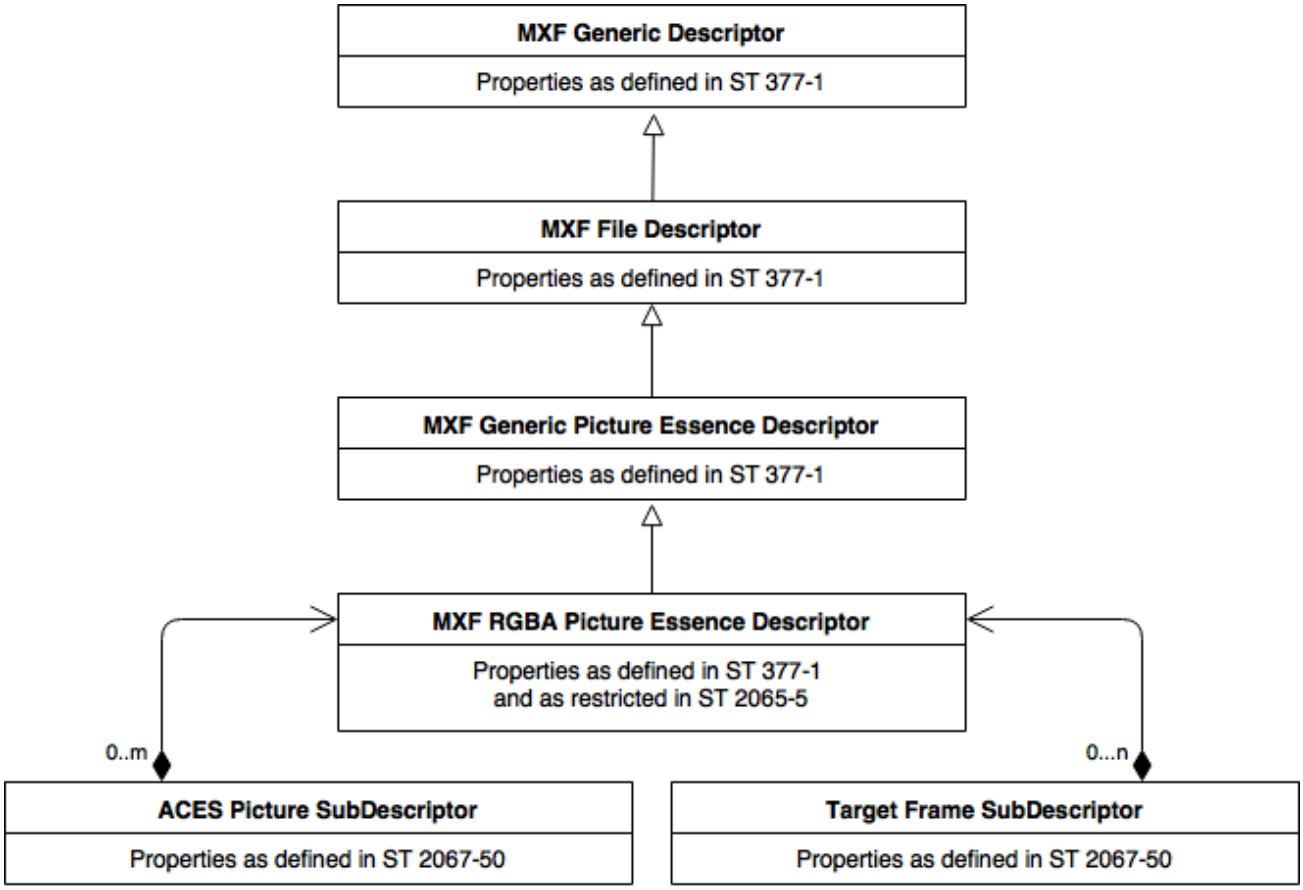

Figure 3: MXF Descriptor and SubDescriptor relationships.

Annex F Bibliography (Informative)

Academy of Motion Picture Arts and Sciences (A.M.P.A.S.) Specification S-2014-002, Academy Color Encoding System – Versioning System.

Academy of Motion Picture Arts and Sciences (A.M.P.A.S.) Specification S-2014-012, Academy Color Encoding System Version 1.0 Component Names.

TIFF, Revision 6.0 Final, Aldus Corporation (now Adobe Systems Incorporated), June 3, 1992, available at https://www.itu.int/itudoc/itu-t/com16/tiff-fx/docs/tiff6.pdf