ASC Technology Committee
Digital Intermediate Subcommittee

ASC Color Decision List (ASC CDL) Transfer Functions and Interchange Syntax

ASC-CDL_Release1.2

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The American Society of Cinematographers would like basic color correction data to be interchangeable between color correction systems made by different manufacturers. Realistically, projects are usually completed in multiple facilities and a standardized interchange that, when accompanied by good communication and consistent viewing conditions, creates the same results on multiple systems will substantially improve the consistency and quality of the resulting images while at the same time increasing efficiency and reducing cost.

This document provides implementation information for color correction system manufacturers. It describes the mathematics of the ASC CDL *Slope*, *Offset*, *Power*, and *Saturation* transfer functions and the basics of communicating ASC CDL parameters via ALE, FLEx, CMX EDL, and XML files. It does **not** address any user-level issues.

PURPOSE OF THESE FUNCTIONS

The ASC CDL transfer functions are mathematical primitives intended to provide the most basic set of color correction operations – operations compatible with or implementable within all vendors' systems. It should be possible to translate or factor a large set of color correction operations into these basic functions (for example, *Lift* translated into a mathematically equivalent combination of *Slope* and *Offset*).

The ASC CDL is not a "magic bullet" – it does not handle everything necessary to communicate a look. A project must manage and communicate basic and critical information like color space, data representation format, display device, and viewing environment. To communicate a look between on-set and post or between post facilities absolutely requires that information be shared and used intelligently.

We expect that most systems will implement interchange by translation into and out of their system, from a subset of internal operations to ASC CDL operations on output and from ASC CDL operations to appropriate internal representations and operations on input.

Communication of the ASC CDL interchange data is accomplished via XML files, or by new fields in ALE and FLEx and special comments in CMX EDL files. Vendors are expected to support the XML format and also CDL comments in whatever other file formats they already support.

While these approaches are plausible candidates for part of a larger metadata effort, our intent is that CDL interchange be implemented and operational as soon as possible. If desirable, CDL communication can be folded in to larger metadata efforts once they are operational.

Clearly not all operations of interest (e.g. log/linear conversions, 3D LUTs, windowing, tracking) can be expressed with these operations. If vendors would like to expand the set of interchangeable operations, and agree on uniform interpretation of those operations, the ASC would be pleased to have a larger set of operations portable between color correction systems. We anticipate that 3D LUTs, additional methods of maintaining shot/color correction associations, and possibly log/lin conversions will be sought.

The basic ASC CDL functions and interchange formats are already supported by most color correction and edit/conform system vendors. Most other major vendors have implementations scheduled or in-process.

One of the key purposes of the ASC CDL is to communicate corrections between different systems at different facilities. It is very important that color correction system vendors test and verify ASC CDL communication and operation with other vendors' systems. An ASC CDL implementation should not be considered complete until interoperation has been demonstrated and verified.

INTENDED APPLICATION OF TRANSFER FUNCTIONS

These functions are intended for purposes of interchange – to communicate basic color correction operations from set to facility and between systems from different vendors. They are mathematical representations intended for that communication. They are not intended to represent or suggest user level controls or interface, although some systems do provide user-level ASC CDL function controls. User interface changes are not required or expected to support use of ASC CDLs for interchange. Only color correction system implementers need to be acquainted with these functions.

The interchange transfer functions should be considered like mathematical operators. As operators, they can be applied as needed to data in linear or log space, whether or not that application would otherwise be common or traditional. The intent is to provide the set of tools or language to be used for interchange. Vendors can use these functions to describe operations on particular sets of data as and when applicable.

A given correction applied on two systems that are assuming data in different formats will almost certainly produce the wrong look. Likewise, a correction applied to the right data in the right way on two systems must still be viewed on calibrated displays with the same characteristics and in the same viewing conditions to communicate the intended look. Coordination of data and viewing conditions is outside the scope of the CDL but **must** be handled in a project's workflow.

ASC CDL TRANSFER FUNCTIONS

Because the terms *Lift*, *Gain*, and *Gamma* have long established definitions, and because those definitions may vary in detail from system to system and manufacturer to manufacturer, to avoid controversy, competition, and confusion, the ASC uses a set of three transfer functions with unique names and orthogonal (non-overlapping) definitions.

The three basic transfer functions – *Offset*, *Slope*, and *Power* – are applied in the order *Slope*, *Offset*, then *Power* and are sometimes referred to collectively as *SOP*. The transfer functions are

in RGB color space and can be applied in the linear or log domains to each color component. The three transfer functions for the three color components (assuming the current trichromatic systems) can collectively be described by nine parameters.

The traditional *Lift*, *Gain*, and *Gamma* operations, individually or in combination, can be readily translated into *Slope*, *Offset*, and *Power.*

The *Saturation* function was added to the ASC CDL in release 1.2. Unlike the *Slope*, *Offset*, and *Power* functions, *Saturation* operates on all three color channels in combination. The ASC CDL uses a common industry definition for *Saturation* (common Rec. 709 weightings). *Saturation* is applied after *Slope*, *Offset*, and *Power*.

Vendors may still have their own proprietary saturation algorithms, but they must support the "ASC_SAT" algorithm when they are operating in "ASC CDL mode". Manufacturers have indicated they can accommodate any differences from their individual default implementations.

SLOPE

Slope (see Figure 1) changes the slope of the transfer function without shifting the black level established by *Offset* (see next section). The input value, *slope*, ranges from 0.0 (constant output at *Offset*) to less than infinity (although, in practice, systems probably limit at a substantially lower value). The nominal *slope* value is 1.0.

$$out = in * slope \quad 0 \leq slope < \infty$$

Slope adjustment is a component of both traditional *Lift* and *Gain*, but *Lift* combines slope adjustment with a change in *offset* so white is held constant at 1.0.

OFFSET

Offset (see Figure 2) raises or lowers overall brightness of a component. It shifts the transfer function up or down while holding the slope constant. The input value, *offset*, can in theory range from -∞ to +∞ although the range –1.0 to 1.0 will fit most traditional use. The nominal *offset* value is 0.0.

$$out = in + offset \quad -\infty < offset < \infty$$

If the underlying data is log, then *Offset* is an interpretation of *printer points* – the most common method of color correction in film lab work.

POWER

Power (see Figure 3) is the only non-linear function. It changes the intermediate shape of the transfer function. The input value, *power*, ranges from greater than 0.0 to less than infinity. The nominal *power* value is 1.0.

$$out = in \,\hat{}\, power \quad (where \,\hat{}\ is\ "raised\ to\ the\ power") \quad 0 < power < \infty$$

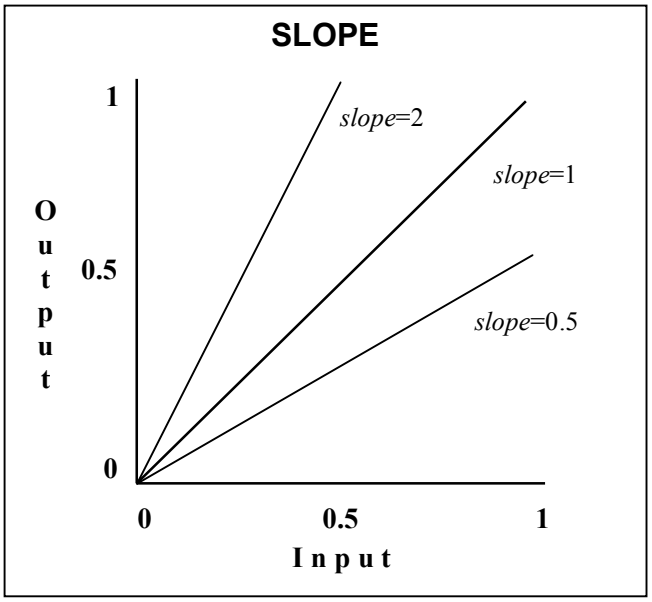

Figure 1

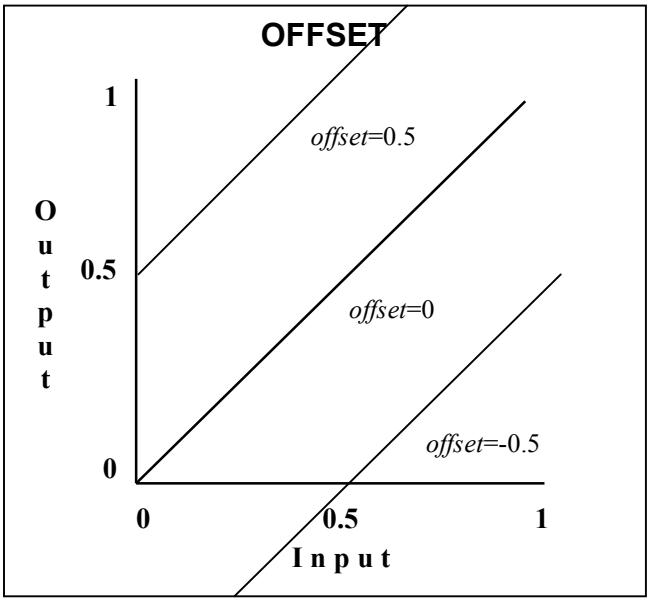

Figure 2

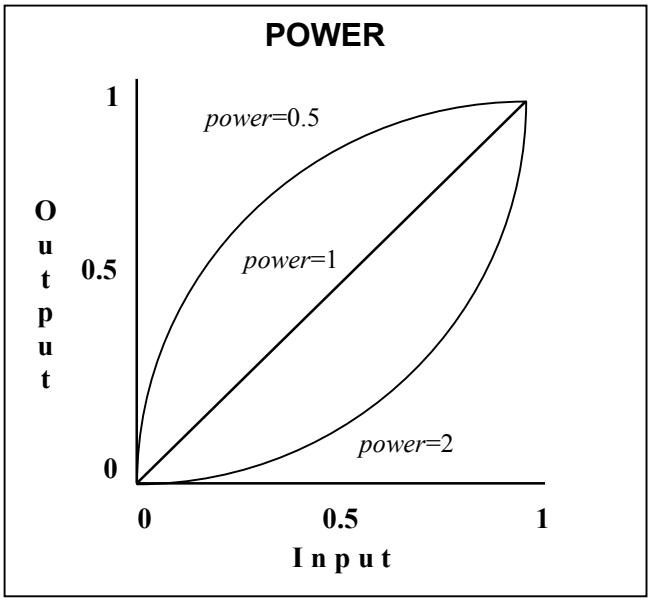

Figure 3

COMBINED SOP FUNCTION

The *Slope*, *Offset*, and *Power* transfer functions can be implemented with three parameters (per color component) – *slope*, *offset*, and *power*. We define order of application as *Slope*, *Offset*, then *Power*. (Note - with proper adjustment of parameters, *Slope* and *Offset* can be applied in reverse order and yield the "reference" result.)

To maintain intended behaviour of signs under exponentiation, we limit the *Slope* and *Offset* combined value to 0 to 1 (inclusive). If the limiting function is called *Clamp*, then

Slope

$$S = in * slope$$

Offset

$$\begin{aligned} O &= S + offset \\ &= (in * slope) + offset \end{aligned}$$

Power

$$\begin{aligned} out &= Clamp(O) \wedge power \\ &= Clamp((in * slope) + offset) \wedge power \end{aligned}$$

SATURATION

Saturation provides a weighted average of the normal color (*saturation* 1.0) and all gray (fully de-saturated, *saturation* 0.0) images. The saturation operation modifies all color components. Color components are weighted by the values most commonly used in Rec. 709 implementations of saturation. *Saturation* values > 1.0 are supported. Values > 4 or so will probably only be used for special purposes.

Saturation is applied after the *SOP* (*Slope, Offset, Power*) operations.

sat is the user input saturation parameter. *inR* is the input red color component value, *G* green, and *B* blue. *outR* is the output red color component value, *G* green, and *B* blue. *luma* is the fully desaturated gray value, based on the color component weightings.

$$\begin{aligned} luma = {} & 0.2126 * inR + \\ & 0.7152 * inG + \\ & 0.0722 * inB \end{aligned}$$

$$\begin{aligned} outR &= Clamp(\ luma + \ sat * (inR - luma)\ ) \\ outG &= Clamp(\ luma + \ sat * (inG - luma)\ ) \\ outB &= Clamp(\ luma + \ sat * (inB - luma)\ ) \end{aligned}$$

$$0 \leq sat < \infty$$

USAGE EXAMPLES

LIFT

Many systems' user interfaces provide a *Lift* function (see Figure 4). *Lift* holds white constant and raises or lowers the value that creates full black. It can be interpreted as a combination of changing the slope of the transfer function and shifting it up or down (so white is maintained). The input (control) value, *lift*, ranges from 0.0 (always white) to less than infinity (always black) (although, in practice, systems probably limit at a substantially lower value). The nominal *lift* value is 1.0.

If *lift* is the value a user has set for the *Lift* control (via ball, slider, text interface, or something else) and we want to export that operation in a CDL, we have to convert *Lift* into CDL operations. The raise/lower element corresponds to *Offset* and the slope element corresponds to *Slope*. *lift* = 1.0 has *slope* 1.0 and *offset* 0; *lift* = 0.5 has *slope* 0.5 and *offset* 0.5; *lift* = 2.0 has *slope* 2.0 and *offset* -1.0. In general...

$$slope = lift$$

$$offset = 1.0 - lift$$

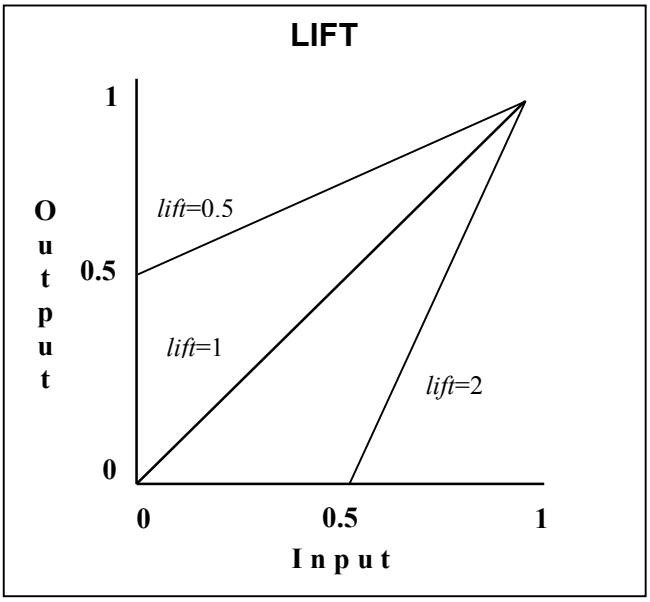

Figure 4

ASC CDL INTERCHANGE FORMATS

The ASC CDL allows basic color corrections to be communicated through the stages of production and post-production and to be interchanged between equipment and software from different manufacturers at different facilities. The underlying color correction algorithms are described in the first part of this document.

The purpose of this section is simply to define the specific syntax employed to transfer the color correction metadata from dailies to editorial and from editorial to post-production so that – provided data representation, color space, and viewing are handled consistently - the initial "look" set for dailies (perhaps from an on-set color correction) can be used as an automatic starting point or first pass for the final color correction session.

We have resisted the urge to completely redefine how information migrates from dailies to editorial to post-production (known as "DI" or digital intermediate), and instead chose to ruthlessly cram this metadata into existing file formats currently employed throughout the industry: namely ALE, FLEx, and CMX EDL files. Well, we've done a little redefining in creation of a couple of XML file types to contain color corrections.

ALE and FLEx files are used to transfer information available at the time of dailies creation to the editorial database. New fields have been added to these files to accommodate ASC CDL color correction metadata for each shot.

CMX EDL files are output from editorial and used primarily to "conform" the individual shots into the final edit. As there is a convention to include shot specific metadata as comment fields after the associated "event" in the EDL file, it made sense to use this mechanism to attach ASC CDL parameters to each "event". There are two ways of specifying this in an EDL file - either "inline" or "via XML reference".

Many vendors are currently using XML to support their internal data structures and have requested there be an official XML syntax for ASC CDL color corrections. We've introduced a hook so that CDL parameters can reside in simple XML text files which can be easily referenced by the CMX EDL format or other vendor-specific formats. We realize that this will require CMX EDL parsers to handle both the "inline" color correction syntax and the "referenced" XML syntax in order to be officially "ASC CDL compliant". (Although it is strongly recommended to parse both CMX EDL syntaxes directly, an acceptable back-door solution would be to provide a stand-alone translation application to convert from one syntax to the other.)

The XML specification defines two types of files:

1. a Color Decision List (CDL) file that contains a set of color decisions (a color correction with a reference to an image) and that may also include other project metadata.

2. a lightweight Color Correction Collection (CCC) file which solely contains one or more color corrections.

Each and every color correction defined in these files requires a unique "ColorCorrection id". Likewise, any specific color correction defined in these XML files can be externally referenced by its unique "ColorCorrection id".

More detailed descriptions are provided in the following documents which are the definitive specifications:

asc-cdl_ale_headers_rev5.pdf
: specifications for the ALE format

asc-cdl_flex_rev3.pdf
: specifications for the FLEx format

asc-cdl_cmx_note_rev12.pdf
: specifications for the CMX EDL format

ASC-CDL_XML_Format_rev2.1.pdf
: specifications for the XML format

ASC-CDL_schema_v1.01.xsd
: xml schema for XML format

(These files can be found in the asc-cdl_documentation/ directory as part of the standard distribution.)

INTERCHANGE SYNTAX EXAMPLES

Here are some brief "excerpted" examples of ASC CDL parameter syntax to help illustrate each of the various file formats. Each example shows an ASC CDL correction with Slope parameters Red 0.9, Green 1.2, and Blue 0.5; Offset Red 0.4, Green -0.5, Blue 0.6; Power Red 1.0, Green 0.8, Blue 1.5; and Saturation 0.85.

Please be advised that some of these legacy file formats are extremely "column" and/or "tab delimiter" dependent. The samples which follow hopefully adhere to that syntax but may have lost a few columns and tabs in translation. Please refer to the documents listed above for complete specifications.

ALE

Sample ALE (extremely tab dependent):

```
Name  Labroll     Camroll     Soundroll   KN Start    KN End      Perf  Tape Start   End
      Scene Take  Pullin      ASC_SOP ASC_SAT
Z109-1      87948 Z29   MOS   EQ581196-9221+00        2     033   13:00:13:25
      13:00:40:00 Z109  1     A     (0.9 1.2 0.5)(0.4 -0.5 0.6)(1.0 0.8 1.5)        0.85
```

FLEx

Sample FLEx (extremely column dependent):

```
701 ASC_SOP(0.9    1.2    0.5   )( 0.4000 -0.5000  0.6000)(1.0    0.8    1.5   )
702 ASC_SAT 0.85
```


CMX EDL "inline"

Sample CMX EDL "inline" (line length constrained)

```
0001 VT029     V    C        09:11:16:20 09:11:22:22 01:00:13:05 01:00:19:07
*ASC_SOP (0.9 1.2 0.5)(0.4 -0.5 0.6)(1.0 0.8 1.5)
*ASC_SAT 0.85
```

CMX EDL "xml reference"

Sample CMX EDL "xml reference"

```
0003 VT032     V    C        12:11:43:21 12:11:52:07 01:00:27:05 01:00:35:15
*ASC_CC_XML cc03345
```

XML Color Correction Collection (CCC)

Sample "CCC" XML file – project.ccc

```
<ColorCorrectionCollection xmlns="urn:ASC:CDL:v1.2">
	<InputDescription> GeneralProducts M1 std thru GP M1 LUT4 </InputDescription>
	<ViewingDescription> GP P1, DCI P3, Pathe color emul </ViewingDescription>
	<ColorCorrection id="cc03345">
		<SOPNode>
			<Slope> 0.9 1.2 0.5 </Slope>
			<Offset> 0.4 -0.5 0.6 </Offset>
			<Power> 1.0 0.8 1.5 </Power>
		</SOPNode>
		<SATNode>
			<Saturation> 0.85 </Saturation>
		</SATNode>
	</ColorCorrection>
</ColorCorrectionCollection>
```

XML Color Correction

Sample "CDL" XML file – project.cdl

```
<ColorDecisionList xmlns="urn:ASC:CDL:v1.2">
	<InputDescription> GeneralProducts M1 std thru GP M1 LUT4 </InputDescription>
	<ViewingDescription> GP P1, DCI P3, Pathe color emul </ViewingDescription>
	<ColorDecision>
		<MediaRef ref="some/Project/image.dpx"/>
		<ColorCorrectionRef ref="cc03345"/>
	</ColorDecision>
</ColorDecisionList>
```


Kudos to David Register for the detailed technical writing and vendor arm-twisting which resulted in the ALE, FLEx, and CMX EDL specifications being supported and implemented. Thanx to Ana Benitez for relentlessly advocating and authoring the XML syntax; Jim Houston and Joachim Zell for keeping things moving forward; and to all the vendors who participated so actively in this work. And thanx to ASC Technology Committee chair Curtis Clark, without whom none of this would be necessary. And to DI sub-committee chair Lou Levinson for agreeing to take all the blame.

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