Technical Bulletin

TB-2014-010

Design, Integration and Use of ACES Look Modification Transforms

The Academy of Motion Picture Arts and Sciences

Science and Technology Council

Academy Color Encoding System (ACES) Project Committee

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Summary: This document describes a component of the ACES viewing pipeline, the Look Modification Transform (LMT). The LMT precedes the sequential application of the ACES Reference Rendering Transform (RRT) and a particular Output Device Transform (ODT), and allows custom and systematic color changes to a set of clips to realize a chosen creative intent. In a workflow built around ACES-based color management, these changes can be limited to paths to a display (a 'nondestructive' color change) or they can be used to produce new ACES image files ('baking in' the color changes).

This Technical Bulletin defines terminology, provides motivating use cases for LMTs, specifies the syntax and carriage of LMTs, discusses how LMTs should be integrated into an ACES-based color managed project, and provides design guidelines for LMT authoring. Appendices provide and discuss example LMTs.

NOTICES

Revision History

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0.1	11/10/14	Created (J. Houston)
0.2	11/14/14	Modified Intro (J. Houston)
0.3	11/19/14	Incorporate Jack Holm edits (J. Houston)
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1.0	12/19/14	Filled in remaining blanks, minor editorial fixes, final formatting for release (A. Maltz)

Related A.M.P.A.S. Documents

Document Name	Version	Date	Description (owner)
ACES Version 1.0 Product Definition	0.5	10/6/14	ACES Version 1 Product Specification (A. Maltz)
Technical Bulletin TB-2019-009 ACES Clip-level Metadata Files Usage	1.0	12/19/14	ACES Clip-level metadata specification
Specification S-2014-1, ACEScc, A Logarithmic Encoding of ACES Data for use within Color Grading Systems	1.0	12/18/14	ACEScc
Specification S-2013-001 "ACESproxy, an Integer Log Encoding of ACES Image Data	1.2	12/18/14	ACESproxy
S-2014-006 Academy-ASC Common LUT Format Specification	1.0	12/19/14	Academy-ASC Common LUT Format

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Introduction

The Look Modification Transform (LMT) imparts an image-wide creative 'look' to the appearance of ACES images. It is a component of the ACES viewing pipeline that precedes the Reference Rendering Transform (RRT) and a selected Output Device Transform (ODT). LMTs exist because some color manipulations can be complex, and having a pre-set for a complex look makes a colorist's work more efficient. In addition, emulation of traditional color reproduction methods such as the projection of film print requires complex interactions of colors that are better modeled in a systematic transform than by requiring a colorist to match 'by eye'.

The LMT is intended to supplement—not replace—a colorist’s traditional tools for grading and manipulating images. There are three places in the viewing pipeline where production staff modifies the look of the image from the default rendering of ACES data:

- Adjustments to the exposure levels or white balance of a particular shot are often done as a 'pre-grade'.
- A colorist applies a grade to further refine and modify the color appearance to achieve the creative look of a shot.
- Finally the LMT provides an additional, optional tool for the colorist to manipulate ACES images and preview the result.

Thus the pre-grade and the LMT bracket the colorist’s grading work.

While the colorist's grading tools allow manipulation of either the overall image or of selected pieces of the image, the LMT is designed to work only across the overall image.

As part of the ACES viewing pipeline, the LMT takes ACES color-encoded values as inputs, and outputs modified ACES-encoded values that may then be immediately processed by the RRT and an ODT (in this case, the ODT appropriate for the colorist’s display).

Outside an immediate ACES viewing pipeline, the LMT’s output can additionally (or alternatively) be saved, creating a new ACES image container file that has ‘baked in’ the effect of the LMT on the original image. When this new file with ‘baked in’ changes is viewed using the standard ACES viewing pipeline, the creative intent reflected in the prior application of the LMT to the original will be preserved.

LMTs can be reused across multiple shots or even across an entire production. They are separate from a shot's ‘grade’ or a particular vendor’s color grade file.

Key characteristics of a well-designed LMT are portability across applications, and preservation (to the extent that is both possible and practical) of ACES’s high dynamic range and wide color gamut while still imparting a designed, creative, target look.

1 Scope

This document describes the use of ACES Look Modification Transforms (LMTs) for ACES-based color management. It provides several use cases for LMTs, defines how LMTs are expressed and are carried along with clips and projects, discusses LMT use in the context of a workflow employing ACES-based color management, and concludes with design guidelines for LMTs. This document also describes optimal use of LMTs and suggests several ways in which an LMT may be designed to support flexible mastering and archiving workflows.

2 References

The following standards, specifications, articles, presentations, and texts are referenced in this text:

SMPTE ST2065-1:2012, Academy Color Encoding Specification

ASC Color Decision List (ASC CDL) Transfer Functions and Interchange Syntax, ASC-CDL_Release 1.2

Specification S-2014-1, ACEScc, A Logarithmic Encoding of ACES Data for use within Color Grading Systems, Version 1.0

Specification S-2013-001, ACESproxy, an Integer Log Encoding of ACES Image Data, Version 2

ACES Clip-level Metadata File and XML Data Model Specification Version 1.0

3 Terms and Definitions

The following terms and definitions are used in this document:

3.1 Academy Color Encoding Specification (ACES)

RGB color encoding for exchange of image data that have not been color rendered, between and throughout production and postproduction, within the Academy Color Encoding System. ACES is specified in SMPTE Standard ST 2065-1.

3.2 ACEScc

A logarithmic encoding of ACES data suitable for color grading, representing ACES data in 32-bit floating-point format, with a smaller set of primaries than the ACES RGB primaries defined in SMPTE ST 2065-1.

3.3 ACEScg

A linear encoding of ACES data suitable for color grading, representing ACES data in 32-bit floating-point format, with a smaller set of primaries than the ACES RGB primaries defined in SMPTE ST 2065-1.

3.4 ACESproxy

A logarithmic encoding of ACES data, with both a 10-bit and 12-bit integer representation, conveying ACES image data for viewing and for determination of grading parameters. ACESproxy-encoded image data are never stored, only displayed.

3.5 American Society of Cinematographers Color Decision List (ASC CDL)

A set of file formats for the exchange of basic primary color grading information between equipment and software from different manufacturers. ASC CDL provides for Slope, Offset and Power operations applied to each of the red, green and blue channels and for an overall Saturation operation affecting all three channels.

3.6 Color operation

A function mapping one color to another. In the context of the ACES viewing pipeline, color operations include but are not limited to arithmetic and table lookup.

3.7 Grade

An ordered set of color operations, the composition of which is determined by a skilled colorist in a reference viewing environment. A grade may be applied to some subset of an image, and in those regions where it is applied, the degree of application may change depending on location within the image. Grades are typically created for each shot or sequence and are managed on a timeline. Grades may be re-used across shots.

3.8 Input Device Transform (IDT)

A transform taking images produced by a capture device and converting them into ACES images.

3.9 Look Modification Transform (LMT)

An ordered set of color operations typically applied at some higher level than an individual shot, and perhaps applied across an entire project. The input to an LMT is always a triplet of ACES RGB relative exposure values; its output is always a new triplet of ACES RGB relative exposure values. LMTs are applied identically across all of the pixels in an ACES image. The LMT's output may be directed towards the last two stages of the ACES viewing pipeline (the RRT and an ODT appropriate for some display), or supplied as input to a subsequent LMT, or saved to an ACES container file for later processing.

3.10 Pre-grade

An ordered set of color operations that are applied uniformly across the entire image. Pre-grading is used to produce a neutral balanced, correctly exposed image when the desired creative grade is not yet known.

3.11 Look Transform

A sequence of one or more LMTs, with the output of one LMT being provided as the input to the next LMT. In the ACES viewing pipeline, the output of the last LMT in the sequence is provided to the RRT and a selected ODT.

4 LMT use cases

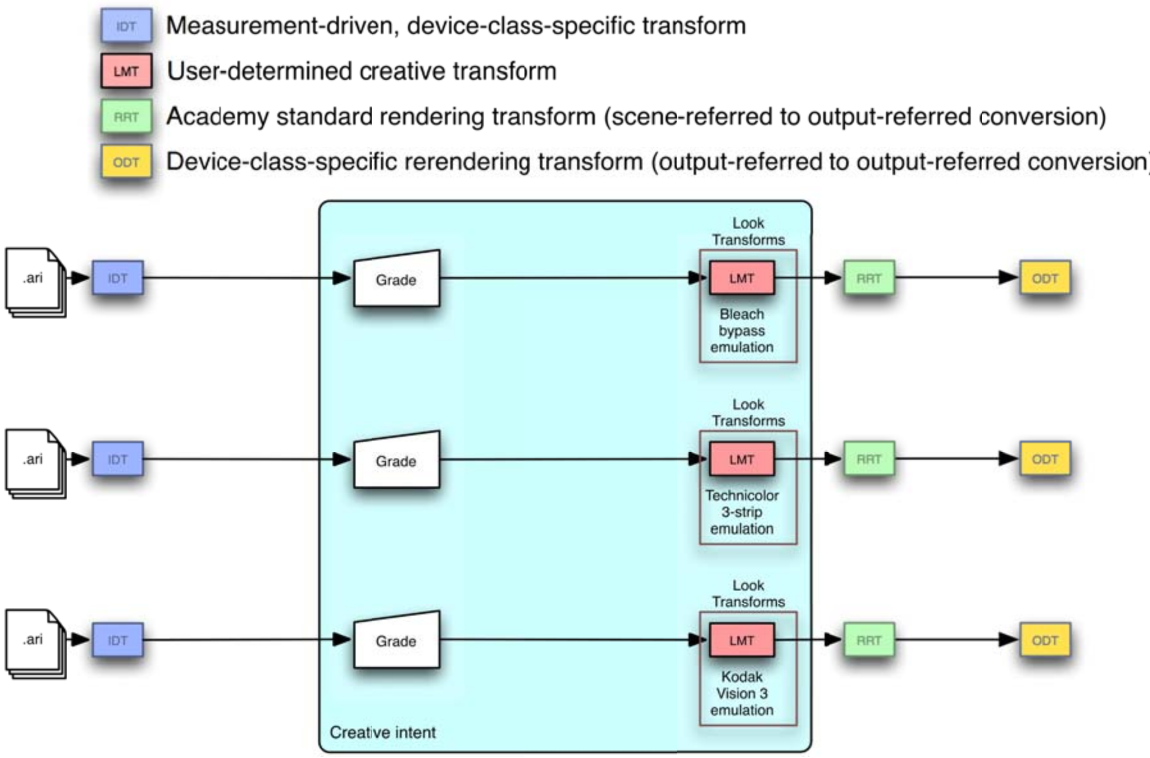
Two styles of image modification are common in post-production: interactive modification, either across the entire frame or in isolated regions of interest, and a preset systematic modification across the entire frame. The interactive image modification is termed 'grading'. The ACES term for preset systematic, full-frame image modification is 'look modification'. Look modification is performed using a Look Modification Transform (LMT).

4.1 Emulation of photochemical processing

Though modern grading systems are very powerful, some whole-frame color transformations are too complex for even a skilled colorist to accomplish using grading system controls. Often the complexity arises when the creative intent is to simulate, for frames captured with digital cinema cameras, the nonlinear color and exposure relationships used in film laboratory photochemical processing, especially nonstandard photochemical processing. Examples of such color transformations include:

- 'Bleach Bypass' emulation: modification of image color values to achieve a unique desaturated appearance mimicking projection of a print that had skipped a normal laboratory bleaching step.
- Technicolor 3-strip emulation: modification of image color values to achieve a saturated, higher-contrast appearance mimicking projection of a print from Technicolor's imbibition dye transfer process (c. 1938)
- Kodak Vision 3 print film emulation: modification of image color values to achieve a reproduction of the relationship between scene exposure values and projected film imagery resulting from the use of Kodak's latest film stocks.

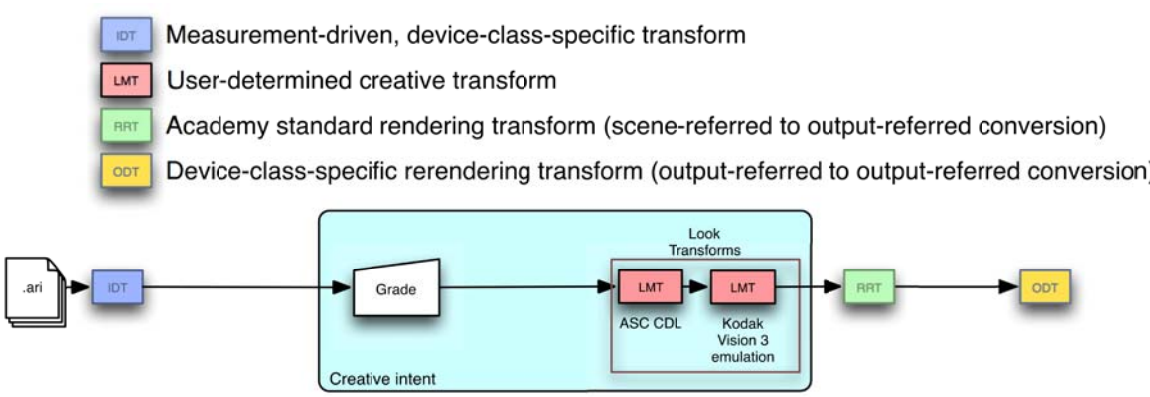
The following diagram illustrates how a colorist could prepend one or more emulation LMTs to the RRT (which itself precedes a selected ODT), so that his or her time could be spent on sequence, shot and/or region-specific color requests from the client. The grade modifies the image first, followed by the process emulation provided by the LMT.



4.2 Systematic Color Correction (and application of ASC CDL)

The LMT takes as input an image in the ACES color space and yields a modified image that is still in the ACES color space. As a consequence, LMTs can be 'chained' together, one after another. The illustration below shows a grading workflow where, prior to applying the 'Kodak Vision 3 emulation' LMT described above, the colorist applies an 'ASC CDL' LMT—very likely one whose parameter values were chosen by the cinematographer on-set to modify the default 'look' of emulated Kodak Vision 3 stock.

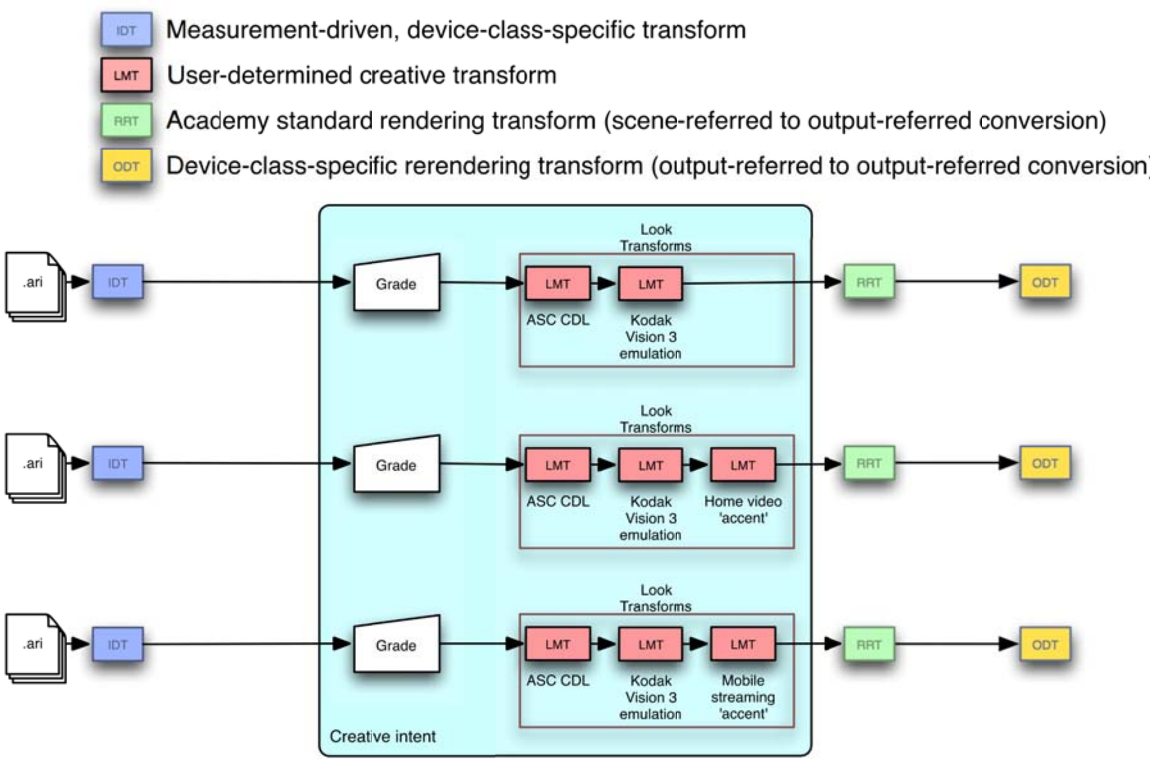
NOTE: The values of the ASC CDL in this case are only valid in the context of the selected 'Kodak Vision 3 emulation' LMT. If this LMT were removed, the ASC CDL values would no longer be valid.



Note that the ASC CDL LMT incorporates a conversion from ACES to ACEScc before the ASC CDL operations will be applied, and likewise incorporates a conversion from ACEScc to ACES after the ASC CDL operations have been applied. This ‘wrapping’ of ASC CDL operations is a key capability of the ACES Common LUT format.

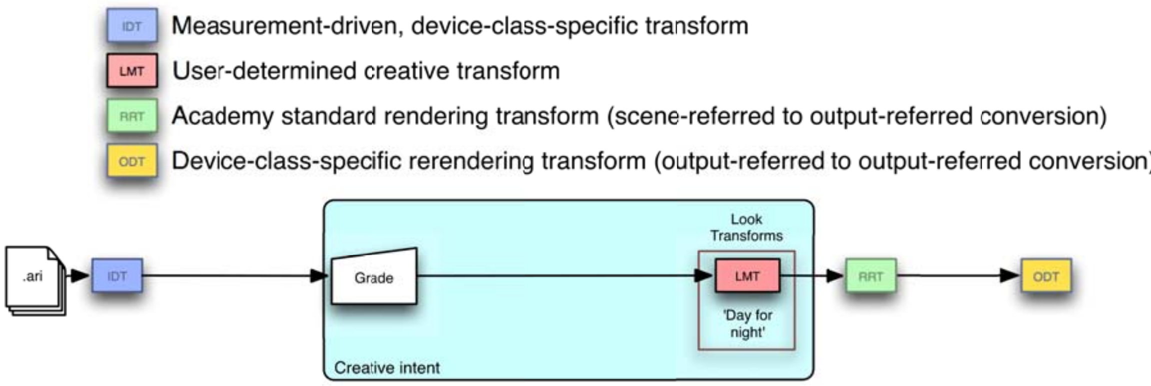
4.3 Trim Pass Grading

Content today is delivered across a wide range of output devices, each of which has their own color space and characteristic brightness. Creative adjustments to the look of shots are often needed to enhance the content's appearance beyond the original creative intent. The client might desire to accentuate the difference between the results of the viewing pipeline for theatrical exhibition, the results of the viewing pipeline appropriate for home video and the results of the viewing pipeline appropriate for mobile streaming. This could be done by having three workflows that differed only in that the first had no LMT ‘accentuating’ the image for any nonstandard viewing environment, the second had an LMT just prior to the application of the RRT and an ODT designated as appropriate for home video viewing, and the second had an LMT just prior to the application of the RRT and an ODT designated as appropriate for viewing with content streamed to mobile devices, as shown below.

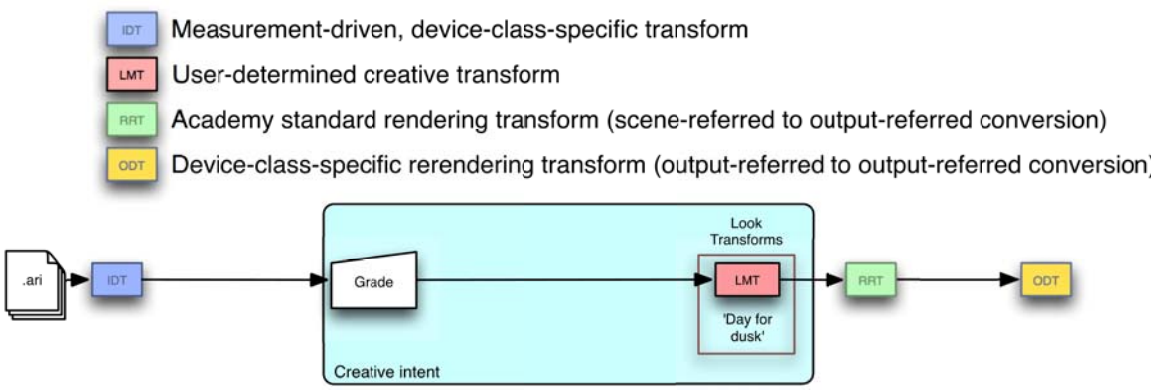


4.4 Flexible pre-sets for creative modifications

Separation of grading and LMT(s) allows for a production to make significant changes in creative decisions that affect the entire frame equally, without requiring the colorist to start from scratch, or ideally without even requiring a trim pass. For example, the client might start a production shooting ‘day for night’ and use an LMT to accomplish this result:

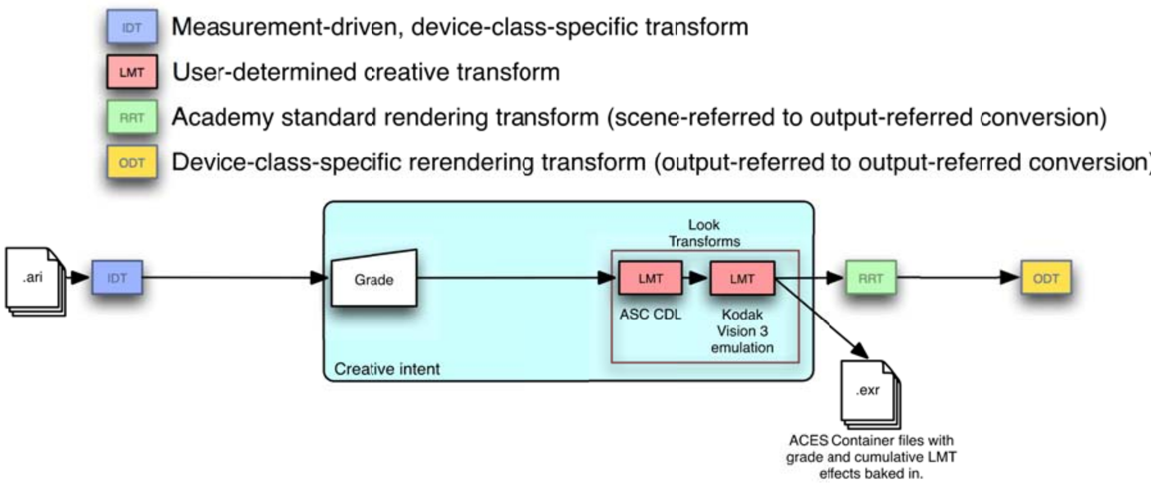


A change in creative direction (say, after a test screening) might place the captured action two hours earlier, so ‘day for night’ might become ‘day for dusk’. Since the LMT is separate from the grade, the change may be made without requiring lengthy and expensive colorist intervention. A new LMT is simply swapped into the old LMT’s place.



4.5 Permanent Color Modification (archival)

The workflows above all show a ‘transient’ processing of image file to displayed output, with the display being a calibrated grading monitor or projector. It is also completely valid and correct to archive the input to the RRT as an ACES container file, ‘baking in’ the grade and any LMT application(s), as shown below:



A person who retrieves an ACES file need not know about the grades and LMT(s) applied to produce the desired creative result; by virtue of being an ACES file, the image 'speaks for itself' when the RRT and a selected ODT are applied.

It is extremely important that the LMT authors preserve as much of the dynamic range of the LMT's input ACES RGB relative exposure values as is possible. This provides the maximum amount of latitude for a colorist grading through the LMT. It also preserves the maximum amount of grading latitude for someone who later retrieves stored ACES container files created by 'baking in' the effect of the LMT to the graded ACES images, when remastering for a radically different display or viewing environment (e.g. for grading on a higher-dynamic-range display than previously available). While full preservation of dynamic range and gamut is almost never possible, when faced with an engineering decision in which all other considerations are equal, the LMT author should choose the option that retains more of the LMT input's dynamic range and color gamut.

Preserving the integrity of the ACES RGB relative exposure values representing the scene means more than just not clipping highlight luminances or very deep shadow tones. It also means avoiding severe distortions of the distributions of ACES values, such as the distortion caused by a strong 'gamma' operation, e.g. by a very large or very small value for one or more CDL 'power' parameters.

Because LMT's are customizable and unique, and because it is essential to maintain the portability and archivability of an ACES project, it is always necessary to preserve the LMT transforms within any project where they are used.

NOTE: If a production wishes to preserve maximum flexibility for later remastering, it should archive the original ACES images, any clip-level metadata-bearing container encapsulating the original image files, any IDT(s), any pre-grading adjustments (see the following 'LMTs and pre-grading for Visual Effects' section), any project-wide and shot-specific grading parameters, and the Look Transform (that is, the set of all LMTs employed to achieve the creative result, in their proper sequence).

4.6 Portability

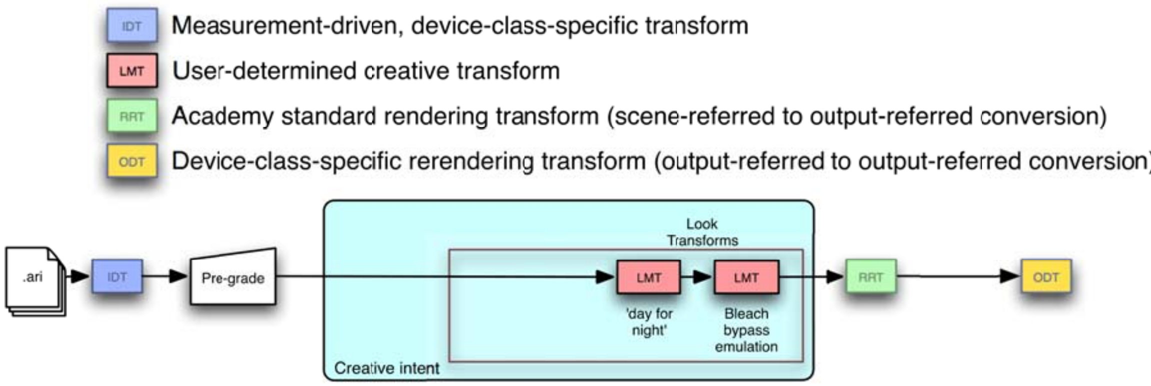
LMTs are expressed and transported using the Common LUT format (also known as the Academy/ASC LUT format or the ASC/Academy LUT format).

The building blocks of an LMT include basic arithmetical operations, simple matrix application, 1D LUTs and 3D LUTs. Straightforward color transforms can often be expressed analytically using the first three of these building blocks. More complex (and typically empirically derived) LMTs may be conveyed as 3D LUTs. The Common LUT format was chosen because it can express, in a portable encoding, all of the abovementioned operations and LUTs, NOTE: Using the floating point ACES RGB relative exposure values directly as 1D LUT indices requires a more complex lookup mechanism than found in traditional 1D LUT implementations. The Common LUT Format supports this type of lookup by using the halfDomain attribute of the LUT1D process node; see the Common LUT Format documentation for more information.

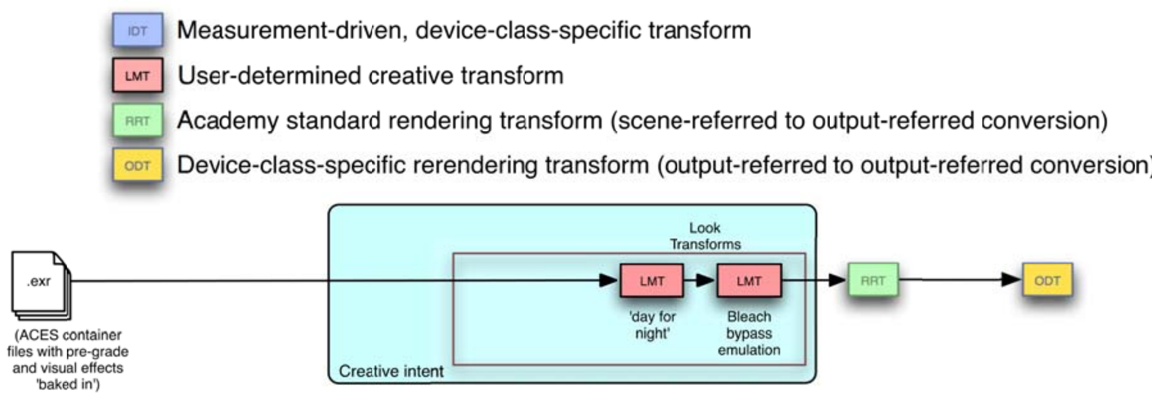
4.7 LMTs and pre-grading for Visual Effects

In some cases, color corrections may be created *prior* to the colorist session in a scene-balancing 'pre-grade'. This allows for all shots in a sequence to share identical LMTs 'downstream' in the color modification pipeline. A motivating case would be a long sequence of daylight shots with varying color temperature.

An example of this workflow, with two illustrations, is shown below. The first illustration shows what might happen at a visual effects facility that receives a number of shots that will be edited together to make up a sequence.



When the visual effects are complete, the frames supplied to the colorist have both the pre-grade and the visual effect(s) 'baked' in. The Look Transform is *not* 'baked in' to this imagery, since it must be applied *after* the grade, but is instead carried as metadata, and is referenced by the ACES clip container.



5 Specification

5.1 Inputs

The inputs to an LMT are ACES RGB relative exposure values.

5.2 Outputs

The outputs of an LMT are ACES RGB relative exposure values.

5.3 Working space

The internal working space of an LMT is unrestricted. An LMT may internally transform its inputs into a non-ACES space and perform color operations there, as long as it transforms the results of those back to ACES before yielding them as outputs.

5.4 Syntax

LMTs are specified in Common LUT XML.

5.5 Transport

LMT metadata is carried in the ACESclip container file within the ACES_Config element. Multiple LMTs are referenced in the TransformList element and are applied in the order in which they are referenced.

6 Workflow integration

6.1 Application to entire image, pixel by individual pixel

As with all other ACES transforms, LMTs are applied across the entire image, and are not applied to any subset of the image. Similarly, as with all other ACES transforms, the outputs of the LMT depend solely on its inputs, with no contribution from neighboring regions of the image.

6.2 Ubiquity

The LMT is a key transform in the ACES system, and must be supported in any system component supporting ACES workflows that allows for image alteration. (An example of an ACES system component not allowing image alteration would be a display that interpreted its inputs as being ACESproxy values.) The ability to specify, record, transport and/or apply LMT(s) can be present in almost any component of an ACES-based workflow, including applications for converting native camera output to ACES imagery, on-set grading and dailies tools, color correctors, displays and CG tools.

6.3 Optimizations

When there are multiple LMTs making up a Look Transform, the hardware or software implementing the ACES viewing pipeline may optimize the application of the Look Transform by combining the LMTs into a single LUT; it may also combine this Look Transform LUT with the RRT and a selected ODT.

6.3.1 Composite transform sampling using a 3D LUT

Applications may also send a lattice of sample values through some set of adjacent transforms (anything from two or more adjacent LMTs in the Look Transform, to the full concatenation of Look Transform plus RRT and a selected ODT) to derive a single 3D LUT.

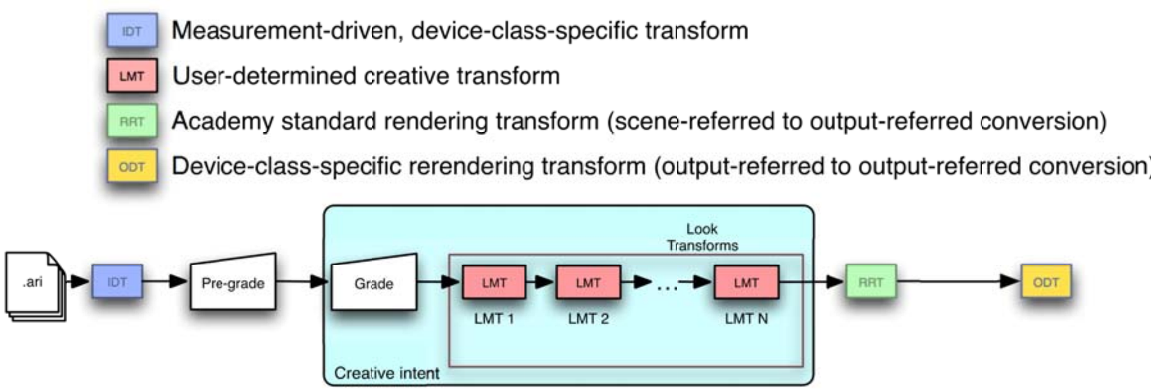
Artifact-free processing across the large range of ACES RGB relative exposure values requires shaper LUTs before and after the 3D LUT to minimize interpolation error.

6.4 Retention

LMTs need to be saved with every clip or project, and loaded automatically into the user's application so that the creatively established Look Transform is maintained at every step of production and post-production. Every LMT contains, as part of its description, an ACES Transform Identifier. To maintain portability of LMTs, the metadata identifying them—their ACES Transform Identifiers—must be included within the ACES clip container; the order in which they are referenced in the ACES clip container 'TransformList' is the order in which they should be applied.

6.5 Nondestructive preview of displayed image appearance

LMTs are one of several types of transform applied to either camera-specific files in proprietary or standard format that have been converted into ACES by an IDT, or to ACES files in OpenEXR containers. In the most general of cases, the input image data will be processed first by zero or more pre-grades, then by the grading transform, then by zero or more LMTs, then by the RRT, then by a selected ODT, and then displayed to the user. This most general case is shown below.



The syntax and semantics of LMTs are given in the Specification section above. The syntax and semantics of pre-grading and grading operations are outside the scope of this document; indeed, they are outside the scope of the ACES project itself.

6.6 Archival of ACES imagery with and without 'baked in' grading and/or LMT application

Every archived ACES image has an implied associated displayed image, namely, the result of processing that archived ACES image with the RRT and the ODT that was used when creative approval was given. Because of this it is critical that the selected ODT (including all relevant versioning information) be archived alongside any archived ACES imagery, whether or not that ACES imagery is the product of 'baking in' grades and/or the application of one or more LMTs making up a Look Transform.

Since many grading operations and LMTs may reduce the color volume in the original image to a smaller color volume that is then delivered to the RRT and a selected ODT, productions wishing to 'future-proof' their assets should store the original ACES files, along with all pre-grading information, grading information, the ordered set of LMTs that make up the Look Transform and the ODT that was selected at the time of creative approval. (An LMT applying ASC CDL would be an example of such a color-volume-reducing transformation, as ASC CDL is applied in the ACEScc color space, a smaller color space than ACES.)

7 Design

Simple LMTs are the best. An LMT should be as simple as possible while still achieving the desired modification to the displayed image.

7.1 Overall principles

7.1.1 Support high dynamic range

ACES image data can represent luminances from far below the detectability threshold of the human visual system all the way up to luminances causing physical pain—the maximum ACES luminance is about 65,505 times as bright as a diffuse white object in the scene. An LMT should endeavor to preserve this luminance range as much as is possible.

7.1.2 Handle a wide color gamut

Creation of ACES imagery by CGI renderers, or by grading operations on live-action capture, can create ACES image values containing colors not found in nature—colors on the spectral locus that only became readily producible with the advent of the laser. An LMT should handle as wide a color gamut as is possible and practical, and avoid imposing arbitrary limits on hue or saturation.

7.1.3 Use high-level constructs to enable optimizations

The Common LUT Format allows the ACES system release to provide a tool chest of predefined operations. LMT authors should use these rather than writing their own for several reasons:

- They were developed as part of the ACES project, have well-defined semantics, and are tested.
- They obey the two principles above (‘Support high dynamic range’ and ‘Handle the full color gamut’) to the maximum extent possible,
- Future releases might introduce performance or quality optimizations that depend on recognition of predefined operations.

7.2 Analytic and empirical approaches

Broadly speaking, LMTs can be characterized as either analytic or empirical.

7.2.1 Analytic LMTs

Analytic LMTs usually have concise mathematical definitions. The prime example of an analytic LMT is probably the ACES-system-provided LMT that applies ASC CDL to ACES data. Another (hypothetical) analytic LMT might be one that increases saturation with luminance at certain hue angles. Analytic LMTs are typically expressed as a set of ordered mathematical operations or 1D LUT lookup operations on colors or color component values.

7.2.2 Empirical LMTs

Empirical LMTs usually are derived by sampling the results of some other color reproduction process, such as normal or special film processing. Empirical LMTs are often provided as sparsely sampled 3D LUTs.

A challenge arises when using ACES values to index the 3D LUT, as ACES values are radiometrically linear and have a very wide floating point range. The Common LUT Format provides for forward and inverse ‘shaper LUT’ operations that (when wrapped around an appropriately constructed 3D LUT) effectively solve this problem. Implementers should review the ‘Shaper LUT’ section of the Common LUT Format definition.

7.3 Importing 'looks' from non-ACES-color-managed workflows

Importing a 'look file' or LUT from a color system not defined using ACES can be quite difficult. Such 'look files' contain transforms to be applied in color spaces other than ACES or the ACES 'working space' used by ACESproxy and ACEScc, often presume the relationship between scene and encoded values is encoded with some (possibly proprietary) power function or log function, and likely are designed to supply a display device with code values directly rather than hand off the image to the RRT and a selected ODT.

For all of these reasons, it is typically better (and often much more efficient over the course of a production) to establish new Look Transforms within a workflow that is built around ACES-based color management rather than to try and mathematically translate a 'look file' or LUT intended for use with a workflow based on some other color management system.

Appendix A: Example analytic LMT supporting ASC CDL

This example shows how a sequence of steps (here, seven steps) can be used to implement an LMT that applies ASC CDL values to effect a grade.

1. Matrix: Convert ACES image data to ACEScg image data.
2. 1DLUT: Convert ACEScg image data to ACEScc image data with a fully enumerated 16-bit LUT.
3. Range: Normalize to select floating-point range for application of CDL.
4. ASC CDL: Apply ASC CDL values using the reference equations.
5. Range: Scale and offset normalized CDL output back to full ACEScc range.
6. 1DLUT: Apply output LUT convert ACEScc image data to ACEScg image data.
7. Matrix: Convert ACEScg image data to ACES image data.

NOTE The matrix values shown are not correct; the values are chosen not for correctness but for clarity of exposition.

```
<ProcessList xmlns="urn:NATAS:ASC:LUT:1.2" id="ProdLMTv1" name="WarmNight_v1">
<Description> Create a warm nightime look </Description>
<InputDescriptor>ACES</InputDescriptor>
<OutputDescriptor>ACES</OutputDescriptor>
<Matrix id="uuid:f81d4fae-7dec-11d0-a765-00a0c91e6bf6" name="ACEScsc.ACES_to_AP1.a1"
inBitDepth="16f" outBitDepth="16f" >
        <Description> ACES_to_AP1 working space D60 white ** not the right numbers** </Description>
        <Array dim="3 3">
                        1.2         0.0       0.0
                        0.0         1.03      0.001
                        0.004       -0.007    1.004
        </Array>
</Matrix>
<LUT1D id="uuid:f81d4fae-7dec-11d0-a765-00a0c91e6bf8" name="ConverttoACESccToneScale"
inBitDepth="16f" outBitDepth="16f">
        <Description>1D LUT </Description>
        <Array dim="65535 3">
                    /* OMIT */
        </Array>
</LUT1D>
<RANGE inBitDepth="16f" outBitDepth="16f" style = “noClamp” >
        <minInValue>12841.570</minInValue>
        <maxInValue>48742.586</maxInValue>
        <minOutValue>0.0</minOutValue>
        <maxOutValue>1.0</maxOutValue>
</RANGE>
<ASC CDL id=”cc01234” inBitDepth=”16f” outBitDepth=”16f” >
        <ASC_SOP>
                <Description> not a real example</Description>
                <Slope>1.0000 1.0000 0.800000</Slope>
                <Offset>0.0000 0.0000 0.000000</Offset>
                <Power>1.0000 1.0000 1.000000</Power>
        </ASC_SOP>
        <SATNode>
                <Saturation>0.9</Saturation>
        </SATNode>
</ASC CDL>
<RANGE inBitDepth="16f" outBitDepth="16f"" style = “Clamp” >
        <minInValue>0.0</minInValue>
        <maxInValue>1.0</maxInValue>
        <minOutValue>12841.570</minOutValue>
        <maxOutValue>48742.586</maxOutValue>
```

```
</RANGE>
<LUT1D id="uuid:f81d4fae-7dec-11d0-a765-00a0c91e6bf9" name="ConvertLogtoLinear" inBitDepth="16f"
outBitDepth="16f">
	<Description> takes ACEScc values and converts back to ACES range NEGS
CLIPPED</Description>
	<IndexMap dim=2>0.0@0  65504.0@31743</IndexMap>
	<Array dim="65535 3">
		/* OMIT */
	</Array>
</LUT1D>
<Matrix id="uuid:f81d4fae-7dec-11d0-a765-00a0c91e6bf9" name="ACEScsc.ap1_to_ACES"
inBitDepth="16f" outBitDepth="16f" >
	<Description> Convert from AP1 to ACES </Description>
	<Array dim="3 3">
		1.2	0.0	0.0
		0.0	1.03	0.001
		0.004	-0.007	1.004
	</Array>
</Matrix>
</ProcessList>
```

Appendix B: Example empirical LMT supporting PFE

This example shows how a 3DLUT can be used to implement an LMT that emulates the look of projected film print.

```
<ProcessList xmlns="urn:NATAS:ASC:LUT:1.1" id="ProdLMTv1" name="WarmNight_v1">
<Description> Create a warm nightime look </Description>
<InputDescriptor>ACES</InputDescriptor>
<OutputDescriptor>ACES</OutputDescriptor>
<LUT1D id="uuid:f81d4fae-7dec-11d0-a765-00a0c91e6bf8" name="ConverttoACESccToneScale"
inBitDepth="16f" outBitDepth="16f">
	<Description> Shaper LUT for interpolation into 3DLUT uses positive value ACEScc spacing.
</Description>
	<Array dim="65535 3">
			/* OMIT */
	</Array>
</LUT1D>
<LUT3D id=" uuid:f81d4fae-7dec-11d0-a765-00a0c91e6bf2" name="PFE_Vision2_12Nov2003"
interpolation="tetrahedral" inBitDepth="16f" outBitDepth="16f" >
	<Description> 3D LUT calculated in ACEScc outputs ACES values </Description>
	<Array dim="64 64 64 3">
		0.0 0.0 0.0
		/* OMIT */
		65504.0 65504.0 65504.0
	</Array>
</LUT3D>
</ProcessList>
```