Global and Local Colour Management for the ergonomic Display Output of SDR and HDR images

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Introduction

New displays of the High Dynamic Range (HDR) may lead to new possibilities for the ergonomic display output compared to the Standard Dynamic Range (SDR). The ergonomic output according to ISO 9241-306 on displays with the HDR range compared to the SDR range is discussed. ISO 9241-306 defines the standard luminance range L_W:L_N=36:1 for output on paper and on displays.

For the black *N*, the Grey *U*, and the White *W* the following standard values are given:

black N:] L_N=3,3 cd/m^2, Y_N=2,5 = Y_U/7,2

grey U: L_U=24 cd/m^2, Y_U=18

white W: L_W=142 cd/m^2, Y_W=90 = 5 Y_U

The luminance contrast ratio is therefore $C = L_W:L_N = Y_W:Y_N$ = 90:2,5 = 36:1

In applications especially the values for black differ, the values may be

Y_N=1,8 = Y_U/10 for high glossy photographic paper,

Y_N=2,5 = Y_U/7,2 for semi glossy offset paper,

Y_N=3,6 = Y_U/5 for matte office paper.

Advantages and disadvantages of the higher contrast *C* of HDR displays are given.

Global and local Colour Management

The *global colour management* (GCM) is usually a professional colour management, especially in the area of displays used in television, in printing and in photography. This global colour management is often based on metadata which describe the colour gamut of the device, and or the image. In applications, the software use these data different and often produce clipping of colour areas. This failure is avoided in *rgb** colour management.

The *local colour management* (LCM) is for example the colour management of ISO 9241-306 [1] which produces an ergonomic output at display work places in offices. The well-being of the users and the reduce of fatigue are the intentions of [1]. However, increasing reflections between about 4% and 100% of the ambient light reduce the contrast range. The intended equal spacing of 9 step colour scales is much reduced in the dark range.

Already the first edition of [1] in 2008 has described the *LCM* using a *colour slider* on the computer operating system *Mac OS X* as example.

The visual effect of 8 ambient reflections on the spacing of achromatic and chromatic colours is simulated in the test chart of Fig. 1 (right side). Increasing reflections lead to many dark grey steps which may not be distinguishable. Colourimetry calculates a gamma value compared to the standard value gamma = 2,4 according to IEC 61966-2-1 [4]. A gamma slider with an inverse gamma makes the steps again equal and visible. For the variable use cases of [1] the *LCM* output seems *not* possible by the application *GCM.*

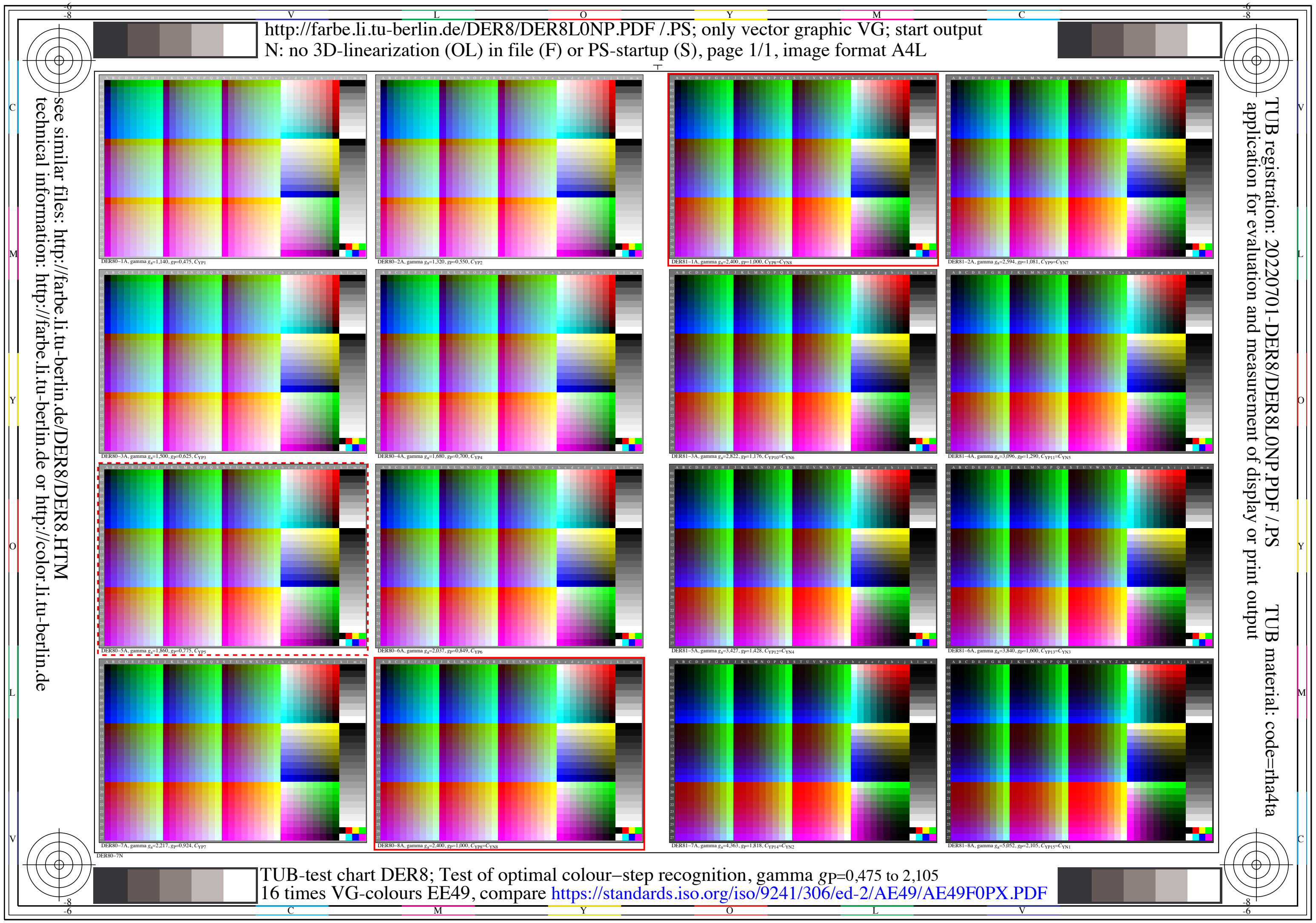


Fig. 1 Fifteen relative gamma values of a test chart AE49 similar to [1]

For the study of many effects of the ambient light *(switch it on or off)* the download of the test chart of Fig. 1 is recommend, see http://farbe.li.tu-berlin.de/DER8/DER8L0NP.PDF

Fig. 1 simulates *on the right* the visual display output with increasing ambient display reflections. With increasing reflections an increasing amount of dark grey steps is not distinguishable. In the many use cases with displays the gamma slider produces equal steps, on the left side of Fig. 1 by an inverse gamma, even if the default gamma deviates.

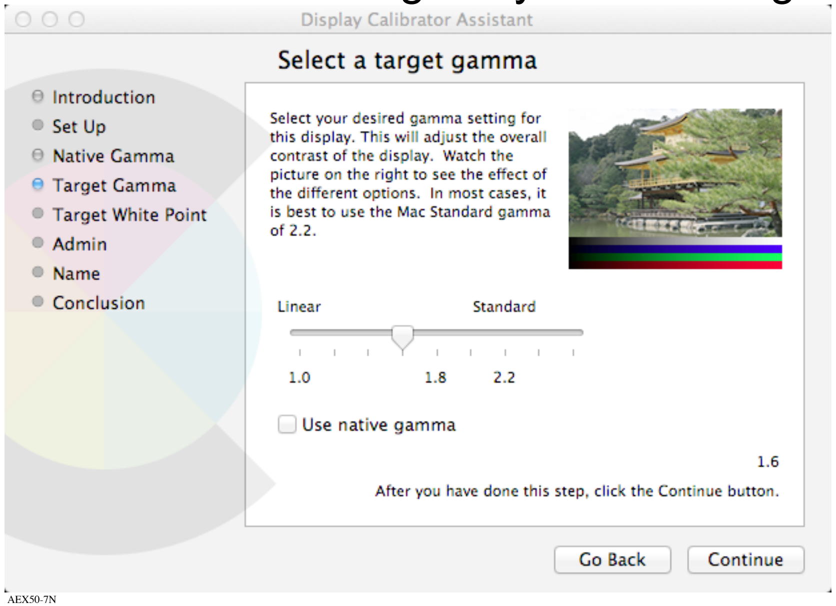


Fig. 2. Gamma slider for visual change of the display output for 8 use cases in [1]

The *rgb** data in the file of Fig. 1 can been transferred by an inverse value of the measured or calculated output. This is shown in the following.

Equal 9 step grey scaling between L^*_N and L^*_W for three reflections of ambient light

$L^*_{0aN}=4.0$, $L^*_{0aU}=50.0$, $L^*_{0aW}=96.0$, $Y_{0aN}=0.4$, $Y_{0aU}=18.4$, $Y_{0aW}=90.0$, $C_{0aY}=Y_{0aW}:Y_{0aN}=203.2$

$L^*_{tN}=73.0$, $L^*_{taU}=78.5$, $L^*_{taW}=96.0$, $Y_{taN}=45.2$, $Y_{taU}=54.2$, $Y_{taW}=90.0$, $C_{taY}=Y_{taW}:Y_{taN}=1.9$

L^*: 100, 75, 50, 25, 0

nr. i	L*0a	L*0r	Y0a	Y0r	L*ta	ΔL*ta	L*tr	Yta	$(L^*tr)^{1/2,00}$	$(L^*tr)^{1/2,00}-L^*0r$
9	96.0	1.0	90.0	1.0	96.0		1.0	90.0	1,000	0,000
						5.4				
8	84.5	0.875	65.0	0.721	90.5		0.763	77.5	0,873	0,001
						4.7				
7	73.0	0.75	45.1	0.499	85.8		0.555	67.5	0,745	0,005
						4.0				
6	61.5	0.625	29.8	0.328	81.7		0.381	59.9	0,617	0,008
						3.2				
5	50.0	0.5	18.4	0.2	78.5		0.241	54.2	0,491	0,009
						2.4				
4	38.5	0.375	10.3	0.11	76.1		0.136	50.1	0,369	0,006
						1.6				
3	27.0	0.25	5.0	0.051	74.5		0.065	47.5	0,255	–0,005
						0.9				
2	15.5	0.125	2.0	0.017	73.5		0.022	46.0	0,148	–0,023
						0.5				
1	4.0	0.0	0.4	0.0	73.0		0.0	45.2	0,010	–0,001

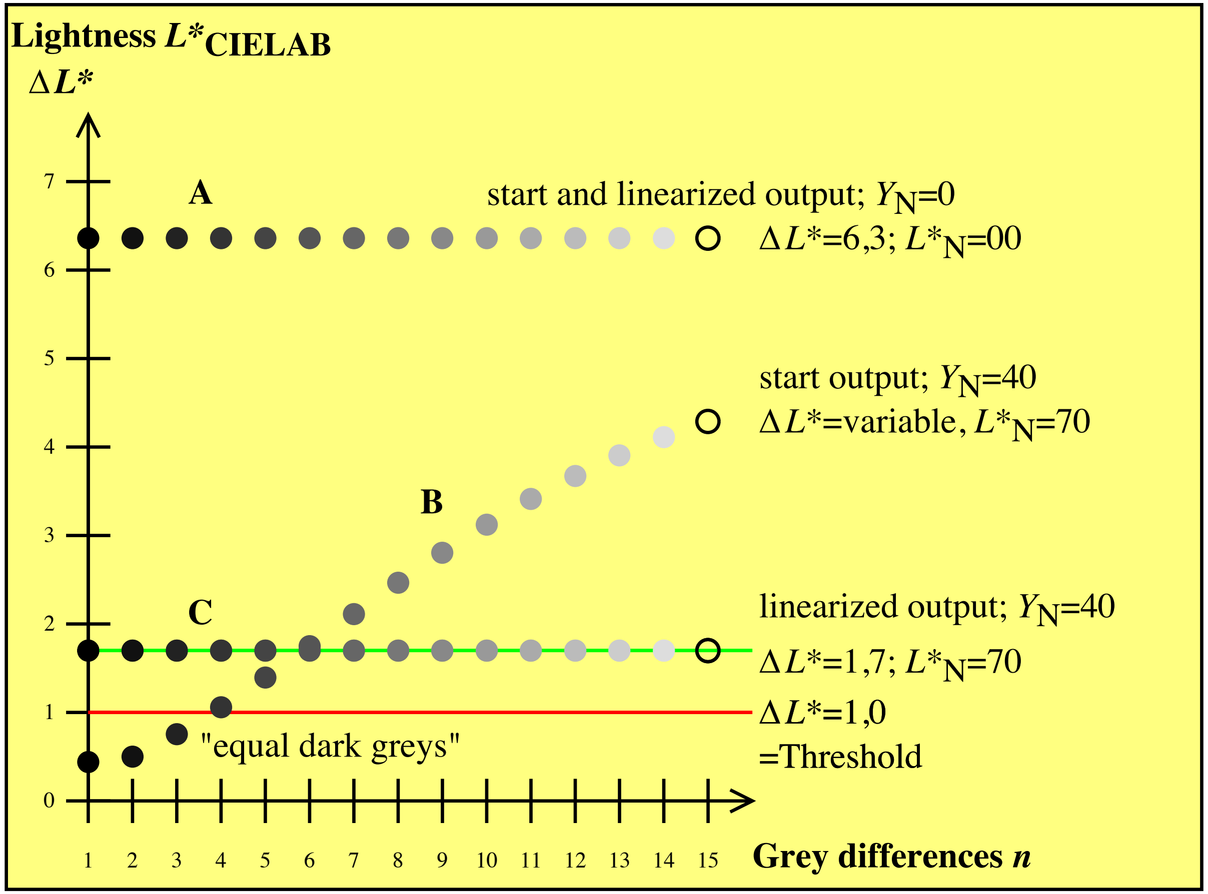
$\Delta L^*_{ta}=11.9$ (i=1,2,...,9) **normalisation: $Y_{ta}=Y_{0aW}\dfrac{Y_{0ai}+Y_{0aN}}{Y_{0aW}+Y_{0aN}}$** Σ=0,0009

DEQ90–7N

Fig. 3 Change of the display colours from contrast range C_Y=203:1 to the range 2:1

In this worse case the reflective ambient luminance is equal to the display luminance.

The column ΔL^*_{ta} shows a decrease of the output colour difference by a factor 10. Three (red) samples have a difference $\Delta L^*_{ta} < 1$. This is below the visual threshold. 3 samples are not distinguishable. Fig. 4 shown this effect by a graphic for a 16 step grey scale.



DEO71-3N

Fig. 4 Change of the display colours from contrast range CY>200:1 to the range 2:1
Three steps are not distinguishable, see B. Output linearization produces equal steps, see C.

CIE *Y* and lightness *L for surface colours and for emissive display colours**

			extrapolated surface-colour range						lighter samples	
Step	0	1	2	3	4	..	9	10	15	20
$L^*_w=100(Y/100)^{1/2}$			extrapolated surface-colour range						lighter samples	
L^*_w	0	10	20	30	40	..	90	100	150	200
			extrapolated surface-colour range						lighter samples	
Y_1	0	1	4	9	16	..	81	100	225	400
			black	real matte surface-colours			white		lighter samples	
Y_2			3,6		18		90		225	400
		black	intended emissive display colours without reflection					white	lighter samples	
Y_3		1,8			18			180	225	400
			black	emissive display colours with 4% reflection				white	lighter samples	
$Y_4=18(Y_3+4)/22$			4,8		18			151	185	353
$L^*_{CIE}=116(Y/100)^{1/3}-16$			extrapolated surface-colour range						lighter samples	
L^*_{CIE}	0	8 14	22 23	35	46 49	57	92	95 100 125	135	168
$L^*_{TUB}=40\log(Y/18)/\log5$			extrapolated surface-colour range						lighter samples	
L^*_{TUB}	–	–71 –57	–40 –37	–17	–2 0	8	37	40 42 57	62	77
			extrapolated surface-colour range						lighter samples	
$50+L^*_{TUB}$	–	–21 –7	10 12	32	47 50	58	87	90 92 107	112	127

DEZ00−1N

Fig. 5 CIE tristimulus value *Y* and lightness *L for surface and display colours**

The matte surface-colour range between 3,6 and 90 is extended by HDR displays.

The luminance contrast range for Y_N=3,6 and Y_W=90 is *C*=25:1.
If this range is extended by a factor 2 at both ends, then the contrast range is *C*=100:1 with Y_N=1,8 and Y_W=180, compare Fig. 5.
If the range is further extended by a factor 2 at both ends, then the contrast range is *C*=400:1 with Y_N=0,9 and Y_W=360. *The value* Y_N*=0,9 is far below the reflection 3,6%.*

[3] ITU-R BT.2446-1 seem to define no real black, and a standard and peak white for television applications. Therefore for the extension of shadows and high lights in images an additional luminance range is proposed. The colours of the reference condition have to be viewed in a black room without any reflection on the display to reach C=400:1.

The HDR production material has to be changed for viewing at SDR displays. Technically a GCM (Global Colour Management) may be used and *two versions* may be distributed. The combined conversion of HDR material for viewing at SDR workstation, and with different ambient reflections seems very effective by only a gamma change, see Fig. 3 and Fig. 4 for the contrast-range transfer *C*=200:1 to *C*=2:1. This contrast-range transfer is much larger compared to *C*=400:1 (HDR, Fig. 5) to *C*=36:1 (SDR according to [1]).

An effective tool for LCM is a *colour slider*, see Fig. 2. However the colour slider has been deleted in 2022 from the computer operating system *MacOSX*. Similar effective tools for LCM are not known on *Windows* and *MacOS*. Only the display user can consider the ambient reflections, and for example the increasing stray light of the eye media with age,

and the colour changes with the viewing angle. It is not possible to consider these effects by GCM. Therefore there are many technical reason why many colour experts describe Colour Management by the following technical experience:
“By Colour Management you usually will not get what you expected.”

Conclusions:
Global Coulour Management (GCM) seems possible for the transfer HDR-SDR by a simple *gamma transfer*. Professional solutions may need a transfer HDR-SDR of [3].

Local Coulour Management (LCM) is recommended for the ergonomic output at office work stations, and widely used since the first edition of [1] in 2008.

There are many technical and physiological variables which influence the viewed colour output. For the display user the standard [1] describes the *colour slider* as an effective tool at eight display use cases. Fig. 1 and 2 describe a test chart, and this effective tool. Fig. 3 and 4 describe how to produce the intended ergonomic output of the visually equally spaced colour series in real application cases. This increases well-being and fatigue of display users.

The deletion of the *colour slider* of the operating system *MacOSX* in 2022 may force users to buy new HDR hardware with new installed appropriate HDR output software. However, the software solution *colour slider* was sustainable and has been deleted. However, the software solution *colour slider* was ergonomic and has been deleted.

Remarks:
New application tools are appropriate for output of images, the whole display and video. For example 4% reflection reduces the colour gamut to 50% compared to no reflection, see [1].

The output quality of a photo may be defined by 65%, if the grey scale is achromatic and equally spaced, and by 30%, if the hue spacing is appropriate. In about 5% of the cases the extended range may be appropriate. One must consider that the range larger C>100:1 is not available by printed photos which have a high quality. In applications the visible contrast range is C=20:1, see CIE ILV 17-31-019 *“visual contrast threshold”.*

The standards ISO 15775 and ISO 9241-306 use the values near Y_N=3,6 for black, Y_U=18 for mean grey and Y_W=90 for white, see Fig. 5. This is the colour range for real matte surface colours. The *extended* visual black and white for emissive display colours may be described by the values Y_N=1,8 for black, Y_U=18 for mean grey and Y_W=180 for white.

This visual display range covers the contrast range C=100:1. This may be called the *expanded* visual window compared to the standard range in offices. However this visual window is reduced to a high degree at the black border by the 4% reflection of the ambient luminance on the display-surface glass for both SDR and HDR displays.

Literature

[1] ISO 9241-306:2019*, Ergonomics of human-system interaction - Part 306: Field assessment methods for electronic visual displays, see for download of the test charts with user question for an ergonomic output on displays*
https://standards.iso.org/iso/9241/306/ed-2/index.html

[2] ISO/IEC 15775/ed-2:2022, *Information Technology – Office Equipment –Method of Specifying image reproduction on colour copying machines and multifunctional devices with copying modes by printed test charts,* see for download of test charts with user questions *for sustainable copiers.* The test charts of [1] and [2] are similar.
https://standards.iso.org/iso-iec/15775/ed-2/en

[3] ITU-R BT.2446-1 - Methods for conversion of high dynamic range content to standard dynamic range content and vice-versa.pdf, see
https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-BT.2446-1-2021-PDF-E.pdf
Remarks: The peak luminance 300 cd/m^2 (HDR) is mapped to 100 cd/m^2 (SDR), see for example Fig. 6, page 18. The transfer in Fig. 6 may be approximated by a gamma change. A gamma change is mentioned in section 2 for the HDR-SDR transfer, but not considered as one of three different professional options A, B and C.

[4] IEC 61966-2-1, Multimedia systems and equipment - Colour measurement and management - Part 2-1: Colour management – Default RGB colour space - sRGB.