Technical Bulletin

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ACES Output Transform Details

The Academy of Motion Picture Arts and Sciences
Science and Technology Council
Academy Color Encoding System (ACES) Project

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Summary: This document summarizes each of the twenty-one Output Transforms available as presets to the user in ACES v1.1. The document provides the design characteristics for each transform, the intended display type and setup on which the output of each transform is intended to be viewed, and test values to confirm the proper pairing of transform and display configuration. Where necessary, notes specific to each Output Transform are provided to explain specific design decisions, caution against common misuse, and to obviate other common misunderstandings.

NOTICES

Revision History

Date	Description
06/xx/2018	Initial Version

Related Academy Documents

Document Name	Description
TB-2014-004	Informative Notes on SMPTE ST 2065-1 – Academy Color Encoding Specification (ACES)

Table of Contents

1 Introduction

ACES 1.1 includes twenty-one preset Output Transforms that can be broadly characterized as applying to five different display classes. These display classes include:

- digital cinema projectors typically used in digital intermediate, motion picture mastering, and theatrical exhibition
- standard dynamic range (SDR) broadcast displays used in editorial, on-set preview applications, motion picture mastering, and home television viewing
- computer desktop monitors such as those typically used in the creation of computer generated visual effects (VFX)
- high dynamic range (HDR) digital cinema projectors
- high dynamic range (HDR) broadcast displays used in mastering and home exhibition of HDR content

The parameters for which each Output Transform was designed are described as well as the recommended display and setup configuration to have the output of the transform appear as intended. In addition, a table of test values is provided for each Output Transform to allow for confirming the proper pairing of display configuration and Output Transform selection.

2 Scope

This document is intended to help users understand the intended combination of design and display configuration that will result in an Output Transform looking as intended.

Notes specific to each Transform are provided in an attempt to explain specific design decisions and obviate common misunderstandings.

For the most part, signal sampling rate (i.e. any chroma subsampling), bit depth and range are not considered because the specifics will rely so much on the particulars of any viewing setup. The cabling to the device and . While certainly important for getting a proper image, the specifics of signal sampling, bit depth handing and range are considered beyond the scope of this document.

3 References

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

4 Definition of Parameters

All modern displays typically have menus and options that allow for various configurations. Each Output Transform is designed for a particular display setup.

4.1 Transform Parameters

4.1.1 Transform ID

A versioned unique identifier that is fully described in Academy S-2014-002.

4.1.2 User Name

The string that is recommended for use in menus, etc. in a product user interface. The user-friendly transform name consists of a prefix followed by a specific name but the prefix can be eliminated if the type of transform is clear from the context.

4.1.3 Device Primaries

The device primaries are the chromaticities expected to be produced by the display when the code values in Table 1 are sent to the display.

Table 1 – Display code values (normalized 0-1) for measuring display primaries

Primary	R	G	B
Red	1	0	0
Green	0	1	0
Blue	0	0	1

4.1.4 Device White Point

The calibration white point is defined as the chromaticities and luminance measured when $R{=}G{=}B{=}1$ code values are sent to the display. To achieve expected image appearance, proper calibration of the display to measure the specified chromaticities and luminance of the display calibration white point is essential.

4.1.5 Limiting Primaries

Limiting primaries specify chromaticities to which the display primaries are limited. Unless trying to simulate another type of display, these are usually the same as the device primaries. For example, chromaticities from a P3 transform with limiting primaries set to Rec. 709 would not produce colorimetry outside the Rec. 709 gamut triangle.

4.1.6 Limiting White Point

The white point associated with the limiting primaries. Unless trying to simulate another type of display, this is usually the same as the device white point.

4.1.7 Assumed Observer Adapted White

Color stimulus that an observer, adapted to a set of viewing conditions, would judge to be perfectly achromatic.

4.1.8 Display Black Luminance

Luminance value when device black is presented.

4.1.9 Display Peak White Luminance

Luminance value expected when device white is presented.

4.1.10 Targeted Mid-gray (18%) Luminance

Luminance value expected when ACES $R{=}G{=}B{=}0.18$, rendered by an Output Transform is presented.

4.1.11 Simulated Black Luminance

Parameter to limit lower end of tone scale to a particular luminance value even when shown on a higher dynamic range device.

4.1.12 Simulated White Luminance

Parameter to limit upper end of tone scale to a particular luminance value even when shown on a higher dynamic range device.

4.1.13 Viewing Environment Surround

The lighting conditions surrounding the screen being viewed. For a theater, this is dark. For home television, assumed to be dim.

4.1.14 EOTF

Electro-optical transfer function defines the relationship between digital code values and visible light produced by a display.

4.1.15 Encoding Range

Specifies whether data is full range or SMPTE legal range.

4.2 Display Setup Parameters

Display setup parameters define the recommended display type and setup for which each Output Transform was designed.

The recommended display settings for each Output Transform are based on the traditional device and application for which that transform was designed. Note that is possible (and in some cases, common) to substitute other devices that have similar capabilities to the Output Transform recommendations. For example, one could substitute a P3-capable reference monitor calibrated to the proper luminance in place of a P3 projector. In such instances, it is possible that the recommended signal and/or bit-depth will need to differ from the recommendation in order to meet the signal-delivery expectations of the alternate display. The test code values are specified in normalized 0-1 range, so the final bit depth and signal formatting can be obtained with simple conversion of the floating-point numbers for device-specific signal formatting.

4.2.1 Display Type

The display type parameter describes the general category of display technology used. Examples include a digital cinema projector, professional broadcast monitor, etc.

4.2.2 Display Dynamic Range

The dynamic range of the display can vary from the manufacturers advertised numbers. Dynamic range is hardly ever consistent. For example, the DCI specification only states a minimum dynamic range of 2000:1, but projector dynamic ranges can fall anywhere from 2000:1 to 10,000:1.

4.2.3 Display Max Luminance

The display maximum luminance is the luminance that the display is set to produce when sent the maximum code value in each channel. It is specified in cd/m^2 (nits).

4.2.4 Viewing Environment

The lighting conditions surrounding the screen being viewed. For a theater, this is dark. For home television, assumed to be dim.

4.2.5 Display Primaries

The display primaries are the chromaticities produced by the display when the code values in Table 1 are sent to the display. For modern broadcast monitors, display primaries are set in the displays menu. For digital cinema projectors, they are specified in a TCGD. To achieve expected image appearance, proper calibration of the display to measure the specified chromaticities for each primary is essential.

4.2.6 Display Calibration White Point

The calibration white point is defined as the chromaticities and luminance measured when $R{=}G{=}B{=}1$ code values are sent to the display. To achieve expected image appearance, proper calibration of the display to measure the specified chromaticities and luminance of the display calibration white point is essential.

4.2.7 Display EOTF

The electro-optical transfer function (EOTF) converts the electrical signal into the linear light output of the display.

4.3 Test Values

A table of test values are provided for each Output Transform that can be used to confirm the proper monitor setup and Output Transform combination.

Each of the nine ACES RGB input values should yield the noted display RGB code values (normalized 0-1, full range) when processed through the Output Transform. If the display RGB code values do not match those in the table when using the corresponding input ACES RGB code values, it is likely the wrong Output Transform is being used.

When driving a properly setup display with the noted display RGB code values, the light from the display should measure with the noted CIE xyY colorimetry. If the proper display RGB code values are being produced by the Output Transform, but the measured display colorimetry does not match the listed display xyY values, the display setup is likely incorrect.

5 SDR Digital Cinema Projection (48-nits)

5.1 P3-D60

5.1.1 Summary

This transform is intended for rendering OCES onto a P3 digital cinema projector calibrated to a D60 white point at $48\,\mathrm{cd}/\mathrm{m}^2$. It can also be used for other display types set for P3 primaries with a D60 white point and a 2.6 gamma.

5.1.2 Transform Parameters

ACES Transform ID	`ODT.Academy.P3D60_48nits.a1.0.3`
ACES User Name	ACES 1.0 Output - P3-D60
Device Primaries	Red x=0.68 y=0.32 Green x=0.265 y=0.69 Blue x=0.15 y=0.06
Device White Point	ACES x=0.32168 y=0.33767 Y=48 cd/m^2
Limiting Primaries	Red x=0.68 y=0.32 Green x=0.265 y=0.69 Blue x=0.15 y=0.06
Limiting White Point	ACES x=0.32168 y=0.33767 Y=48 cd/m^2
Assumed Observer Adapted White	ACES x=0.32168 y=0.33767
Display Black Luminance	$\leq$ 0.024 cd/m^2
Display Peak White Luminance	48 cd/m^2
Targeted Mid-gray (18%) Luminance	4.8 cd/m^2
Simulated Black Luminance	N/A
Simulated White Luminance	N/A
Viewing Environment Surround	Dark
EOTF	Gamma 2.6
Encoding Range	Full

Table 2 – Transform Parameters: P3-D60

5.1.3 Recommended Display and Setup

Display Type	DCI compliant projector
Display Dynamic Range	$\geq$ 2,000:1 to $\sim$10,000:1
Display Max Luminance	48 cd/m^2
Viewing Environment	Dark
Display Primaries	Red x=0.68 y=0.32 Green x=0.265 y=0.69 Blue x=0.15 y=0.06
Display Calibration White Point	ACES x=0.32168 y=0.33767 Y=48 cd/m^2
EOTF	Gamma 2.6

Table 3 – Display Setup: P3-D60

5.1.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.9056	0.9056	0.9056	0.3217	0.3377	37.09
N2	0.2753	0.2753	0.2753	0.5209	0.5209	0.5209	0.3217	0.3377	8.81
N3	0.0898	0.0898	0.0898	0.2714	0.2714	0.2714	0.3217	0.3377	1.62
R	0.4689	0.1193	0.0417	0.7786	0.2303	0.1783	0.6412	0.3307	6.72
G	0.339	0.8068	0.0936	0.4185	0.8322	0.2411	0.3043	0.6246	21.79
B	0.2162	0.133	0.8711	0.1648	0.1554	0.816	0.1562	0.0692	2.44
C	0.5187	0.9138	1.0432	0.4174	0.8317	0.8371	0.2263	0.3398	23.87
M	0.58	0.2096	0.9086	0.7818	0.2207	0.8243	0.3325	0.1593	8.79
Y	0.8237	0.9378	0.0855	0.8392	0.8399	0.246	0.4336	0.5192	28.34

Table 4 – Test Values: ACES 1.0 Output - P3-D60

5.1.5 Notes

The "P3-D60" PCF is not typically included by the manufacturer by default in most digital cinema projectors. It must be downloaded an installed in the projector using the appropriate projector configuration software (e.g. DCP Librarian). Once the PCF is installed and activate neutral ACES values (ACES $R{=}G{=}B$) processed through the transform will produce equal red, green and blue projector code values, will have equal levels on the waveform, will land in the middle of the vector scope, will appear neutral on a D65 calibrated computer monitor, and will produce the chromaticity $x{=}0.32168$ $y{=}0.33767$ (aka D60) on the projection screen.

Often the resulting projector code values are saved into a file an converted using specialized tools (e.g. R&S Clipster, Colorfront Transkoder, etc.) into DCDMs and/or a DPC for distribution. It is important to note that many conversion tool assume that equal red, green, and blue projector code values are intended to produce a chromaticity of $x{=}0.3140$ $y{=}0.3510$ on the screen. Converting the projector code values from using tools that assume the white is encoded as $x{=}0.3140$ $y{=}0.3510$ will result in incorrect DCDM and/or DCP files. The tools must explicitly be capable of converting projector code values where equal red, green, and blue projector code values are intended to produce a chromaticity $x{=}0.32168$ $y{=}0.33767$ (aka D60) on the screen.

5.2 P3-D65

5.2.1 Summary

This transform is intended for rendering OCES onto a P3 digital cinema projector calibrated to a D65 white point at $48\,\mathrm{cd/m^2}$. It can also be used for other display types set for P3 primaries with a D65 white point and a 2.6 gamma.

5.2.2 Transform Parameters

ACES Transform ID	`ODT.Academy.P3D65_48nits.a1.1`			
ACES User Name	ACES 1.0 Output - P3-D65			
Device Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Device White Point	D65	x=0.3127	y=0.329	Y=48 cd/m^2
Limiting Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Limiting White Point	D65	x=0.3127	y=0.329	Y=48 cd/m^2
Assumed Observer Adapted White	D65	x=0.3127	y=0.329	
Display Black Luminance	$\leq 0.024\,\mathrm{cd/m^2}$			
Display Peak White Luminance	$48\,\mathrm{cd/m^2}$			
Targeted Mid-gray (18%) Luminance	$4.8\,\mathrm{cd/m^2}$			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dark			
EOTF	Gamma 2.6			
Encoding Range	Full			

Table 5 – Transform Parameters: P3-D65

5.2.3 Recommended Display and Setup

Display Type	DCI compliant projector			
Display Dynamic Range	$\geq$ 2,000:1 to $\sim$10,000:1			
Display Max Luminance	$48\,\mathrm{cd/m^2}$			
Viewing Environment	Dark			
Display Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=48 cd/m^2
EOTF	Gamma 2.6			

Table 6 – Display Setup: P3-D65

5.2.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.9056	0.9056	0.9056	0.3127	0.329	37.09
N2	0.2753	0.2753	0.2753	0.5209	0.5209	0.5209	0.3127	0.329	8.81
N3	0.0898	0.0898	0.0898	0.2714	0.2714	0.2714	0.3127	0.329	1.62
R	0.4689	0.1193	0.0417	0.7847	0.2315	0.1792	0.6387	0.3304	6.63
G	0.339	0.8068	0.0936	0.405	0.8326	0.2427	0.2988	0.6262	21.77
B	0.2162	0.133	0.8711	0.1475	0.1475	0.8157	0.1543	0.0671	2.55
C	0.5187	0.9138	1.0432	0.3998	0.8315	0.837	0.22	0.3287	23.96
M	0.58	0.2096	0.9086	0.7866	0.2176	0.8241	0.3209	0.1529	8.82
Y	0.8237	0.9378	0.0855	0.8404	0.8404	0.2483	0.4288	0.521	28.22

Table 7 – Test Values: ACES 1.0 Output - P3-D65

5.2.5 Notes

The "P3-D65" PCF is not typically included by the manufacturer by default in most digital cinema projectors. It must be downloaded an installed in the projector using the appropriate projector configuration software (e.g. DCP Librarian). Once the PCF is installed and activate neutral ACES values (ACES R=G=B) processed through the transform will produce equal red, green and blue projector code values, will have equal levels on the waveform, will land in the middle of the vector scope, will appear neutral on a D65 calibrated computer monitor, and will produce the chromaticity x=0.3127 y=0.3290 (aka D65) on the projection screen.

Often the resulting projector code values are saved into a file an converted using specialized tools (e.g. R&S Clipster, Colorfront Transkoder, etc.) into DCDMs and/or a DPC for distribution. It is important to note that many conversion tool assume that equal red, green, and blue projector code values are intended to produce a chromaticity of x=0.3140 y=0.3510 on the screen. Converting the projector code values from using tools that assume the white is encoded as x=0.3140 y=0.3510 will result in incorrect DCDM and/or DCP files.

The tools must explicitly be capable of converting projector code values where equal red, green, and blue projector code values are intended to produce a chromaticity x=0.32168 y=0.33767 (aka D60) on the screen.

5.3 P3-D65 (D60 Simulation)

5.3.1 Summary

This transform is intended for rendering OCES onto a P3 digital cinema projector calibrated to a D65 white point at $48\,\mathrm{cd/m^2}$. It can also be used for other display types set for P3 primaries with a D65 white point and a 2.6 gamma.

5.3.2 Transform Parameters

ACES Transform ID	`ODT.Academy.P3D65_D60sim_48nits.a1.1`			
ACES User Name	ACES 1.0 Output - P3-D65 (D60 Simulation)			
Device Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Device White Point	D65	x=0.3127	y=0.329	Y=48 cd/m^2
Limiting Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Limiting White Point	D65	x=0.3127	y=0.329	Y=48 cd/m^2
Assumed Observer Adapted White	ACES	x=0.32168	y=0.33767	
Display Black Luminance	$\leq 0.024\,\mathrm{cd/m^2}$			
Display Peak White Luminance	$48\,\mathrm{cd/m^2}$			
Targeted Mid-gray (18%) Luminance	$4.8\,\mathrm{cd/m^2}$			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dark			
EOTF	Gamma 2.6			
Encoding Range	Full			

Table 8 – Transform Parameters: P3-D65 (D60 Simulation)

5.3.3 Recommended Display and Setup

Display Type	DCI compliant projector			
Display Dynamic Range	$\geq$ 2,000:1 to $\sim$10,000:1			
Display Max Luminance	$48\,\mathrm{cd/m^2}$			
Viewing Environment	Dark			
Display Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=48 cd/m^2
EOTF	Gamma 2.6			

Table 9 – Display Setup: P3-D65 (D60 Simulation)

5.3.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.9058	0.8917	0.866	0.3217	0.3377	35.76
N2	0.2753	0.2753	0.2753	0.521	0.5129	0.4981	0.3217	0.3377	8.49
N3	0.0898	0.0898	0.0898	0.2715	0.2673	0.2595	0.3217	0.3377	1.56
R	0.4689	0.1193	0.0417	0.7788	0.2267	0.1704	0.6412	0.3307	6.48
G	0.339	0.8068	0.0936	0.4186	0.8194	0.2305	0.3043	0.6246	21.01
B	0.2162	0.133	0.8711	0.1648	0.153	0.7803	0.1562	0.0692	2.35
C	0.5187	0.9138	1.0432	0.4174	0.8189	0.8004	0.2263	0.3398	23.02
M	0.58	0.2096	0.9086	0.782	0.2173	0.7882	0.3325	0.1593	8.48
Y	0.8237	0.9378	0.0855	0.8393	0.8269	0.2353	0.4336	0.5192	27.32

Table 10 – Test Values: ACES 1.0 Output - P3-D65 (D60 Simulation)

5.3.5 Notes

See Section 5.2.5.

5.4 P3-D65 (Rec. 709 Limited)

5.4.1 Summary

This transform is intended for rendering OCES onto a P3 digital cinema projector calibrated to a D65 white point at $48\,\mathrm{cd/m^2}$. It can also be used for other display types set for P3 primaries with a D65 white point and a 2.6 gamma. This transform will limit output colorimetry to the Rec.709 gamut.

5.4.2 Transform Parameters

ACES Transform ID	`ODT.Academy.P3D65_Rec709limited_48nits.a1.1`			
ACES User Name	ACES 1.0 Output - P3-D65 (Rec. 709 Limited)			
Device Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Device White Point	D65	x=0.3127	y=0.329	Y=48 cd/m^2
Limiting Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Limiting White Point	D65	x=0.3127	y=0.329	Y=48 cd/m^2
Assumed Observer Adapted White	D65	x=0.3127	y=0.329	
Display Black Luminance	$\leq 0.024\,\mathrm{cd/m^2}$			
Display Peak White Luminance	$48\,\mathrm{cd/m^2}$			
Targeted Mid-gray (18%) Luminance	$4.8\,\mathrm{cd/m^2}$			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dark			
EOTF	Gamma 2.6			
Encoding Range	Full			

Table 11 – Transform Parameters: P3-D65 (Rec. 709 Limited)

5.4.3 Recommended Display and Setup

Display Type	DCI compliant projector			
Display Dynamic Range	$\geq$ 2,000:1 to $\sim$10,000:1			
Display Max Luminance	$48\,\mathrm{cd/m^2}$			
Viewing Environment	Dark			
Display Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=48 cd/m^2
EOTF	Gamma 2.6			

Table 12 – Display Setup: P3-D65 (Rec. 709 Limited)

5.4.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.9056	0.9056	0.9056	0.3127	0.329	37.09
N2	0.2753	0.2753	0.2753	0.5209	0.5209	0.5209	0.3127	0.329	8.81
N3	0.0898	0.0898	0.0898	0.2714	0.2714	0.2714	0.3127	0.329	1.62
R	0.4689	0.1193	0.0417	0.7847	0.2315	0.1792	0.6387	0.3304	6.63
G	0.339	0.8068	0.0936	0.4341	0.833	0.3074	0.3	0.6	22.08
B	0.2162	0.133	0.8711	0.1475	0.1475	0.8157	0.1543	0.0671	2.55
C	0.5187	0.9138	1.0432	0.4335	0.832	0.8373	0.2246	0.3287	24.23
M	0.58	0.2096	0.9086	0.7869	0.2289	0.8242	0.3209	0.1542	8.91
Y	0.8237	0.9378	0.0855	0.8404	0.8404	0.3321	0.4193	0.5053	28.34

Table 13 – Test Values: ACES 1.0 Output - P3-D65 (Rec. 709 Limited)

5.4.5 Notes

See Section 5.2.5.

5.5 P3-DCI (D60 Simulation)

5.5.1 Summary

This transform is intended for rendering OCES onto a P3 digital cinema projector calibrated to a DCI white point at $48\,\mathrm{cd/m^2}$. It can also be used for other display types set for P3 primaries with a DCI white point and a 2.6 gamma.

5.5.2 Transform Parameters

ACES Transform ID	`ODT.Academy.P3DCI_D60sim_48nits.a1.1`			
ACES User Name	ACES 1.0 Output - P3-DCI (D60 Simulation)			
Device Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Device White Point	DCI	x=0.314	y=0.351	Y=48 cd/m^2
Limiting Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Limiting White Point	DCI	x=0.314	y=0.351	Y=48 cd/m^2
Assumed Observer Adapted White	ACES	x=0.32168	y=0.33767	
Display Black Luminance	$\leq 0.024\,\mathrm{cd/m^2}$			
Display Peak White Luminance	$48\,\mathrm{cd/m^2}$			
Targeted Mid-gray (18%) Luminance	$4.8\,\mathrm{cd/m^2}$			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dark			
EOTF	Gamma 2.6			
Encoding Range	Full			

Table 14 – Transform Parameters: P3-DCI (D60 Simulation)

5.5.3 Recommended Display and Setup

Display Type	DCI compliant projector			
Display Dynamic Range	$\geq$ 2,000:1 to $\sim$10,000:1			
Display Max Luminance	$48\,\mathrm{cd/m^2}$			
Viewing Environment	Dark			
Display Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	DCI	x=0.314	y=0.351	Y=48 cd/m^2
EOTF	Gamma 2.6			

Table 15 – Display Setup: P3-DCI (D60 Simulation)

5.5.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.9243	0.8651	0.9013	0.3217	0.3377	34.49
N2	0.2753	0.2753	0.2753	0.5383	0.5038	0.5249	0.3217	0.3377	8.46
N3	0.0898	0.0898	0.0898	0.2805	0.2625	0.2735	0.3217	0.3377	1.55
R	0.4689	0.1193	0.0417	0.8046	0.2227	0.1796	0.6412	0.3307	6.45
G	0.339	0.8068	0.0936	0.4336	0.8035	0.2433	0.3046	0.624	20.84
B	0.2162	0.133	0.8711	0.1709	0.1504	0.8215	0.1562	0.0693	2.34
C	0.5187	0.9138	1.0432	0.4331	0.8028	0.8406	0.2269	0.3404	22.82
M	0.58	0.2096	0.9086	0.808	0.2136	0.8294	0.333	0.1596	8.44
Y	0.8237	0.9378	0.0855	0.8654	0.8096	0.2488	0.4338	0.5187	26.99

Table 16 – Test Values: ACES 1.0 Output - P3-DCI (D60 Simulation)

5.5.5 Notes

Using the "DCI-P3" PCF, the projector will be configured such that equal red, green, and blue display code values will produce the chromaticity CIE x=0.3140 y=0.3510 on the screen. However, the P3-DCI (D60 Simulation) Output Transform is configured such that neutral ACES source file values (ACES R=G=B) will produce non-equal projector code values. The chromaticity produced on screen by those non-equal projector code values will be CIE x=0.32168 y=0.33767 (aka D60).

It is important to note that the image on the projection screen may look distinctly less green than some workflows that utilize a projector setup with the "DCI-P3" PCF. This will also be reflected on the color corrector scopes when neutral ACES values are sent through the Output Transform. Neutral ACES values processed through will *not* have equal levels on the waveform, nor will they land in the middle of the vector scope. This behavior is intentional.

The image may also have a distinct magenta cast if viewed on a computer monitor such as the one used for

the color corrector user interface. This is because that monitor is typically calibrated to a D65 white point. Although not denoted in the name prior to ACES 1.1, this transform mimics the behavior found in other Output Transforms included in ACES 1.0 that are labeled “D60 sim”. Due to this “D60 sim” behavior the maximum output screen luminance of neutral ACES values will be slightly less than the maximum calibration luminance (e.g. $48\,\mathrm{cd}/\mathrm{m}^2$) produced by the maximum equal projector code values (CV $R{=}G{=}B{=}1$).

5.6 P3-DCI (D65 Simulation)

5.6.1 Summary

This transform is intended for rendering OCES onto a P3 digital cinema projector calibrated to a DCI white point at $48\,\mathrm{cd/m^2}$. It can also be used for other display types set for P3 primaries with a DCI white point and a 2.6 gamma.

5.6.2 Transform Parameters

ACES Transform ID	`ODT.Academy.P3DCI_D65sim_48nits.a1.1`			
ACES User Name	ACES 1.0 Output - P3-DCI (D65 Simulation)			
Device Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Device White Point	DCI	x=0.314	y=0.351	Y=48 cd/m^2
Limiting Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Limiting White Point	DCI	x=0.314	y=0.351	Y=48 cd/m^2
Assumed Observer Adapted White	D65	x=0.3127	y=0.329	
Display Black Luminance	$\leq 0.024\,\mathrm{cd/m^2}$			
Display Peak White Luminance	$48\,\mathrm{cd/m^2}$			
Targeted Mid-gray (18%) Luminance	$4.8\,\mathrm{cd/m^2}$			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dark			
EOTF	Gamma 2.6			
Encoding Range	Full			

Table 17 – Transform Parameters: P3-DCI (D65 Simulation)

5.6.3 Recommended Display and Setup

Display Type	DCI compliant projector			
Display Dynamic Range	$\geq$ 2,000:1 to $\sim$10,000:1			
Display Max Luminance	$48\,\mathrm{cd/m^2}$			
Viewing Environment	Dark			
Display Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	DCI	x=0.314	y=0.351	Y=$48\,\mathrm{cd/m^2}$
EOTF	Gamma 2.6			

Table 18 – Display Setup: P3-DCI (D65 Simulation)

5.6.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.9089	0.8642	0.927	0.3127	0.329	34.26
N2	0.2753	0.2753	0.2753	0.5301	0.5041	0.5407	0.3127	0.329	8.43
N3	0.0898	0.0898	0.0898	0.2762	0.2626	0.2817	0.3127	0.329	1.55
R	0.4689	0.1193	0.0417	0.7985	0.224	0.186	0.6387	0.3304	6.35
G	0.339	0.8068	0.0936	0.4136	0.8041	0.2524	0.2992	0.6255	20.75
B	0.2162	0.133	0.8711	0.151	0.1429	0.8458	0.1544	0.0672	2.43
C	0.5187	0.9138	1.0432	0.4092	0.8028	0.8655	0.2206	0.3293	22.83
M	0.58	0.2096	0.9086	0.8006	0.2107	0.854	0.3214	0.1532	8.44
Y	0.8237	0.9378	0.0855	0.8533	0.8101	0.2587	0.4291	0.5204	26.79

Table 19 – Test Values: ACES 1.0 Output - P3-DCI (D65 Simulation)

5.6.5 Notes

Using the "DCI-P3" PCF, the projector will be configured such that equal red, green, and blue display code values will produce the chromaticity CIE x=0.3140 y=0.3510 on the screen. However, the P3-DCI (D65 Simulation) Output Transform is configured such that neutral ACES source file values (ACES R=G=B) will produce non-equal projector code values. The chromaticity produced on screen by those non-equal projector code values will be CIE x=0.32168 y=0.33767 (aka D60).

It is important to note that the image on the projection screen may look distinctly less green than some workflows that utilize a projector setup with the "DCI-P3" PCF. This will also be reflected on the color corrector scopes when neutral ACES values are sent through the Output Transform. Neutral ACES values processed through will *not* have equal levels on the waveform, nor will they land in the middle of the vector scope. This behavior is intentional.

The image may also have a distinct magenta cast if viewed on a computer monitor such as the one used for

the color corrector user interface. This is because that monitor is typically calibrated to a D65 white point.

This transform mimics the behavior found in other Output Transforms that are labeled "D65 sim". Due to this "D65 sim" behavior the maximum output screen luminance of neutral ACES values will be slightly less than the maximum calibration luminance (e.g. $48\,\mathrm{cd}/\mathrm{m}^2$) produced by the maximum equal projector code values (CV $R{=}G{=}B{=}1$).

5.7 DCDM

5.7.1 Summary

This transform is intended for rendering OCES onto a digital cinema projector calibrated to match the Digital Cinema Reference Projector Specification outlined in SMPTE RP 431-2-2007 (e.g. XYZ). It can also be used for other displays set to expect XYZ colorimetry encoded with a gamma 2.6.

5.7.2 Transform Parameters

ACES Transform ID	`ODT.Academy.DCDM.a1.0.3`			
ACES User Name	ACES 1.0 Output - DCDM			
Device Primaries	Red	x=0.0	y=1.0	
	Green	x=1.0	y=0.0	
	Blue	x=0.0	y=0.0	
Device White Point	DCI	x=0.314	y=0.351	Y=48 cd/m^2
Limiting Primaries	Red	x=0.0	y=1.0	
	Green	x=1.0	y=0.0	
	Blue	x=0.0	y=0.0	
Limiting White Point	DCI	x=0.314	y=0.351	Y=48 cd/m^2
Assumed Observer Adapted White	ACES	x=0.32168	y=0.33767	
Display Black Luminance	$\leq$ 0.024 cd/m^2			
Display Peak White Luminance	48 cd/m^2			
Targeted Mid-gray (18%) Luminance	4.8 cd/m^2			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dark			
EOTF	Gamma 2.6			
Encoding Range	Full			

Table 20 – Transform Parameters: DCDM

5.7.3 Recommended Display and Setup

Display Type	DCI compliant projector			
Display Dynamic Range	$\geq$ 2,000:1 to $\sim$10,000:1			
Display Max Luminance	$48\,\mathrm{cd/m^2}$			
Viewing Environment	Dark			
Display Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	DCI	x=0.314	y=0.351	Y=48 cd/m^2
EOTF	Gamma 2.6			

Table 21 – Display Setup: DCDM

5.7.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.8596	0.8758	0.8787	0.3217	0.3377	37.09
N2	0.2753	0.2753	0.2753	0.4945	0.5038	0.5055	0.3217	0.3377	8.81
N3	0.0898	0.0898	0.0898	0.2576	0.2625	0.2634	0.3217	0.3377	1.62
R	0.4689	0.1193	0.0417	0.5856	0.4539	0.1757	0.6412	0.3307	6.72
G	0.339	0.8068	0.0936	0.5413	0.7137	0.3096	0.3043	0.6246	21.79
B	0.2162	0.133	0.8711	0.4204	0.3074	0.7782	0.1562	0.0692	2.44
C	0.5187	0.9138	1.0432	0.6323	0.7392	0.812	0.2263	0.3398	23.87
M	0.58	0.2096	0.9086	0.668	0.5034	0.7864	0.3325	0.1593	8.79
Y	0.8237	0.9378	0.0855	0.7367	0.7896	0.314	0.4336	0.5192	28.34

Table 22 – Test Values: ACES 1.0 Output - DCDM

5.7.5 Notes

It is not recommended to use the DCDM ODT during the DI process. Rather, the DCDM ODT is provided as a convenience to aid in the conversion of the final RGB graded master into a DCDM version when more appropriate tools are not available. In general, it is recommended RGB master files be produced with the appropriate ODT for the mastering display device and that those RGB files be converted to a DCDM using a tool designed for DCDM transcodings.

This DCDM ODT does not limit the rendered colorimetry to any particular display color gamut; therefore, changing from a mastering display ODT (e.g. P3-D65) to the DCDM ODT may allow colorimetry outside the mastering display color gamut. This may lead to unintended colors being reproduced on an exhibition display with a larger color gamut than the original mastering display. To limit gamut, see Section 5.8 or Section 5.9.

5.8 DCDM (P3-D60 Limited)

5.8.1 Summary

This transform is intended for rendering OCES onto a digital cinema projector calibrated to match the Digital Cinema Reference Projector Specification outlined in SMPTE RP 431-2-2007 (e.g. XYZ). It can also be used for other displays set to expect XYZ colorimetry encoded with a gamma 2.6.

This transform limits the output color gamut to P3 primaries with an ACES (D60) whitepoint. Assuming the content was graded (and approved) on a projector with a P3-D60 gamut, limiting the XYZ colorimetry to that gamut assures there will be no unexpected color appearance if the DCDM files are later viewed on a device with a wider gamut.

Thus, gamut mapping is handled by the ODT by clipping any XYZ values that map outside of the P3 gamut. Without clipping, the handling of any colorimetry outside of the P3 gamut it would be left to the projectors processing. In most devices, this is performed using a simple clip anyway, but not always. If out-of-gamut values were left to be handled by the device, different image appearance could potentially result on different devices even though they have the same gamut.

5.8.2 Transform Parameters

ACES Transform ID	`ODT.Academy.DCDM_P3D60limited.a1.1`			
ACES User Name	ACES 1.0 Output - DCDM (P3-D60 Limited)			
Device Primaries	Red	x=0.0	y=1.0	
	Green	x=1.0	y=0.0	
	Blue	x=0.0	y=0.0	
Device White Point	DCI	x=0.314	y=0.351	Y=48 cd/m^2
Limiting Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Limiting White Point	ACES	x=0.32168	y=0.33767	Y=48 cd/m^2
Assumed Observer Adapted White	ACES	x=0.32168	y=0.33767	
Display Black Luminance	≤ 0.024 cd/m^2			
Display Peak White Luminance	48 cd/m^2			
Targeted Mid-gray (18%) Luminance	4.8 cd/m^2			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dark			
EOTF	Gamma 2.6			
Encoding Range	Full			

Table 23 – Transform Parameters: DCDM (P3-D60 Limited)

5.8.3 Recommended Display and Setup

Display Type	DCI compliant projector			
Display Dynamic Range	$\geq$ 2,000:1 to $\sim$10,000:1			
Display Max Luminance	$48\,\mathrm{cd/m^2}$			
Viewing Environment	Dark			
Display Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	DCI	x=0.314	y=0.351	Y=48 cd/m^2
EOTF	Gamma 2.6			

Table 24 – Display Setup: DCDM (P3-D60 Limited)

5.8.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.8596	0.8758	0.8787	0.3217	0.3377	37.09
N2	0.2753	0.2753	0.2753	0.4945	0.5038	0.5055	0.3217	0.3377	8.81
N3	0.0898	0.0898	0.0898	0.2576	0.2625	0.2634	0.3217	0.3377	1.62
R	0.4689	0.1193	0.0417	0.5856	0.4539	0.1757	0.6412	0.3307	6.72
G	0.339	0.8068	0.0936	0.5413	0.7137	0.3096	0.3043	0.6246	21.79
B	0.2162	0.133	0.8711	0.4204	0.3074	0.7782	0.1562	0.0692	2.44
C	0.5187	0.9138	1.0432	0.6323	0.7392	0.812	0.2263	0.3398	23.87
M	0.58	0.2096	0.9086	0.668	0.5034	0.7864	0.3325	0.1593	8.79
Y	0.8237	0.9378	0.0855	0.7367	0.7896	0.314	0.4336	0.5192	28.34

Table 25 – Test Values: ACES 1.0 Output - DCDM (P3-D60 Limited)

5.8.5 Notes

It is not recommended to use the DCDM ODT during the DI process. Rather, the DCDM ODT is provided as a convenience to aid in the conversion of the final RGB graded master into a DCDM version when more appropriate tools are not available. In general, it is recommended that RGB master files be produced with the appropriate ODT for the mastering display device and that those RGB files be converted to a DCDM using a tool designed for DCDM transcodings.

This DCDM ODT limits the rendered colorimetry to the color gamut of P3-D60. This prevents unintended colors from being reproduced on an exhibition display with a larger color gamut than the original mastering display.

5.9 DCDM (P3-D65 Limited)

5.9.1 Summary

This transform is intended for rendering OCES onto a digital cinema projector calibrated to match the Digital Cinema Reference Projector Specification outlined in SMPTE RP 431-2-2007 (e.g. XYZ). It can also be used for other displays set to expect XYZ colorimetry encoded with a gamma 2.6.

This transform limits the output color gamut to P3 primaries with a D65 white point. Assuming the content was graded (and approved) on a projector with a P3-D65 gamut, limiting the XYZ colorimetry to that gamut assures there will be no unexpected color appearance if the DCDM files are later viewed on a device with a wider gamut.

Thus, gamut mapping is handled by the ODT by clipping any XYZ values that map outside of the P3 gamut. Without clipping, the handling of any colorimetry outside of the P3 gamut it would be left to the projectors processing. In most devices, this is performed using a simple clip anyway, but not always. If out-of-gamut values were left to be handled by the device, different image appearance could potentially result on different devices even though they have the same gamut.

5.9.2 Transform Parameters

ACES Transform ID	`ODT.Academy.DCDM_P3D65limited.a1.1`			
ACES User Name	ACES 1.0 Output - DCDM (P3-D65 Limited)			
Device Primaries	Red	x=0.0	y=1.0	
	Green	x=1.0	y=0.0	
	Blue	x=0.0	y=0.0	
Device White Point	DCI	x=0.314	y=0.351	Y=48 cd/m^2
Limiting Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Limiting White Point	D65	x=0.3127	y=0.329	Y=48 cd/m^2
Assumed Observer Adapted White	ACES	x=0.32168	y=0.33767	
Display Black Luminance	≤ 0.024 cd/m^2			
Display Peak White Luminance	48 cd/m^2			
Targeted Mid-gray (18%) Luminance	4.8 cd/m^2			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dark			
EOTF	Gamma 2.6			
Encoding Range	Full			

Table 26 – Transform Parameters: DCDM (P3-D65 Limited)

5.9.3 Recommended Display and Setup

Display Type	DCI compliant projector			
Display Dynamic Range	$\geq$ 2,000:1 to $\sim$10,000:1			
Display Max Luminance	$48\,\mathrm{cd/m^2}$			
Viewing Environment	Dark			
Display Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	DCI	x=0.314	y=0.351	Y=48 cd/m^2
EOTF	Gamma 2.6			

Table 27 – Display Setup: DCDM (P3-D65 Limited)

5.9.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.8588	0.8758	0.905	0.3127	0.329	37.09
N2	0.2753	0.2753	0.2753	0.494	0.5038	0.5206	0.3127	0.329	8.81
N3	0.0898	0.0898	0.0898	0.2574	0.2625	0.2712	0.3127	0.329	1.62
R	0.4689	0.1193	0.0417	0.5821	0.4517	0.1818	0.6387	0.3304	6.63
G	0.339	0.8068	0.0936	0.5367	0.7134	0.3154	0.2988	0.6262	21.77
B	0.2162	0.133	0.8711	0.4305	0.3125	0.8022	0.1543	0.0671	2.55
C	0.5187	0.9138	1.0432	0.6343	0.7403	0.8362	0.22	0.3287	23.96
M	0.58	0.2096	0.9086	0.6703	0.504	0.8106	0.3209	0.1529	8.82
Y	0.8237	0.9378	0.0855	0.7315	0.7884	0.3204	0.4288	0.521	28.22

Table 28 – Test Values: ACES 1.0 Output - DCDM (P3-D65 Limited)

5.9.5 Notes

It is not recommended to use the DCDM ODT during the DI process. Rather, the DCDM ODT is provided as a convenience to aid in the conversion of the final RGB graded master into a DCDM version when more appropriate tools are not available. In general, it is recommended that RGB master files be produced with the appropriate ODT for the mastering display device and that those RGB files be converted to a DCDM using a tool designed for DCDM transcodings.

This DCDM ODT limits the rendered colorimetry to the color gamut of P3-D60. This prevents unintended colors from being reproduced on an exhibition display with a larger color gamut than the original mastering display.

6 SDR Broadcast Monitor (100 nits)

6.1 Rec.709

6.1.1 Summary

This transform is intended for mapping OCES onto a Rec.709 broadcast monitor that is calibrated to a D65 white point at $100\,\mathrm{cd/m^2}$. The assumed observer adapted white is D65, and the viewing environment is that of a dim surround.

A possible use case for this transform would be HDTV/video mastering.

6.1.2 Transform Parameters

ACES Transform ID	`ODT.Academy.Rec709_100nits_dim.a1.0.3`			
ACES User Name	ACES 1.0 Output - Rec.709			
Device Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Device White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Limiting Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Limiting White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Assumed Observer Adapted White	D65	x=0.3127	y=0.329	
Display Black Luminance	$\sim$0.01 cd/m^2			
Display Peak White Luminance	100 cd/m^2			
Targeted Mid-gray (18%) Luminance	$\sim$10 cd/m^2			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dim			
EOTF	ITU-R BT.1886			
Encoding Range	Full			

Table 29 – Transform Parameters: Rec.709

6.1.3 Recommended Display and Setup

Display Type	Rec. 709 Broadcast Monitor			
Display Dynamic Range	∼10,000:1			
Display Max Luminance	$100\,\mathrm{cd/m^2}$			
Viewing Environment	Dim			
Display Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
EOTF	ITU-R BT.1886			

Table 30 – Display Setup: Rec.709

6.1.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.9	0.9	0.9	0.3127	0.329	77.66
N2	0.2753	0.2753	0.2753	0.5	0.5	0.5	0.3127	0.329	18.95
N3	0.0898	0.0898	0.0898	0.2501	0.2501	0.2501	0.3127	0.329	3.59
R	0.4689	0.1193	0.0417	0.8274	0.1526	0.1499	0.6155	0.3303	14.36
G	0.339	0.8068	0.0936	0.1506	0.83	0.1499	0.3006	0.5889	46.03
B	0.2162	0.133	0.8711	0.1501	0.1501	0.83	0.1566	0.0709	5.59
C	0.5187	0.9138	1.0432	0.1498	0.83	0.83	0.2265	0.3287	50.57
M	0.58	0.2096	0.9086	0.83	0.1503	0.83	0.3207	0.1589	18.97
Y	0.8237	0.9378	0.0855	0.83	0.83	0.1502	0.4164	0.5005	59.4

Table 31 – Test Values: ACES 1.0 Output - Rec.709

6.1.5 Notes

Because this output is a designed for a display with a higher luminance than standard projection at $48\,\mathrm{cd/m^2}$, there is a saturation compensation factor to account for the Hunt effect, wherein images presented at a higher luminance appear to have more colorfulness.

This ODT is defined for a dim surround, so there is an adjustment in the output gamma. No version of this transform is supplied for a dark surround, although one could easily be created.

6.2 Rec.709 (D60 Simulation)

6.2.1 Summary

This transform is intended for mapping OCES onto a Rec.709 broadcast monitor that is calibrated to a D65 white point at $100\,\mathrm{cd/m^2}$. The assumed observer adapted white is D60, and the viewing environment is that of a dim surround.

A possible use case for this transform would be HDTV/video mastering while simultaneously viewing the output on a projector that assumes an observer adaptive white of D60.

6.2.2 Transform Parameters

ACES Transform ID	`ODT.Academy.Rec709_D60sim_100nits_dim.a1.0.3`			
ACES User Name	ACES 1.0 Output - Rec.709 (D60 Simulation)			
Device Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Device White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Limiting Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Limiting White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Assumed Observer Adapted White	ACES	x=0.32168	y=0.33767	
Display Black Luminance	$\sim$0.01 cd/m^2			
Display Peak White Luminance	100 cd/m^2			
Targeted Mid-gray (18%) Luminance	$\sim$10 cd/m^2			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dim			
EOTF	ITU-R BT.1886			
Encoding Range	Full			

Table 32 – Transform Parameters: Rec.709 (D60 Simulation)

6.2.3 Recommended Display and Setup

Display Type	Rec. 709 Broadcast Monitor			
Display Dynamic Range	∼10,000:1			
Display Max Luminance	$100\,\mathrm{cd/m^2}$			
Viewing Environment	Dim			
Display Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
EOTF	ITU-R BT.1886			

Table 33 – Display Setup: Rec.709 (D60 Simulation)

6.2.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.9003	0.8812	0.8512	0.3217	0.3377	74.23
N2	0.2753	0.2753	0.2753	0.5002	0.4896	0.4729	0.3217	0.3377	18.11
N3	0.0898	0.0898	0.0898	0.2502	0.2449	0.2365	0.3217	0.3377	3.43
R	0.4689	0.1193	0.0417	0.818	0.145	0.1342	0.6193	0.3312	13.88
G	0.339	0.8068	0.0936	0.2185	0.8126	0.1109	0.3064	0.5895	44.05
B	0.2162	0.133	0.8711	0.1643	0.1522	0.7881	0.1587	0.0733	5.14
C	0.5187	0.9138	1.0432	0.2267	0.8131	0.7857	0.233	0.3397	48.17
M	0.58	0.2096	0.9086	0.8219	0.1481	0.7874	0.3321	0.1655	18.08
Y	0.8237	0.9378	0.0855	0.8289	0.8122	0.1001	0.422	0.5004	56.99

Table 34 – Test Values: ACES 1.0 Output - Rec.709 (D60 Simulation)

6.2.5 Notes

Because this output is a designed for a display with a higher luminance than standard projection at $48\,\mathrm{cd/m^2}$, there is a saturation compensation factor to account for the Hunt effect, wherein images presented at a higher luminance appear to have more colorfulness.

This ODT is defined for a dim surround, so there is an adjustment in the output gamma. No version of this transform is supplied for a dark surround, although one could easily be created

6.3 Rec.2020

6.3.1 Summary

This transform is intended for mapping OCES onto a Rec.2020 broadcast monitor that is calibrated to a D65 white point at $100\,\mathrm{cd/m^2}$. The assumed observer adapted white is D65, and the viewing environment is that of a dim surround.

A possible use case for this transform would be UHDTV/video mastering.

6.3.2 Transform Parameters

ACES Transform ID	`ODT.Academy.Rec2020_100nits_dim.a1.0.3`			
ACES User Name	ACES 1.0 Output - Rec.2020			
Device Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Device White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Limiting Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Limiting White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Assumed Observer Adapted White	D65	x=0.3127	y=0.329	
Display Black Luminance	$\sim$0.01 cd/m^2			
Display Peak White Luminance	100 cd/m^2			
Targeted Mid-gray (18%) Luminance	$\sim$10 cd/m^2			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dim			
EOTF	ITU-R BT.1886			
Encoding Range	Full			

Table 35 – Transform Parameters: Rec.2020

6.3.3 Recommended Display and Setup

Display Type	Rec.2020 Broadcast Monitor			
Display Dynamic Range	∼10,000:1			
Display Max Luminance	$100\,\mathrm{cd/m^2}$			
Viewing Environment	Dim			
Display Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
EOTF	ITU-R BT.1886			

Table 36 – Display Setup: Rec.2020

6.3.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.9	0.9	0.9	0.3127	0.329	77.66
N2	0.2753	0.2753	0.2753	0.5	0.5	0.5	0.3127	0.329	18.95
N3	0.0898	0.0898	0.0898	0.2501	0.2501	0.2501	0.3127	0.329	3.59
R	0.4689	0.1193	0.0417	0.6843	0.2965	0.1991	0.6155	0.3303	14.36
G	0.339	0.8068	0.0936	0.5298	0.802	0.3219	0.3006	0.5889	46.03
B	0.2162	0.133	0.8711	0.2554	0.1862	0.7934	0.1566	0.0709	5.59
C	0.5187	0.9138	1.0432	0.5564	0.806	0.8244	0.2265	0.3287	50.57
M	0.58	0.2096	0.9086	0.7051	0.3122	0.7993	0.3207	0.1589	18.97
Y	0.8237	0.9378	0.0855	0.8151	0.8261	0.3421	0.4164	0.5005	59.4

Table 37 – Test Values: ACES 1.0 Output - Rec.2020

6.3.5 Notes

Because this output is a designed for a display with a higher luminance than standard projection at $48\,\mathrm{cd/m^2}$, there is a saturation compensation factor to account for the Hunt effect, wherein images presented at a higher luminance appear to have more colorfulness.

This ODT is defined for a dim surround, so there is an adjustment in the output gamma. No version of this transform is supplied for a dark surround, although one could easily be created.

6.4 Rec.2020 (P3-D65 Limited)

6.4.1 Summary

This transform is intended for mapping OCES onto a Rec.2020 broadcast monitor that is calibrated to a D65 white point at $100\,\mathrm{cd/m^2}$. The assumed observer adapted white is D65, and the viewing environment is a dim surround. The color gamut is limited to P3-D65 within the Rec.2020 encoding.

A possible use case for this transform would be UHDTV/video mastering while trying to match a P3-D65 version.

6.4.2 Transform Parameters

ACES Transform ID	`ODT.Academy.Rec2020_P3D65limited_100nits_dim.a1.1`			
ACES User Name	ACES 1.0 Output - Rec.2020 (P3-D65 Limited)			
Device Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Device White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Limiting Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Limiting White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Assumed Observer Adapted White	D65	x=0.3127	y=0.329	
Display Black Luminance	$\sim$0.01 cd/m^2			
Display Peak White Luminance	100 cd/m^2			
Targeted Mid-gray (18%) Luminance	$\sim$10 cd/m^2			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dim			
EOTF	ITU-R BT.1886			
Encoding Range	Full			

Table 38 – Transform Parameters: Rec.2020 (P3-D65 Limited)

6.4.3 Recommended Display and Setup

Display Type	Rec.2020 Broadcast Monitor			
Display Dynamic Range	∼10,000:1			
Display Max Luminance	$100\,\mathrm{cd/m^2}$			
Viewing Environment	Dim			
Display Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
EOTF	ITU-R BT.1886			

Table 39 – Display Setup: Rec.2020 (P3-D65 Limited)

6.4.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.9	0.9	0.9	0.3127	0.329	77.66
N2	0.2753	0.2753	0.2753	0.5	0.5	0.5	0.3127	0.329	18.95
N3	0.0898	0.0898	0.0898	0.2501	0.2501	0.2501	0.3127	0.329	3.59
R	0.4689	0.1193	0.0417	0.6843	0.2965	0.1991	0.6155	0.3303	14.36
G	0.339	0.8068	0.0936	0.5298	0.802	0.3219	0.3006	0.5889	46.03
B	0.2162	0.133	0.8711	0.2554	0.1862	0.7934	0.1566	0.0709	5.59
C	0.5187	0.9138	1.0432	0.5564	0.806	0.8244	0.2265	0.3287	50.57
M	0.58	0.2096	0.9086	0.7051	0.3122	0.7993	0.3207	0.1589	18.97
Y	0.8237	0.9378	0.0855	0.8151	0.8261	0.3421	0.4164	0.5005	59.4

Table 40 – Test Values: ACES 1.0 Output - Rec.2020 (P3-D65 Limited)

6.4.5 Notes

Because this output is a designed for a display with a higher luminance than standard projection at $48\,\mathrm{cd/m^2}$, there is a saturation compensation factor to account for the Hunt effect, wherein images presented at a higher luminance appear to have more colorfulness.

This ODT is defined for a dim surround, so there is an adjustment in the output gamma. No version of this transform is supplied for a dark surround, although one could easily be created

6.5 Rec.2020 (Rec.709 Limited)

6.5.1 Summary

This transform is intended for mapping OCES onto a Rec.2020 broadcast monitor that is calibrated to a D65 white point at $100\,\mathrm{cd/m^2}$. The assumed observer adapted white is D65, and the viewing environment is a dim surround. The color gamut is limited to Rec.709 within the Rec.2020 encoding.

A possible use case for this transform would be UHDTV/video mastering while trying to match a Rec.709 HDTV/video version.

6.5.2 Transform Parameters

ACES Transform ID	`ODT.Academy.Rec2020_Rec709limited_100nits_dim.a1.1`			
ACES User Name	ACES 1.0 Output - Rec.2020 (Rec.709 Limited)			
Device Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Device White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Limiting Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Limiting White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Assumed Observer Adapted White	D65	x=0.3127	y=0.329	
Display Black Luminance	$\sim$0.01 cd/m^2			
Display Peak White Luminance	100 cd/m^2			
Targeted Mid-gray (18%) Luminance	$\sim$10 cd/m^2			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dim			
EOTF	ITU-R BT.1886			
Encoding Range	Full			

Table 41 – Transform Parameters: Rec.2020 (Rec.709 Limited)

6.5.3 Recommended Display and Setup

Display Type	Rec.2020 Broadcast Monitor			
Display Dynamic Range	∼10,000:1			
Display Max Luminance	$100\,\mathrm{cd/m^2}$			
Viewing Environment	Dim			
Display Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
EOTF	ITU-R BT.1886			

Table 42 – Display Setup: Rec.2020 (Rec.709 Limited)

6.5.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.9	0.9	0.9	0.3127	0.329	77.66
N2	0.2753	0.2753	0.2753	0.5	0.5	0.5	0.3127	0.329	18.95
N3	0.0898	0.0898	0.0898	0.2501	0.2501	0.2501	0.3127	0.329	3.59
R	0.4689	0.1193	0.0417	0.6843	0.2965	0.1991	0.6155	0.3303	14.36
G	0.339	0.8068	0.0936	0.5298	0.802	0.3219	0.3006	0.5889	46.03
B	0.2162	0.133	0.8711	0.2554	0.1862	0.7934	0.1566	0.0709	5.59
C	0.5187	0.9138	1.0432	0.5564	0.806	0.8244	0.2265	0.3287	50.57
M	0.58	0.2096	0.9086	0.7051	0.3122	0.7993	0.3207	0.1589	18.97
Y	0.8237	0.9378	0.0855	0.8151	0.8261	0.3421	0.4164	0.5005	59.4

Table 43 – Test Values: ACES 1.0 Output - Rec.2020 (Rec.709 Limited)

6.5.5 Notes

Because this output is a designed for a display with a higher luminance than standard projection at $48\,\mathrm{cd/m^2}$, there is a saturation compensation factor to account for the Hunt effect, wherein images presented at a higher luminance appear to have more colorfulness.

This ODT is defined for a dim surround, so there is an adjustment in the output gamma. No version of this transform is supplied for a dark surround, although one could easily be created

7 SDR Desktop Computer Display

7.1 sRGB

7.1.1 Summary

This transform is intended for mapping OCES onto a desktop computer monitor typical of those used in motion picture visual effects production. These displays are calibrated to sRGB primaries, the assumed observer adapted white is D65, and the viewing environment is a dim surround.

The monitor specified is intended to be more typical of those found in visual effects production.

7.1.2 Transform Parameters

ACES Transform ID	`ODT.Academy.RGBmonitor_100nits_dim.a1.0.1`			
ACES User Name	ACES 1.0 Output - sRGB			
Device Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Device White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Limiting Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Limiting White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Assumed Observer Adapted White	D65	x=0.3127	y=0.329	
Display Black Luminance	$\sim$0.01 cd/m^2			
Display Peak White Luminance	100 cd/m^2			
Targeted Mid-gray (18%) Luminance	$\sim$10 cd/m^2			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dim			
EOTF	IEC 61966-2-1:1999			
Encoding Range	Full			

Table 44 – Transform Parameters: sRGB

7.1.3 Recommended Display and Setup

Display Type	sRGB Computer Monitor			
Display Dynamic Range	$\sim$10,000:1			
Display Max Luminance	$100\,\mathrm{cd/m^2}$			
Viewing Environment	Dim			
Display Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
EOTF	IEC 61966-2-1:1999			

Table 45 – Display Setup: sRGB

7.1.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.8945	0.8945	0.8945	0.3127	0.329	77.66
N2	0.2753	0.2753	0.2753	0.4725	0.4725	0.4725	0.3127	0.329	18.95
N3	0.0898	0.0898	0.0898	0.2088	0.2088	0.2088	0.3127	0.329	3.59
R	0.4689	0.1193	0.0417	0.818	0.106	0.1032	0.6155	0.3303	14.36
G	0.339	0.8068	0.0936	0.1039	0.8206	0.1031	0.3006	0.5889	46.03
B	0.2162	0.133	0.8711	0.1034	0.1033	0.8206	0.1566	0.0709	5.59
C	0.5187	0.9138	1.0432	0.103	0.8207	0.8206	0.2265	0.3287	50.57
M	0.58	0.2096	0.9086	0.8206	0.1035	0.8207	0.3207	0.1589	18.97
Y	0.8237	0.9378	0.0855	0.8207	0.8206	0.1034	0.4164	0.5005	59.4

Table 46 – Test Values: ACES 1.0 Output - sRGB

7.1.5 Notes

The name of this transform implies that the monitors are ”sRGB” displays. However, the monitor for which this transform is designed does not exactly match the specifications in IEC 61966-2-1:1999. Specifically, the peak luminance is expected to be $\sim 100\,\mathrm{cd/m^2}$ rather than the $80\,\mathrm{cd/m^2}$ in IEC 61966-2-1:1999.

Because this output is a designed for a display with a higher luminance than standard 48 nit projection, there is a saturation compensation factor to account for the Hunt effect, wherein images presented at a higher luminance appear to have more colorfulness.

This ODT is defined for a dim surround, so there is an adjustment in the output gamma. No version of this transform is supplied for a dark surround, although one could easily be created.

7.2 sRGB (D60 Simulation)

7.2.1 Summary

This transform is intended for mapping OCES onto a desktop computer monitor typical of those used in motion picture visual effects production. These displays are calibrated to sRGB primaries, the assumed observer adapted white is D60, and the viewing environment is a dim surround.

The monitor specified is intended to be more typical of those found in visual effects production.

7.2.2 Transform Parameters

ACES Transform ID	`ODT.Academy.RGBmonitor_D60sim_100nits_dim.a1.0.1`			
ACES User Name	ACES 1.0 Output - sRGB (D60 Simulation)			
Device Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Device White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Limiting Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Limiting White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
Assumed Observer Adapted White	ACES	x=0.32168	y=0.33767	
Display Black Luminance	$\sim$0.01 cd/m^2			
Display Peak White Luminance	100 cd/m^2			
Targeted Mid-gray (18%) Luminance	$\sim$10 cd/m^2			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dim			
EOTF	IEC 61966-2-1:1999			
Encoding Range	Full			

Table 47 – Transform Parameters: sRGB (D60 Simulation)

7.2.3 Recommended Display and Setup

Display Type	sRGB Computer Monitor			
Display Dynamic Range	∼10,000:1			
Display Max Luminance	$100\,\mathrm{cd/m^2}$			
Viewing Environment	Dim			
Display Primaries	Red	x=0.64	y=0.33	
	Green	x=0.3	y=0.6	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=100 cd/m^2
EOTF	IEC 61966-2-1:1999			

Table 48 – Display Setup: sRGB (D60 Simulation)

7.2.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.8948	0.8747	0.8431	0.3217	0.3377	74.23
N2	0.2753	0.2753	0.2753	0.4727	0.4615	0.4439	0.3217	0.3377	18.11
N3	0.0898	0.0898	0.0898	0.2089	0.2033	0.1945	0.3217	0.3377	3.43
R	0.4689	0.1193	0.0417	0.808	0.0979	0.0865	0.6193	0.3312	13.88
G	0.339	0.8068	0.0936	0.1755	0.8023	0.062	0.3064	0.5895	44.05
B	0.2162	0.133	0.8711	0.1183	0.1056	0.7764	0.1587	0.0733	5.14
C	0.5187	0.9138	1.0432	0.1841	0.8028	0.7739	0.233	0.3397	48.17
M	0.58	0.2096	0.9086	0.8121	0.1012	0.7757	0.3321	0.1655	18.08
Y	0.8237	0.9378	0.0855	0.8195	0.8018	0.0506	0.422	0.5004	56.99

Table 49 – Test Values: ACES 1.0 Output - sRGB (D60 Simulation)

7.2.5 Notes

The name of this transform implies that the monitors are ”sRGB” displays. However, the monitor for which this transform is designed does not exactly match the specifications in IEC 61966-2-1:1999. Specifically, the peak luminance is expected to be $\sim 100\,\mathrm{cd/m^2}$ rather than the $80\,\mathrm{cd/m^2}$ in IEC 61966-2-1:1999.

Because this output is a designed for a display with a higher luminance than standard 48 nit projection, there is a saturation compensation factor to account for the Hunt effect, wherein images presented at a higher luminance appear to have more colorfulness.

This ODT is defined for a dim surround, so there is an adjustment in the output gamma. No version of this transform is supplied for a dark surround, although one could easily be created.

8 HDR Digital Cinema Projection

In ACES 1.1, all HDR Output Transforms are provided as RRT+ODT combinations. This means that the single Output Transform includes all necessary rendering steps to transform ACES to display-referred colorimetry. The single step Output Transform is fully parameterized, allowing for far easier customization to accommodate display setups that differ from the standard ones provided.

The provided Output Transforms in ACES 1.1 are presets for those setups anticipated to be the most commonly used, although the specific preset values may be refined with experience in HDR production as feedback is collected.

Rec. ITU-R BT.2100-2 specifies the reference luminance of the surround for critical viewing of HDR material at $5\,\mathrm{cd/m^2}$. However, the ACES 1.1 Output Transforms are specified as being designed for HDR devices in dark surround environments. Despite this classification, the transforms are deemed suitable for use in both dark and dim surround environments and have been successfully used in dim surround mastering on several major motion pictures by using a corresponding "trim pass" to adjust contrast and saturation. Future ACES releases should activate a surround parameter inside the individual HDR Output Transforms which will automatically provide compensation for the viewing environment surround.

According to ITU-R BT.2408-0, the preliminary nominal luminance for 18% gray is $26\,\mathrm{cd/m^2}$, although they signal levels are expected to be refined as experience is gained in HDR production. Likewise, the values selected for nominal luminance in ACES 1.1 Output Transforms for HDR, with mid-gray (18%) at $7.2\,\mathrm{cd/m^2}$ and $15\,\mathrm{cd/m^2}$, are also preliminary and were selected as an average value from across a few productions that used the pre-release ACES 1.1 transforms for HDR deliverable creation.

8.1 P3-D65 ST2084 (108 nits)

8.1.1 Summary

This transform is intended for rendering ACES onto a P3 digital cinema projector calibrated to a D65 white point at $108\,\mathrm{cd/m^2}$.

A use case for this transform would be mastering for a theatrical release in Dolby Cinema.

The Output Transform can also be used for other HDR displays set to P3 primaries with a D65 white point, $108\,\mathrm{cd/m^2}$ luminance, and ST.2084 EOTF.

8.1.2 Transform Parameters

ACES Transform ID	`RRTODT.Academy.P3D65_108nits_7.2nits_ST2084.a1.1`
ACES User Name	ACES 1.0 Output - P3-D65 ST2084 (108 nits)
Device Primaries	Red x=0.68 y=0.32 Green x=0.265 y=0.69 Blue x=0.15 y=0.06
Device White Point	D65 x=0.3127 y=0.329 Y=108 cd/m^2
Limiting Primaries	Red x=0.68 y=0.32 Green x=0.265 y=0.69 Blue x=0.15 y=0.06
Limiting White Point	D65 x=0.3127 y=0.329 Y=108 cd/m^2
Assumed Observer Adapted White	D65 x=0.3127 y=0.329
Display Black Luminance	0.0001 cd/m^2
Display Peak White Luminance	108 cd/m^2
Targeted Mid-gray (18%) Luminance	7.2 cd/m^2
Simulated Black Luminance	N/A
Simulated White Luminance	N/A
Viewing Environment Surround	Dark
EOTF	SMPTE ST2084 (PQ)
Encoding Range	Full

Table 50 – Transform Parameters: P3-D65 ST2084 (108 nits)

8.1.3 Recommended Display and Setup

Display Type	Dolby Cinema projector
Display Dynamic Range	∼1,000,000:1
Display Max Luminance	108 cd/m^2
Viewing Environment	Dark
Display Primaries	Red x=0.68 y=0.32 Green x=0.265 y=0.69 Blue x=0.15 y=0.06
Display Calibration White Point	D65 x=0.3127 y=0.329 Y=108 cd/m^2
EOTF	SMPTE ST2084 (PQ)

Table 51 – Display Setup: P3-D65 ST2084 (108 nits)

8.1.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.4582	0.4582	0.4582	0.3127	0.329	60.25
N2	0.2753	0.2753	0.2753	0.3186	0.3186	0.3186	0.3127	0.329	12.66
N3	0.0898	0.0898	0.0898	0.2012	0.2012	0.2012	0.3127	0.329	2.48
R	0.4689	0.1193	0.0417	0.4065	0.184	0.1421	0.6308	0.3342	9.33
G	0.339	0.8068	0.0936	0.2688	0.4239	0.1888	0.2988	0.6204	30.75
B	0.2162	0.133	0.8711	0.137	0.1223	0.418	0.1567	0.0693	3.69
C	0.5187	0.9138	1.0432	0.2636	0.4238	0.4271	0.2192	0.3261	33.93
M	0.58	0.2096	0.9086	0.4066	0.1783	0.4211	0.3167	0.1538	12.39
Y	0.8237	0.9378	0.0855	0.4265	0.4281	0.1914	0.4259	0.5203	40.47

Table 52 – Test Values: ACES 1.0 Output - P3-D65 ST2084 (108 nits)

8.1.5 Notes

Dolby Cinema actually expects XYZ data encoded using the ST2084 EOTF. Appropriate conversion tools to translate from P3D65 to that data format are supplied by Dolby.

9 HDR Broadcast Monitor

9.1 Rec.2020 ST2084 (1000 nits)

9.1.1 Summary

This transform is intended for mapping ACES onto a Rec.2020 broadcast monitor that is calibrated to a D65 white point at $1000\,\mathrm{cd/m^2}$. The assumed observer adapted white is D65, and the viewing environment is a dark surround. It assumes the reference electro-optical transfer function specified in SMPTE ST 2084.

9.1.2 Transform Parameters

ACES Transform ID	`RRTODT.Academy.Rec2020_1000nits_15nits_ST2084.a1.1`			
ACES User Name	ACES 1.0 Output - Rec.2020 ST2084 (1000 nits)			
Device Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Device White Point	D65	x=0.3127	y=0.329	Y=1000 cd/m^2
Limiting Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Limiting White Point	D65	x=0.3127	y=0.329	Y=1000 cd/m^2
Assumed Observer Adapted White	D65	x=0.3127	y=0.329	
Display Black Luminance	$\leq 0.005\,\mathrm{cd/m^2}$			
Display Peak White Luminance	$1000\,\mathrm{cd/m^2}$			
Targeted Mid-gray (18%) Luminance	$15\,\mathrm{cd/m^2}$			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dark			
EOTF	SMPTE ST2084 (PQ)			
Encoding Range	Full			

Table 53 – Transform Parameters: Rec.2020 ST2084 (1000 nits)

9.1.3 Recommended Display and Setup

Display Type	HDR Reference Monitor			
Display Dynamic Range	$\geq$ 200,000:1			
Display Max Luminance	$1000\,\mathrm{cd/m^2}$			
Viewing Environment	Dark			
Display Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=1000 cd/m^2
EOTF	SMPTE ST2084 (PQ)			

Table 54 – Display Setup: Rec.2020 ST2084 (1000 nits)

9.1.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.5685	0.5685	0.5685	0.3127	0.329	180.62
N2	0.2753	0.2753	0.2753	0.3805	0.3805	0.3805	0.3127	0.329	26.13
N3	0.0898	0.0898	0.0898	0.2546	0.2546	0.2546	0.3127	0.329	5.5
R	0.4689	0.1193	0.0417	0.4553	0.276	0.185	0.6302	0.3337	20.47
G	0.339	0.8068	0.0936	0.3852	0.5061	0.2566	0.283	0.6413	74.07
B	0.2162	0.133	0.8711	0.2564	0.1984	0.5014	0.1545	0.0676	8.63
C	0.5187	0.9138	1.0432	0.3957	0.508	0.5186	0.2068	0.3221	82.43
M	0.58	0.2096	0.9086	0.4634	0.2824	0.5061	0.3058	0.1468	27.94
Y	0.8237	0.9378	0.0855	0.5114	0.5182	0.2557	0.4261	0.5275	102.44

Table 55 – Test Values: ACES 1.0 Output - Rec.2020 ST2084 (1000 nits)

9.2 Rec.2020 ST2084 (2000 nits)

9.2.1 Summary

This transform is intended for mapping ACES onto a Rec.2020 broadcast monitor that is calibrated to a D65 white point at $2000\,\mathrm{cd/m^2}$. The assumed observer adapted white is D65, and the viewing environment is a dark surround. It assumes the reference electro-optical transfer function specified in SMPTE ST 2084.

9.2.2 Transform Parameters

ACES Transform ID	`RRTODT.Academy.Rec2020_2000nits_15nits_ST2084.a1.1`			
ACES User Name	ACES 1.0 Output - Rec.2020 ST2084 (2000 nits)			
Device Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Device White Point	D65	x=0.3127	y=0.329	Y=2000 cd/m^2
Limiting Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Limiting White Point	D65	x=0.3127	y=0.329	Y=2000 cd/m^2
Assumed Observer Adapted White	D65	x=0.3127	y=0.329	
Display Black Luminance	$\leq 0.005\,\mathrm{cd/m^2}$			
Display Peak White Luminance	$2000\,\mathrm{cd/m^2}$			
Targeted Mid-gray (18%) Luminance	$15\,\mathrm{cd/m^2}$			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dark			
EOTF	SMPTE ST2084 (PQ)			
Encoding Range	Full			

Table 56 – Transform Parameters: Rec.2020 ST2084 (2000 nits)

9.2.3 Recommended Display and Setup

Display Type	HDR Reference Monitor			
Display Dynamic Range	$\geq$ 400,000:1			
Display Max Luminance	$2000\,\mathrm{cd/m^2}$			
Viewing Environment	Dark			
Display Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=$2000\,\mathrm{cd/m^2}$
EOTF	SMPTE ST2084 (PQ)			

Table 57 – Display Setup: Rec.2020 ST2084 (2000 nits)

9.2.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.584	0.584	0.584	0.3127	0.329	209.6
N2	0.2753	0.2753	0.2753	0.3817	0.3818	0.3817	0.3127	0.329	26.51
N3	0.0898	0.0898	0.0898	0.2538	0.2538	0.2538	0.3127	0.329	5.44
R	0.4689	0.1193	0.0417	0.4601	0.2752	0.1838	0.6342	0.3317	21.18
G	0.339	0.8068	0.0936	0.3863	0.5147	0.2527	0.2777	0.6517	80.09
B	0.2162	0.133	0.8711	0.255	0.1971	0.5094	0.1524	0.0657	9.03
C	0.5187	0.9138	1.0432	0.3972	0.5167	0.5283	0.2026	0.321	89.41
M	0.58	0.2096	0.9086	0.4686	0.2815	0.5145	0.3026	0.1433	29.31
Y	0.8237	0.9378	0.0855	0.5204	0.5279	0.2503	0.427	0.531	112.52

Table 58 – Test Values: ACES 1.0 Output - Rec.2020 ST2084 (2000 nits)

9.3 Rec.2020 ST2084 (4000 nits)

9.3.1 Summary

This transform is intended for mapping ACES onto a Rec.2020 broadcast monitor that is calibrated to a D65 white point at $4000\,\mathrm{cd/m^2}$. The assumed observer adapted white is D65, and the viewing environment is a dark surround. It assumes the reference electro-optical transfer function specified in SMPTE ST 2084.

9.3.2 Transform Parameters

ACES Transform ID	`RRTODT.Academy.Rec2020_4000nits_15nits_ST2084.a1.1`			
ACES User Name	ACES 1.0 Output - Rec.2020 ST2084 (4000 nits)			
Device Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Device White Point	D65	x=0.3127	y=0.329	Y=4000 cd/m^2
Limiting Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Limiting White Point	D65	x=0.3127	y=0.329	Y=4000 cd/m^2
Assumed Observer Adapted White	D65	x=0.3127	y=0.329	
Display Black Luminance	$\leq 0.005\,\mathrm{cd/m^2}$			
Display Peak White Luminance	$4000\,\mathrm{cd/m^2}$			
Targeted Mid-gray (18%) Luminance	$15\,\mathrm{cd/m^2}$			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dark			
EOTF	SMPTE ST2084 (PQ)			
Encoding Range	Full			

Table 59 – Transform Parameters: Rec.2020 ST2084 (4000 nits)

9.3.3 Recommended Display and Setup

Display Type	HDR Reference Monitor			
Display Dynamic Range	$\geq$ 800,000:1			
Display Max Luminance	$4000\,\mathrm{cd/m^2}$			
Viewing Environment	Dark			
Display Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=4000 cd/m^2
EOTF	SMPTE ST2084 (PQ)			

Table 60 – Display Setup: Rec.2020 ST2084 (4000 nits)

9.3.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.5961	0.5961	0.5961	0.3127	0.329	235.24
N2	0.2753	0.2753	0.2753	0.3827	0.3827	0.3827	0.3127	0.329	26.8
N3	0.0898	0.0898	0.0898	0.2532	0.2532	0.2532	0.3127	0.329	5.39
R	0.4689	0.1193	0.0417	0.4637	0.2746	0.1829	0.6373	0.3303	21.76
G	0.339	0.8068	0.0936	0.3872	0.5214	0.2495	0.2736	0.6595	85.11
B	0.2162	0.133	0.8711	0.2539	0.1962	0.5156	0.1509	0.0643	9.36
C	0.5187	0.9138	1.0432	0.3983	0.5236	0.5359	0.1996	0.32	95.23
M	0.58	0.2096	0.9086	0.4727	0.2807	0.5211	0.3001	0.1407	30.43
Y	0.8237	0.9378	0.0855	0.5275	0.5355	0.2457	0.4275	0.5336	121

Table 61 – Test Values: ACES 1.0 Output - Rec.2020 ST2084 (4000 nits)

9.4 Rec.2020 HLG (1000 nits)

9.4.1 Summary

This transform is intended for mapping ACES onto a Rec.2020 broadcast monitor that is calibrated to a D65 white point at $1000\,\mathrm{cd/m^2}$. The assumed observer adapted white is D65, and the viewing environment is a dark surround. It assumes the reference electro-optical transfer function specified in Table 5 of ITU-R BT.2100 (HLG).

9.4.2 Transform Parameters

ACES Transform ID	`RRTODT.Academy.Rec2020_1000nits_15nits_HLG.a1.1`			
ACES User Name	ACES 1.0 Output - Rec.2020 HLG (1000 nits)			
Device Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Device White Point	D65	x=0.3127	y=0.329	$Y=1000\,\mathrm{cd/m^2}$
Limiting Primaries	Red	x=0.708	y=0.292	
	Green	x=0.17	y=0.797	
	Blue	x=0.131	y=0.046	
Limiting White Point	D65	x=0.3127	y=0.329	$Y=1000\,\mathrm{cd/m^2}$
Assumed Observer Adapted White	D65	x=0.3127	y=0.329	
Display Black Luminance	$\leq 0.005\,\mathrm{cd/m^2}$			
Display Peak White Luminance	$1000\,\mathrm{cd/m^2}$			
Targeted Mid-gray (18%) Luminance	$15\,\mathrm{cd/m^2}$			
Simulated Black Luminance	N/A			
Simulated White Luminance	N/A			
Viewing Environment Surround	Dark			
EOTF	HLG			
Encoding Range	Full			

Table 62 – Transform Parameters: Rec.2020 HLG (1000 nits)

9.4.3 Recommended Display and Setup

Display Type	HDR Reference Monitor			
Display Dynamic Range	$\geq$ 200,000:1			
Display Max Luminance	$1000\,\mathrm{cd/m^2}$			
Viewing Environment	Dark			
Display Primaries	Red	x=0.68	y=0.32	
	Green	x=0.265	y=0.69	
	Blue	x=0.15	y=0.06	
Display Calibration White Point	D65	x=0.3127	y=0.329	Y=1000 cd/m^2
EOTF	HLG			

Table 63 – Display Setup: Rec.2020 HLG (1000 nits)

9.4.4 Test Values

Patch	ACES RGB			Display RGB			Display xyY		
N1	1.8233	1.8233	1.8233	0.5685	0.5685	0.5685	0.3127	0.329	180.62
N2	0.2753	0.2753	0.2753	0.3805	0.3805	0.3805	0.3127	0.329	26.13
N3	0.0898	0.0898	0.0898	0.2546	0.2546	0.2546	0.3127	0.329	5.5
R	0.4689	0.1193	0.0417	0.4553	0.276	0.185	0.6302	0.3337	20.47
G	0.339	0.8068	0.0936	0.3852	0.5061	0.2566	0.283	0.6413	74.07
B	0.2162	0.133	0.8711	0.2564	0.1984	0.5014	0.1545	0.0676	8.63
C	0.5187	0.9138	1.0432	0.3957	0.508	0.5186	0.2068	0.3221	82.43
M	0.58	0.2096	0.9086	0.4634	0.2824	0.5061	0.3058	0.1468	27.94
Y	0.8237	0.9378	0.0855	0.5114	0.5182	0.2557	0.4261	0.5275	102.44

Table 64 – Test Values: ACES 1.0 Output - Rec.2020 HLG (1000 nits)

9.4.5 Notes

Support for HLG in ACES is tricky, because HLG is ”scene-referred” and ACES Output transforms produce display-referred output. ACES supports HLG output at $1000\,\mathrm{cd/m^2}$ by converting the ST2084 output to HLG using the method specified in Section 7 of ITU-R BT.2390-0.