



# **Color on the Web and Broadcast**

**THE FUTURE  
OF COLOR  
MANAGEMENT**





**Hello!**  
I'm Chris or @svgeesus



**Technical Director at W3C**  
Strategy lead, Core Web Technologies



**The Prehistoric Web**



**Color managed screens**



**Web vs. Everything Else**



**Broadcast**



**CSS Color 4**



**Mixing & manipulating colors**



**High Dynamic Range**



**Future challenges**

A 3D pyramid with a metallic, reflective surface is positioned centrally. A bright white light beam enters from the top, passes through the pyramid, and exits from its base as a vibrant rainbow spectrum of light. The background is a dark, gradient blue, with two white light rays forming a triangular shape that frames the pyramid. The text "The Prehistoric Web" is overlaid in a bold, black, sans-serif font across the middle of the image.

# The Prehistoric Web

# ITU Rec BT.709 (1990) part 2

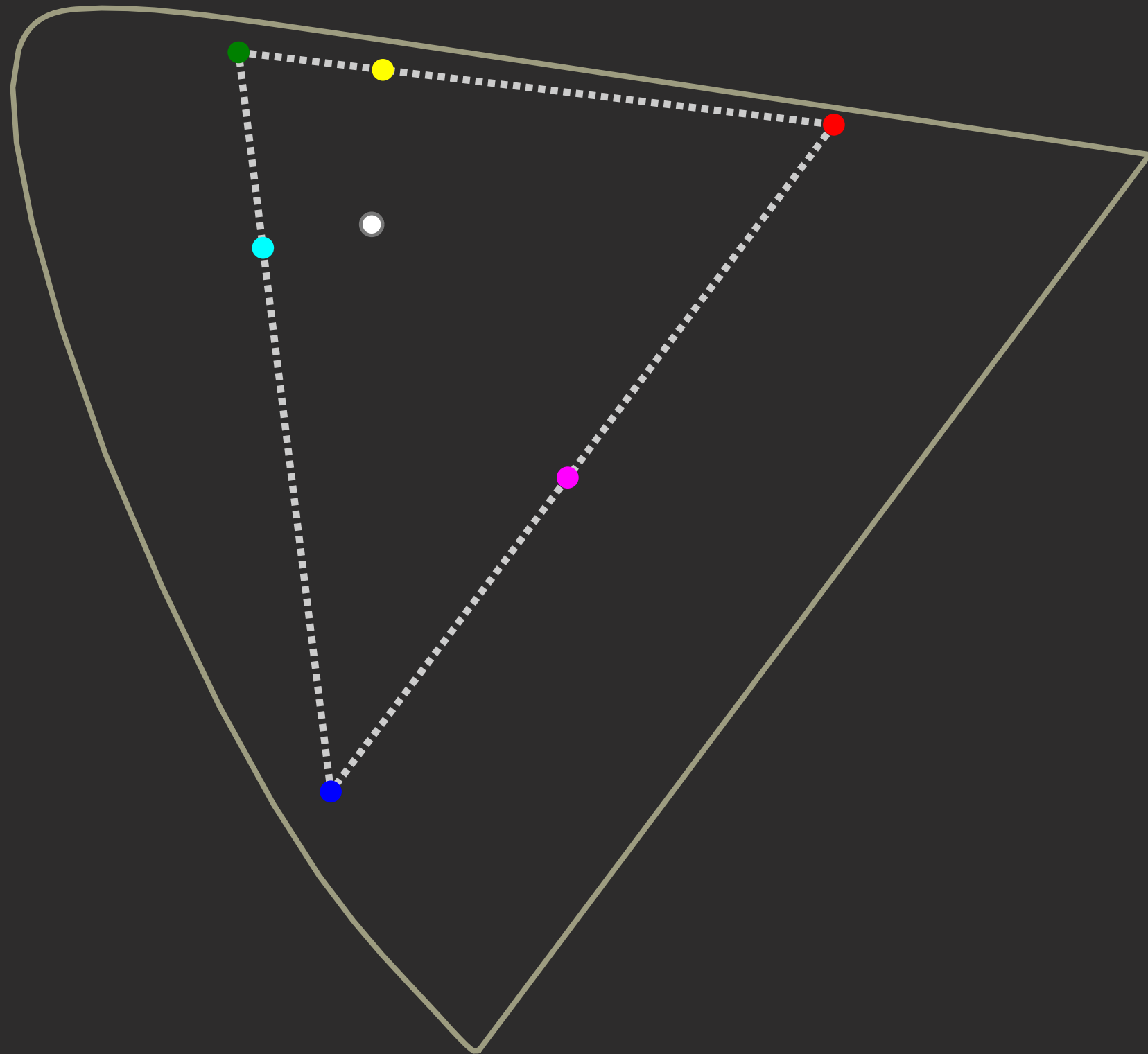
1080i and 1080p High Definition TV

Defines chromaticities, D65 white

OETF with linear segment

Scene referred

Overall system gamma 1.2 (dim surround)



A black CRT monitor is shown from a side-rear perspective, resting on a red carpet. The monitor has a silver-colored bezel on the right side. A blue VGA cable is plugged into the back of the monitor, and its other end is coiled on the carpet. The text "CRT monitor" is overlaid in white on a dark horizontal band across the center of the image.

**CRT monitor**



# Indexed-color displays

16 color VGA displays. **256 colors common.**

“Truecolor” for the lucky few

# Gamma mayhem

**Mac:**  $2.6/1.45 = 1.79$

**SGI:**  $2.4/1.7 = 1.4$

**PC, Unix:** 2.2 (ish)



# W3C Workshop on High Quality Printing from the Web, April 25th '96 Cambridge, Massachusetts

Workshop is sponsored by the [World Wide Web Consortium \(W3C\)](#).

Organizers: [Dave Raggett](#) and [Susan Hardy](#)

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[Home Papers](#) ● [Topics](#) ● [Agenda](#) ● [Minutes](#) ● [Where](#) ● [Registration](#)

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## Introduction

The success of the World Wide Web for online publishing, the time has now come to focus on improving the quality of printing from the Web. This one day workshop will draw together participants to identify technical issues that will enable improved quality of printing. It is intended that the workshop will lead to the formation of a W3C subgroup to address these issues with members drawn from W3C member companies and organizations.

## Papers submitted by Participants

Participants are strongly encouraged to provide position papers on these or closely related topics **in advance of the workshop** to be made publically available on W3C's Web site.

Papers should be submitted in HTML by e-mail to Susan Hardy at [susan@w3c.org](mailto:susan@w3c.org). Where possible you may also submit a URL for the document instead of itself.

# W3C Print Workshop

[A paper on typographic integration of HTML](#) by [Leslie Cuff](#)

[Printing on the Web](#) by [Stephen Zilles, Adobe](#)

# sRGB proposal

There are many issues involved with printing documents available on the Web. In this statement I only wish to address two of the major issues: a medium resolution independent graphics and fonts. Adobe Systems believes HTML and the Portable Document Format (PDF) are complementary. A good example of the synergistic relationship possible between HTML and PDF is using PDF for graphical objects within HTML documents. The case for PDF as a medium for graphics in HTML is presented in the second section of this paper.

[Quality Printing of Web Documents](#) by [Brad Chase](#), Bitstream Inc.

Over the past year, Bitstream has been working closely with industry leaders to resolve the problems of formatting, displaying, and printing web documents. This work, combined with Bitstream's experience in the font and printing industries has led to a number of insights in the areas of fonts, style sheets, and printing.

[A Proposal to Make Web Printing More Satisfying](#) by [John C. Thomas](#)

Since I find it easier to read long textual documents from a printed page than from my workstation screen, I find myself reaching for the "Print" button in my favorite web browser any time a document must be scrolled more than a few times. This becomes inconvenient, however, if the document has many Hyperlinks, since the document tree must be manually traversed. The "[Next]" link which is beginning to appear on web pages from some of the more professionally administered web sites is only a partial solution. The tool I want is an interactive web crawler which retrieves, indexes and prints a document and any linked documents out to some predefined sphere of context.

[Electronic Publishing](#) by Sumner M. Saitz <[sumner@harlequin.com](mailto:sumner@harlequin.com)>.

Harlequin as a leader in high-quality electronic printing would like to collaborate with other members of the W3C to develop open standards and solutions to the rapidly growing demands of the Web community.

[A Proposal for a Standard Color Space for the Internet](#) by [Matthew Anderson](#)/, [Ricardo Motta/Hewlett-Packard](#), [Srinivasan Chandrasekar/Microsoft](#), [Michael Anderson/Hewlett-Packard](#)

Microsoft and Hewlett-Packard propose the addition of support for a standard color space within the Microsoft OS's, HP products and the Internet. The aim of this color space is to complement the current color management strategies by enabling a third method of handling color in the OS's and the Internet that utilizes a robust device independent color definition that will provide good quality with minimum transmission and system overhead. Based on a colorimetric color space well suited to CRT monitors, television, scanners, digital cameras, and printing systems, such a space can be supported with minimum cost by software and hardware vendors. Our intent here is to promote its adoption by showing the benefits of supporting a standard color space, the suitability of a standard color space we are proposing, and describe some of the system issues and propose a methodology for its implementation on the Web.

[A Proposal for Font Embedding on the WWW](#) by [Andrew Pennock](#)

This is a high-level proposal for embedding fonts in HTML documents on the World Wide Web. Clients interact with platform-specific services (called "embedding services" in this document) that provide much of the embedding functionality.

# sRGB

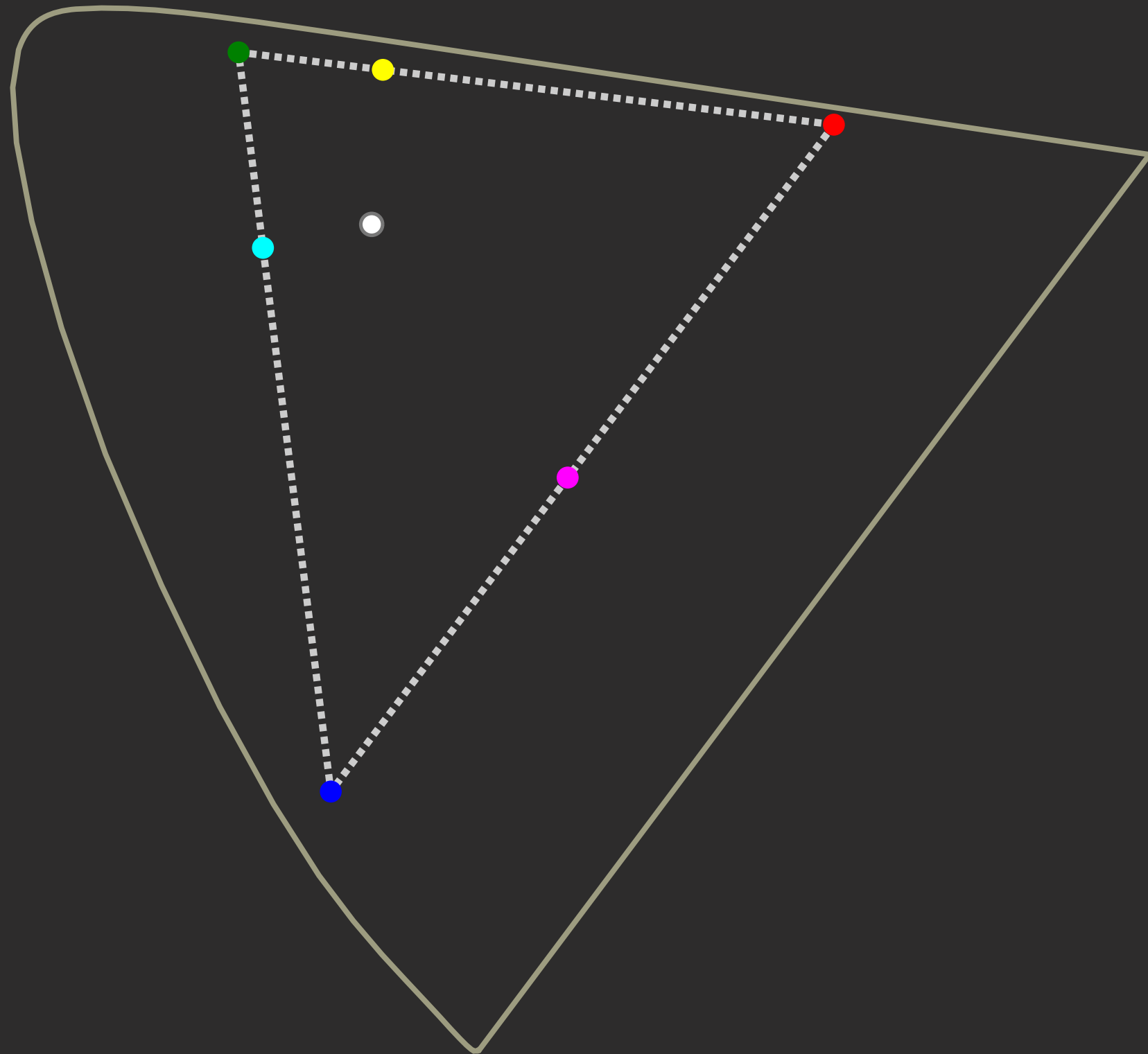
Same chromaticities, D65 white as BT.709

“Inverse OETF” with linear segment

Display referred

Overall system gamma 1.0 (normal surround)

Assumes 5% viewing flare





# Cascading Style Sheets, level 1

W3C Recommendation 17 Dec 1996

<http://www.w3.org/pub/WWW/TR/REC-CSS1>

Authors:  
[Åke Wium Lie](mailto:howcome@w3.org) (howcome@w3.org)  
[Bert Bos](mailto:bert@w3.org) (bert@w3.org)

## Summary of this document

This document is a W3C Recommendation. It has been reviewed by [W3C](http://www.w3.org/) (http://www.w3.org/) Members and general consensus that the recommendation is appropriate for use has been reached. It is a stable document and may be used as reference material or cited as a normative reference from another document. W3C promotes widespread deployment of this Recommendation.

For current W3C Recommendations and other technical documents can be found at <http://www.w3.org/pub/WWW/TR/>.

## Abstract

# Cascading Style Sheets

This document specifies level 1 of the Cascading Style Sheet mechanism (CSS1). CSS1 is a simple style sheet mechanism that allows authors and readers to attach style (e.g. fonts, colors and spacing) to HTML documents. The CSS1 language is

The format of an RGB value in hexadecimal notation is a '#' immediately followed by either three or six hexadecimal characters. The three-digit RGB notation (#rgb) is converted into six-digit form (#rrggbb) by replicating digits, not by adding zeros. For example, #fb0 expands to #ffbb00. This makes sure that white (#ffffff) can be specified with the short notation (#fff) and removes any dependencies on the color depth of the display.

# CSS1 uses sRGB

The format of an RGB value in the functional notation is 'rgb(' followed by a comma-separated list of three numerical values (either three integer values in the range of 0-255, or three percentage values in the range of 0.0% to 100.0%) followed by a closing parenthesis. Whitespace characters are allowed around the numerical values.

Values outside the numerical ranges should be clipped. The three rules below are therefore equivalent:

```
EM { color: rgb(255,0,0) } /* integer range 0 - 255 */
EM { color: rgb(300,0,0) } /* clipped to 255 */
EM { color: rgb(110%, 0%, 0%) } /* clipped to 100% */
```

RGB colors are specified in the sRGB color space [\[9\]](#). UAs may vary in the fidelity with which they represent these colors, but use of sRGB provides an unambiguous and objectively measurable definition of what the color should be, which can be related to international standards [\[10\]](#).

UAs may limit their efforts in displaying colors to performing a gamma-correction on them. sRGB specifies a display gamma of 2.2 under specified viewing conditions. UAs adjust the colors given in CSS such that, in combination with an output device having a "natural" display gamma, an effective display gamma of 2.2 is produced. [Appendix D](#) gives further details of this. Note that only colors specified in CSS are affected; e.g., images are expected to carry their own color information.

## URL

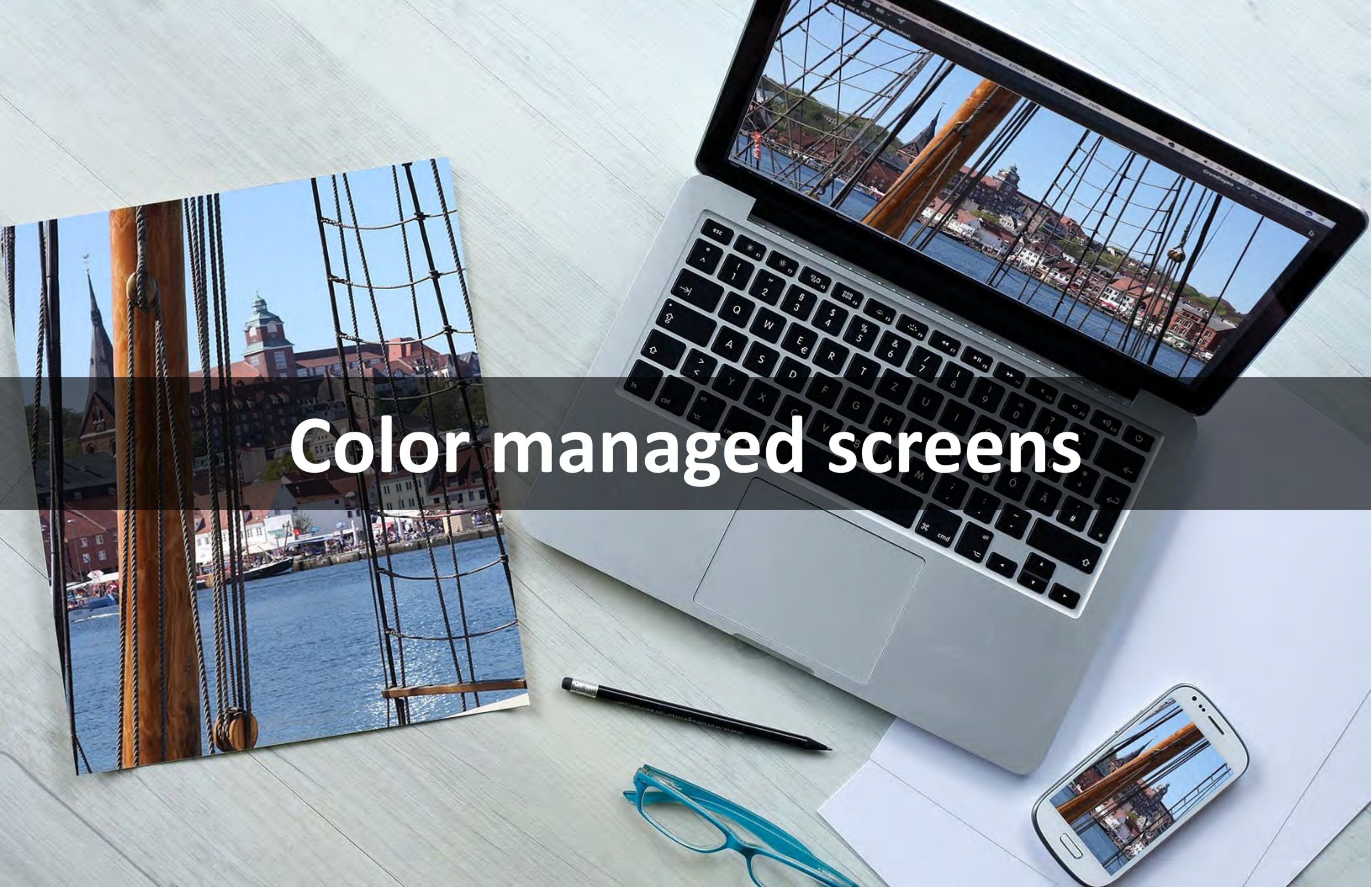
A Uniform Resource Locator (URL) is identified with a functional notation:

```
BODY { background: url(http://www.bg.com/pinkish.gif) }
```

The format of a URL value is 'url(' followed by optional white space followed by an optional single quote (') or double quote (") character followed by the URL itself (as defined in [\[11\]](#)) followed by an optional single quote (') or double quote (") character followed by optional whitespace followed by ')'. Quote characters that are not part of the URL itself must be balanced.



# Color managed screens



# Color Management arrives

**Mac:** ColorSync

**Win95/NT:** Kodak CMS (aftermarket)

**Win98/2000:** ICM

**WinXP:** ICM 2.0

**Linux/GNOME:** GNOME Color Manager

**Linux/KDE:** colord-kde



**Success!**



**Not so fast**

A person's hands are shown holding a white tablet. The tablet screen displays a solid blue color. Overlaid on the scene are vibrant, multi-colored digital waves in shades of purple, blue, green, yellow, and red, resembling data or network connections. A semi-transparent dark horizontal band is positioned across the middle of the image, containing the text 'Web vs. Everything Else' in white. The person holding the tablet has red nail polish on their left hand and a gold ring on their right hand. A black leather watch is visible on the left wrist.

# Web vs. Everything Else

# Color Management in Industry

Commercial printing, production of paint, plastics, fabric, 3D print

- There is a **paying** customer
- Design is **finished** before production
- Production is **centralized**
- Reliable, **calibrated** instruments for color QA



# Color Management on the Web

Even with color-managed screens:

- Content & browsers are **free**
- Design **customized** to end-user display
- Production is **distributed**
- End-user calibration **rare**





# CSS Color 3 (2011)

sRGB only, 8 bits per component

Chrome, Safari color managed; Firefox threw data at screen

```
fill: rgb(243, 214, 155);  
// looks fine on sRGB,  
// too saturated on P3 wide gamut
```





# Broadcast



SONY

*bungmedia*

**RED**

AUX 1

AUX 2

PWR

REC

TITAN-11

22'  
16'  
11'  
8'  
5.6'  
4'

2'  
2'  
2'  
3'  
3'  
4'  
4'  
5'  
6'  
8'  
10'  
15'  
30'  
8'

ft

www.bungmedia.com

↑

# DCI P3 - SMPTE EG 432

Digital Cinema Initiative

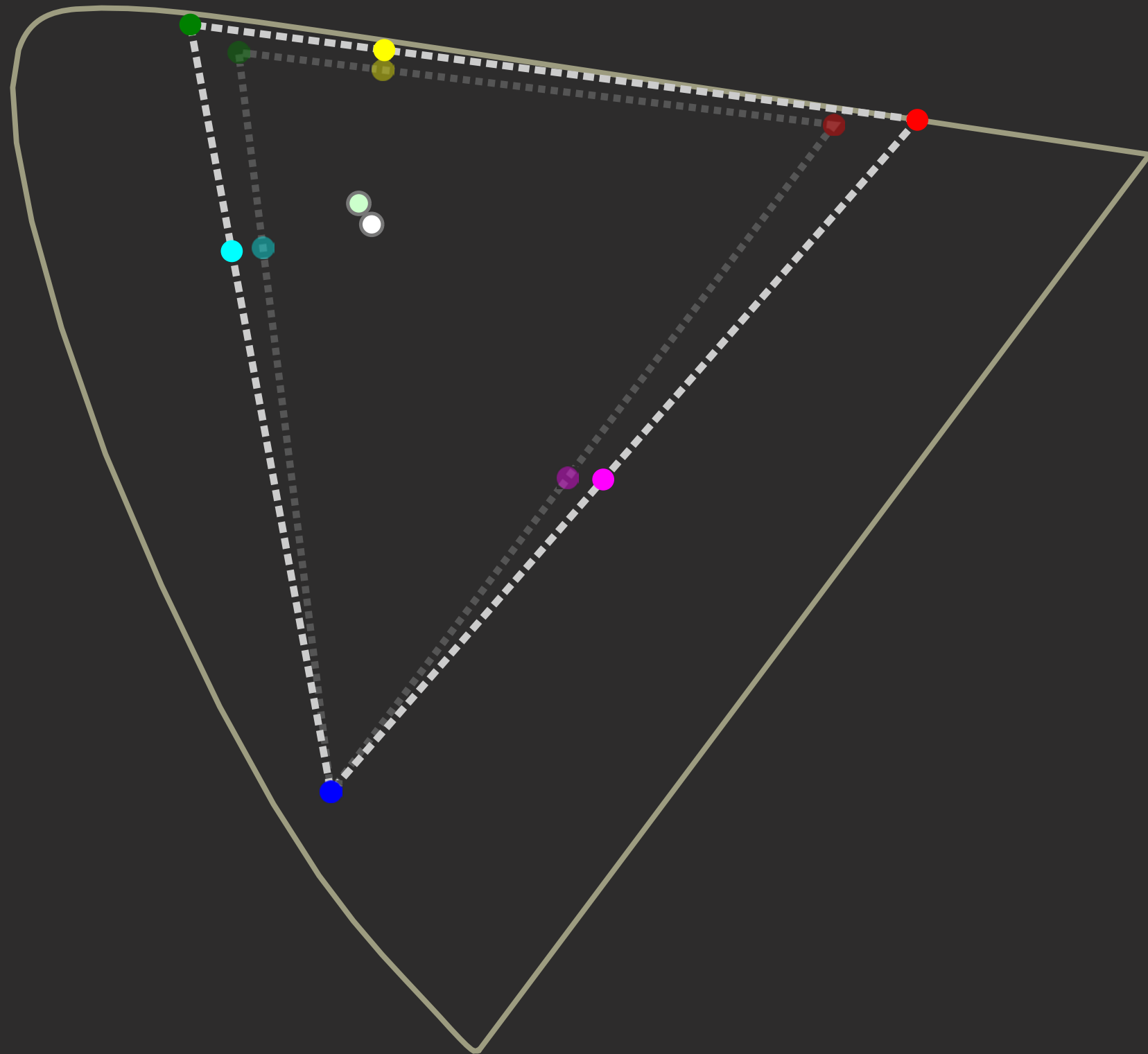
Projectors for digital cinema

Defines chromaticities, **weird** white

Monochromatic red, 615nm

White luminance 48 cd/m<sup>2</sup>

Dark surround



# UltraHD Premium

Conforming devices required to display at least 90% of DCI P3



# VESA DisplayHDR

(For tier 500 and greater)

Conforming devices required to display at least 90% of DCI P3



**VESA** CERTIFIED

**DisplayHDR™**



# Apple Display P3

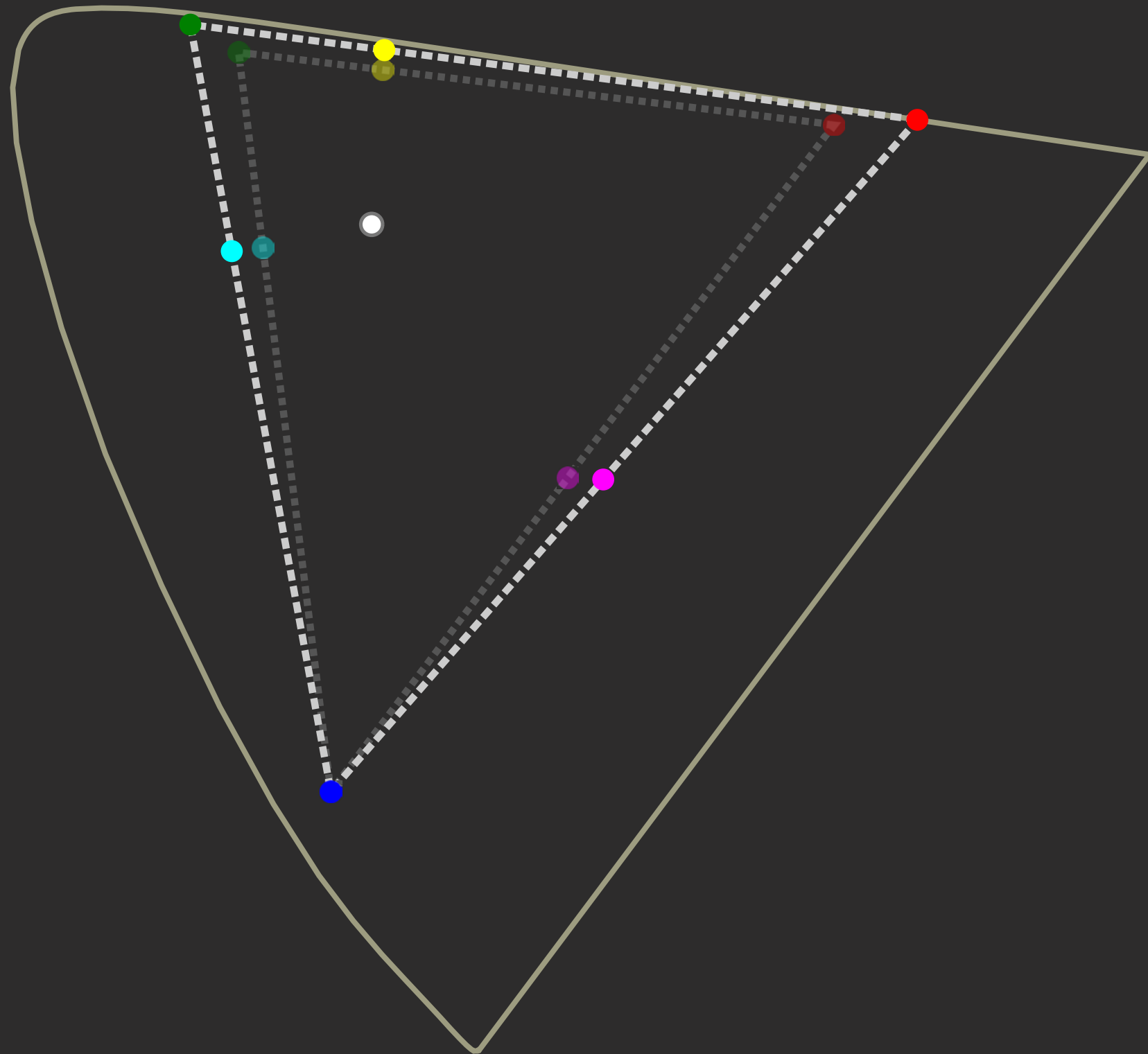
White, EOTF, viewing conditions same as sRGB

Primaries same as DCI-P3

Display-referred

Factory-calibrated phones, tablets, laptops, *watches*

*All* color managed



# ITU Rec BT.2020 (2012)

Ultrawide gamut

Monochromatic primaries (630, 532, 467nm)

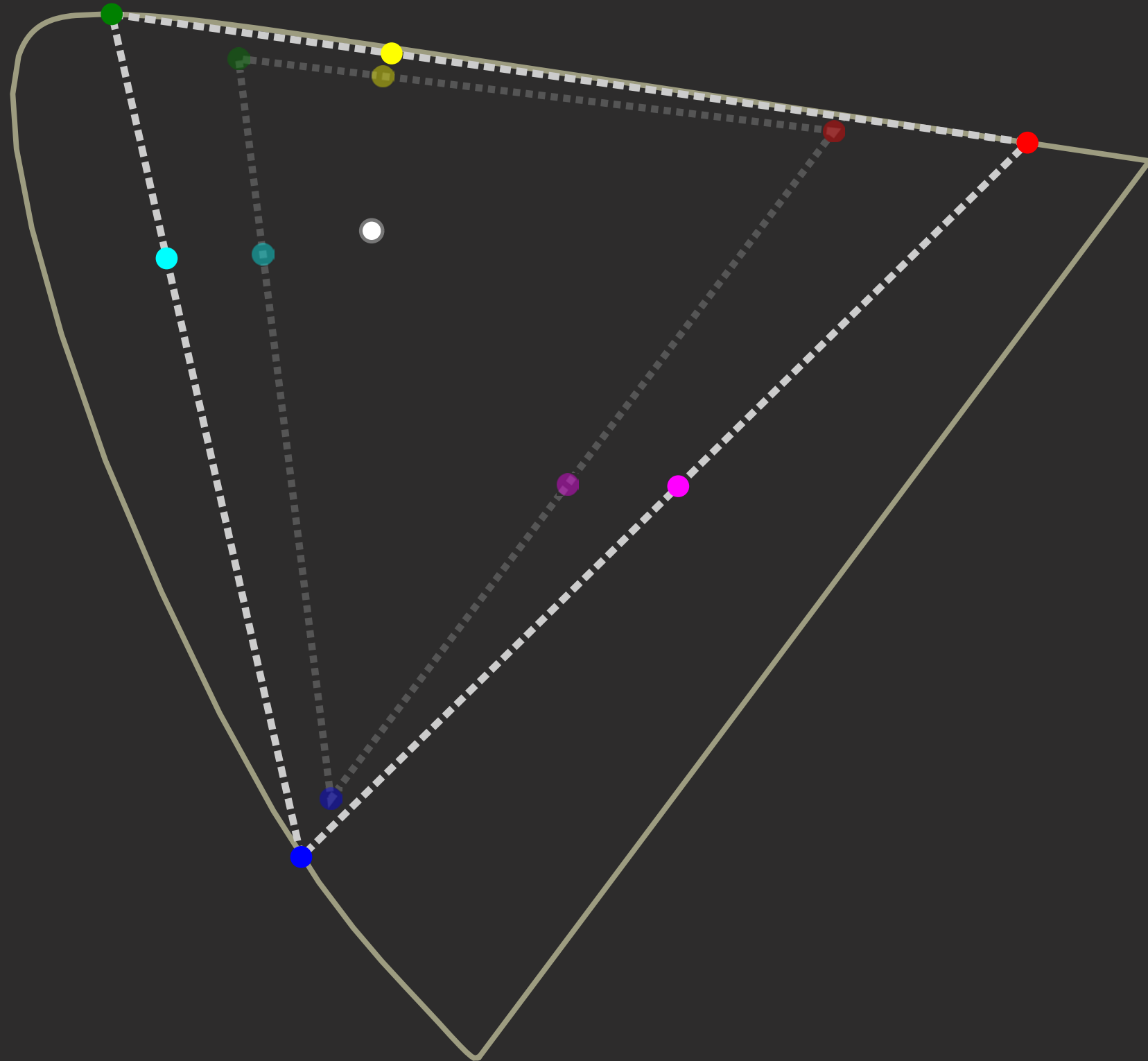
10 or 12 bits per component

OETF, and non-matching EOTF (gamma 2.4)

D65 white, dim surround

Display-referred

UltraHD (4k, 8k) broadcast, streaming



# BT.2020 in practice

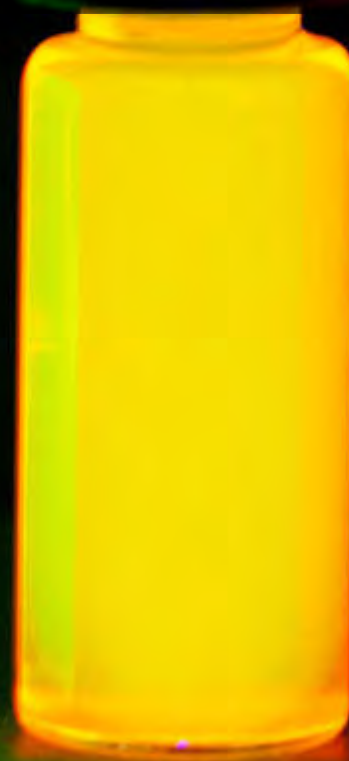
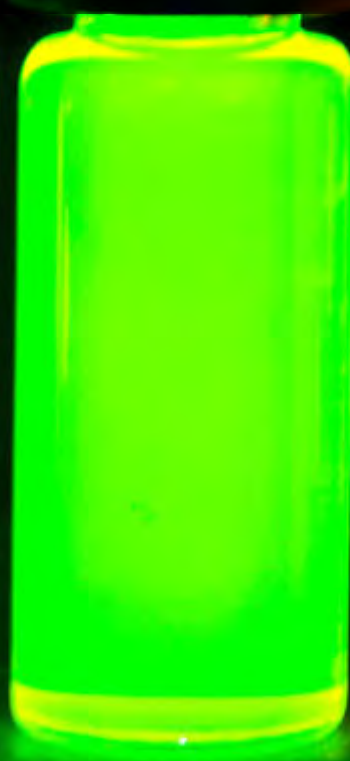
Content mostly mastered in DCI-P3

HDMI 2.0 supports BT.2020, 12bit

Content thus delivered in BT.2020 container

For HDR, metadata declares the mastering gamut volume

# CSS Color 4



# CSS Color Module Level 4

W3C First Public Working Draft, 05 July 2016



## This version:

<http://www.w3.org/TR/2016/WD-css-color-4-20160705/>

## Latest version:

<http://www.w3.org/TR/css-color-4/>

## Editor's Draft:

<https://drafts.csswg.org/css-color/>

## Feedback:

[www-style@w3.org](mailto:www-style@w3.org) with subject line “[css-color] ... message topic ...” ([archives](#))

## Issue Tracking:

[Inline In Spec](#)

## Editors:

[Tab Atkins Jr.](#) (Google)

[Chris Lilley](#) (W3C)

## Former Editor:

[L. David Baron](#) (Mozilla Corporation)

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# CSS Color 4

# What changed?

- ~~Wider color gamuts in digital SLR photography~~
- Apple Display P3 devices
- Dell, HP, Microsoft wide gamut laptop screens
- Samsung, Pixel, OnePlus wide gamut phones
- Wide gamut, HDR TV/movies/streaming
- Mobile CMS, *finally*
- Safari support for CSS Color 4 display-p3

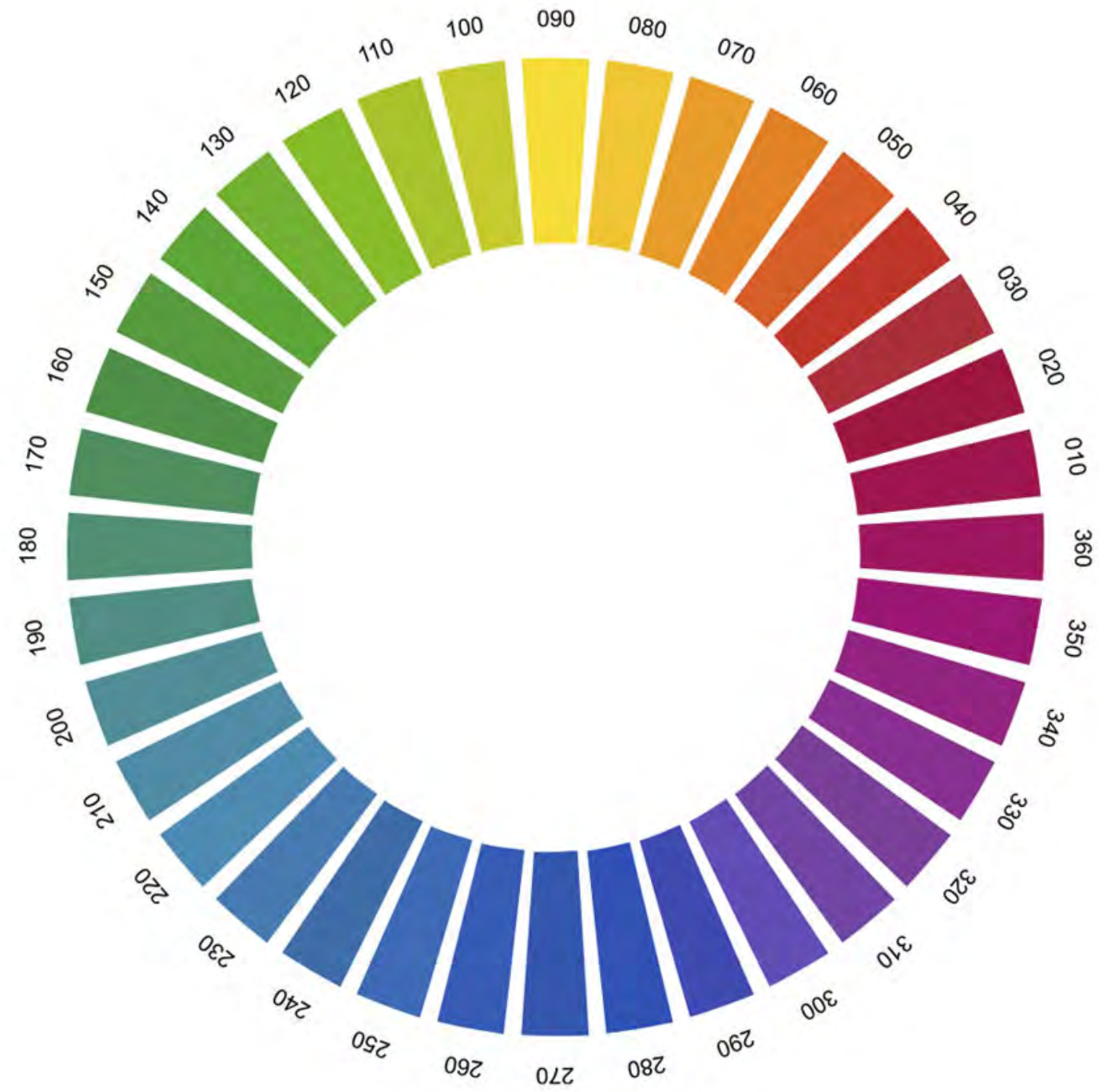


## Predefined Colorspaces

```
fill: color(display-p3 0.9341 0.8433 0.6361)  
fill: color(prophoto-rgb 0.8474 0.8103 0.5824)  
fill: color(rec2020 0.9151 0.8359 0.5960)  
// these are the same color, L=87.16 C=38.25 H=79.93
```



# CIE Hue, Chroma (LCH)



## LCH in CSS Color 4

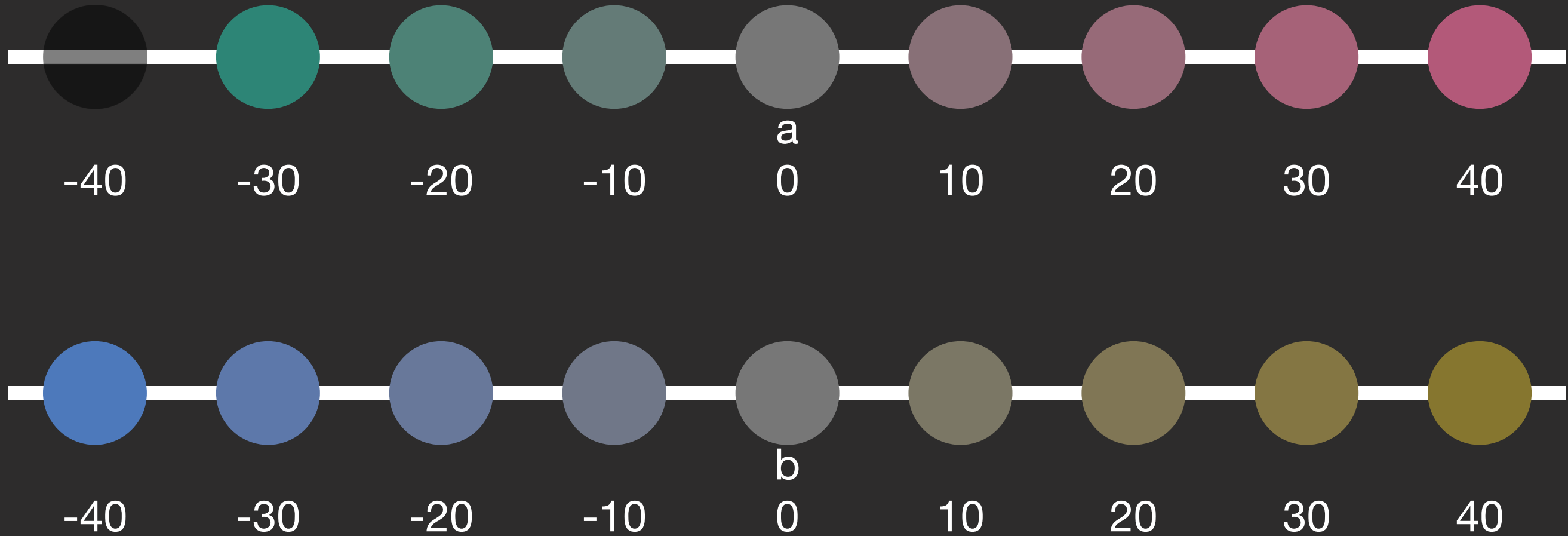
```
background: lch(50% 0 0);
```

```
border-color: lch(65% 30 180 / 50%);
```

```
color: lch(55.3% 84.5 10.25, #F06);
```

Hue can be NaN for neutrals

# CIE a & b



## Lab in CSS Color 4

```
background: lab(50% 0 0);
```

```
border-color: lab(65% 46 -8 / 50%);
```

```
color: lab(55.3% 83.1 15.0 / 75%, #F06);
```

## CMYK: ICC Color in CSS Color 4

At-rule (like *@font-face*) points to ICC profile

```
@color-profile --fogra39 {  
  src: url('https://example.org/C_Fogra39L.icc');  
}  
  
.header {  
  background-color: color(--fogra39 0% 70% 20% 0%);  
}
```

# CMYKOGV: ICC Color in CSS Color 4

Not limited to 4 components

```
@color-profile --fogra55beta {  
  src: url('https://example.org/FOGRA55beta_CL.icc');  
}  
  
.bluish_green {  
  background-color:  
  color(--fogra55beta 0.397575 0.010047 0.223682  
        0.031140 0.000000 0.317066 0.000000);  
}
```

A top-down view of a watercolor palette. The palette is a light-colored, textured surface with several circular wells containing different colors of watercolor paint. The colors include various shades of orange, red, yellow, green, blue, and purple. Two brushes with black handles and gold ferrules are resting on the palette. One brush is positioned horizontally across the middle, and the other is positioned vertically in the lower half. The text "Mixing & manipulating colors" is overlaid in white on a dark horizontal band across the center of the image.

# Mixing & manipulating colors



# CSS Color Module Level 5

Editor's Draft, 13 November 2020



## ► Specification Metadata

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## Abstract

This module extends CSS Color [\[css-color-4\]](#) to add color modification functions.

[CSS](#) is a language for describing the rendering of structured documents (such as HTML and XML) on screen, on paper, etc.

## Status of this document

This is a public copy of the editors' draft. It is provided for discussion only and may change at any moment. Its publication here does not imply endorsement by W3C. Do not cite this document other than as work in progress.

Please send feedback by [filing issues in GitHub](#) (preferred), including the spec code "css-color" in the title, like this: "[css-color] ...summary of comment...". All issues and comments are [archived](#). Alternately, feedback can be sent to the ([archived](#)) public mailing list [www-style@w3.org](mailto:www-style@w3.org).

This document is governed by the [15 September 2020 W3C Process Document](#).

## Table of Contents

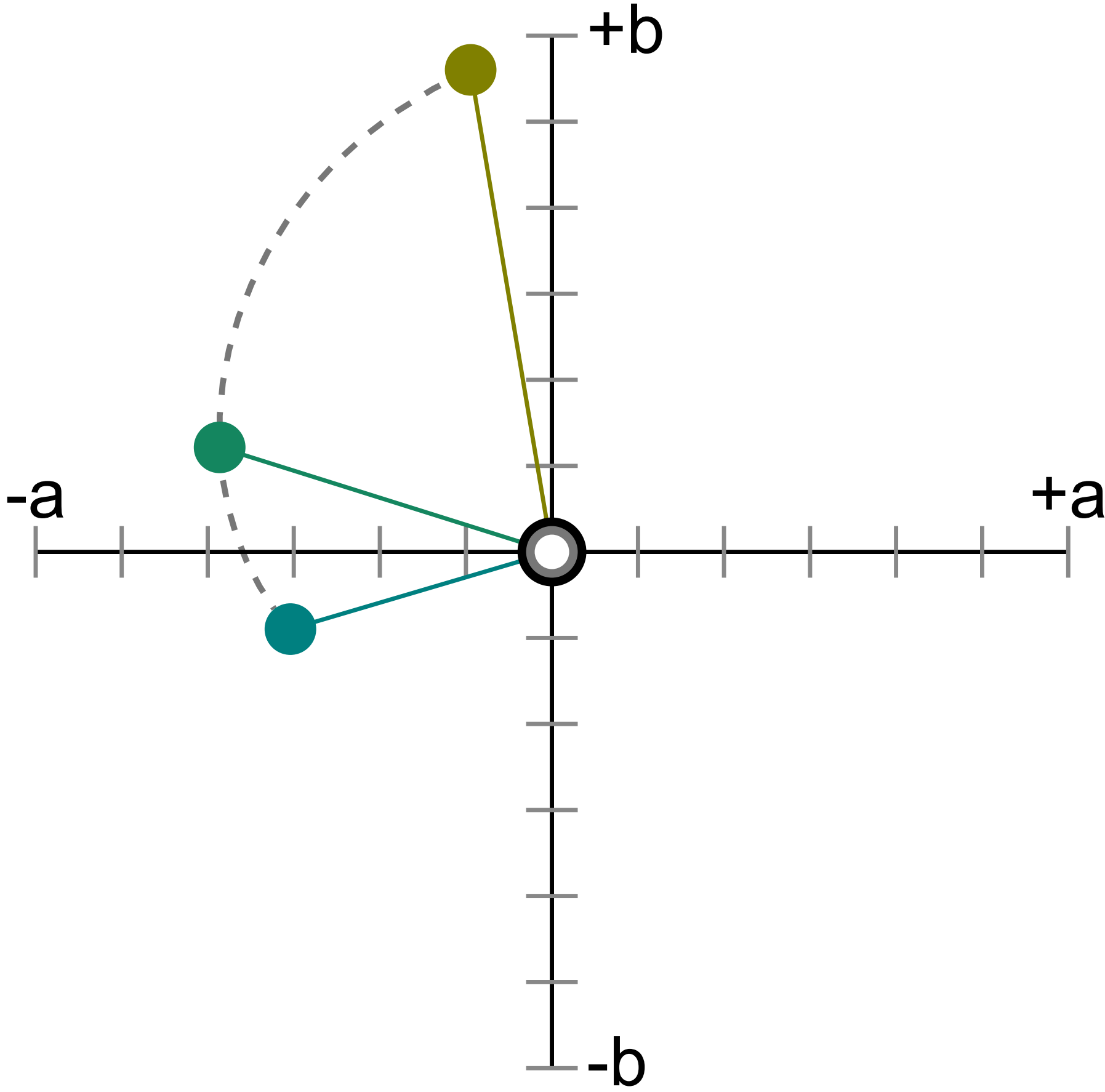
- 1 Introduction
- 2 Colorspaces
- 3 **Mixing colors: the 'color-mix()' function**
- 4 **Selecting the most contrasting color: the 'color-contrast()' function**
- 5 **Modifying colors**
  - 5.1 ~~Adjusting colors: the 'color-adjust' function~~

# CSS Color 5: manipulating color

## Mixing colors in CSS Color 5

Two colors can be mixed in any colorspace; default is LCH

```
color-mix(teal 65%, olive);
```



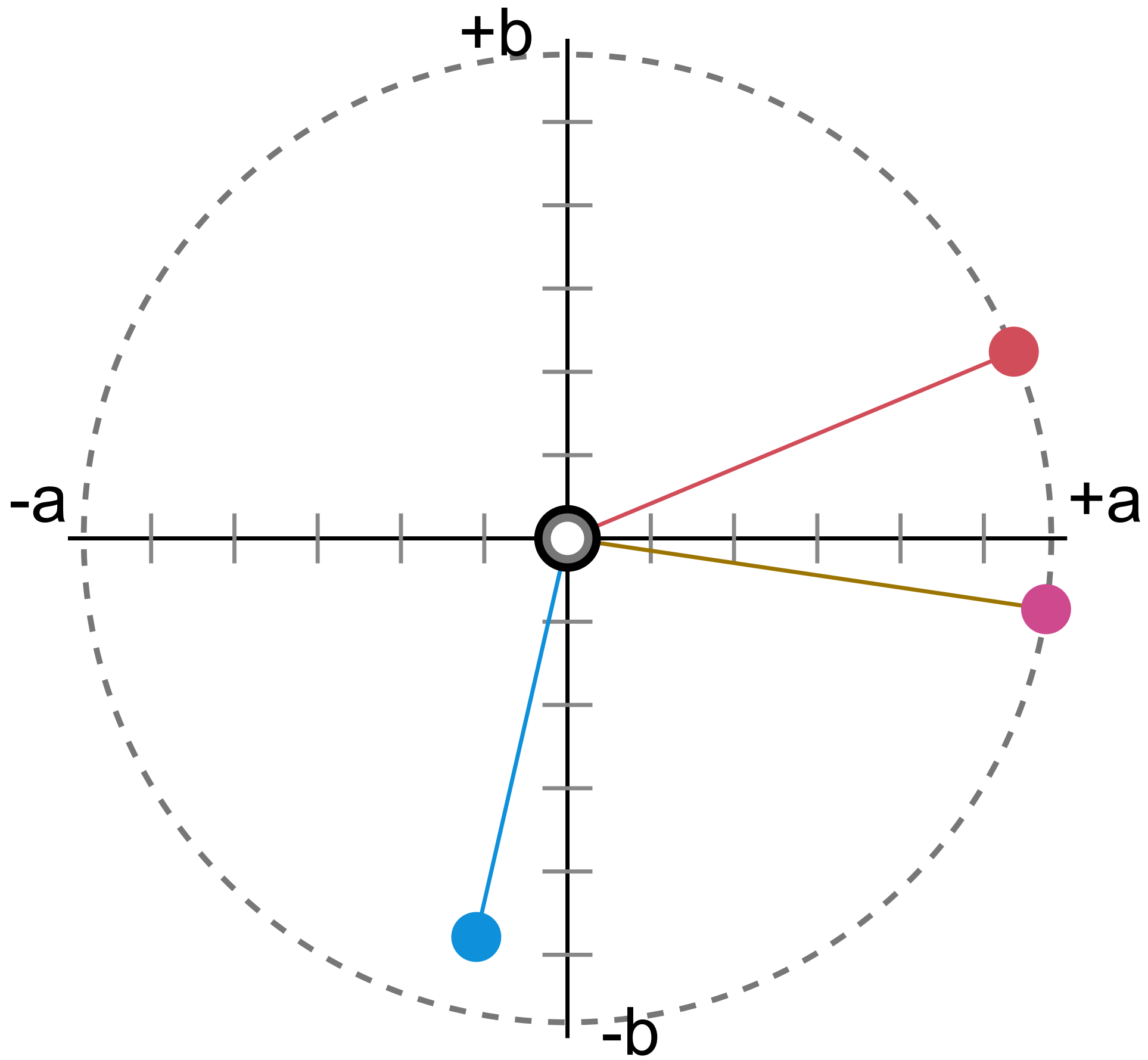
# Mixing colors in CSS Color 5

Individual components can be mixed

```
--tomato: lch(52% 58.1 22.7);
```

```
--sky: lch(56% 49.1 257.1);
```

```
color-mix(var(--tomato) hue 75.23%, var(--sky));
```



# Mix colors

Can be in different colorspaces

Space for mixing (LCH, Lab, XYZ)

Can specify long arc for hue mixing

Result can be out of gamut, *needs gamut mapping*

## Most contrasting color in CSS Color 5

Base color, list of alternates

```
-myAccent: #b22222;
```

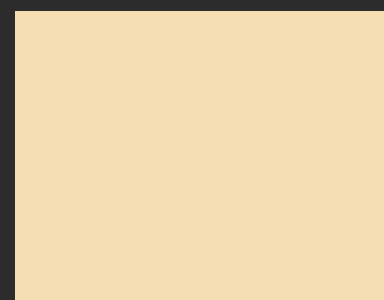
```
color-contrast(wheat vs tan, sienna, var(--myAccent), #d2691e
```

$$\text{WCAG Contrast} = (Y_b + 0.05) / (Y_a + 0.05)$$

**Color**

**Luminance**

**Contrast**



0.749



0.482

**1.501**



0.137

**4.273**



0.107

**5.081**



0.305

**2.249**



# High Dynamic Range

A sunset scene with a silhouette of a traffic light and a utility pole. The text "High Dynamic Range" is overlaid in white on a dark horizontal band. The background shows a bright sun low on the horizon, casting a glow over a body of water and some vegetation. The sky transitions from a deep purple at the top to a bright orange near the sun.

# Need for HDR

Consumer WCG, HDR films, series, news, sports (BT.2100 PQ, HLG)

Consumer HDR gaming consoles

Consumer WCG, HDR-ready TVs commonplace

Consumer WCG (P3) laptops, tablets, phones; HDR coming

WCG, HDR still images coming (AVIF)

# ITU Rec BT.2100 (2016)

BT.2020 gamut

10 or 12 bits per component

D65 white, dim surround

PQ or HLG

# Hybrid Log Gamma

Scene-referred, relative luminance

Diffuse white at 0.75

2.5 stops highlights

Range of viewing environments (dim to bright)

*“Brighter displays for brighter environments”*

# Perceptual Quantizer

Reference display referred, absolute luminance

Diffuse white varies (0.54, 0.58, 0.66)?

5.5 stops highlights

Dim viewing environment

*“Brighter displays for more highlights”*

# Problems with CIE Lab

Hue *non-linearity* in blue area

Primarily designed for reflective, low-luminance (120 cd/m<sup>2</sup>), print gamuts

Hard to extend for *specular whites* brighter than paper white

Under-tested for *wide-gamut colors*, over-estimates  $\Delta E$

Redefined colorspace for HDR:

- ec2100-pq
- ec2100-hlg
- zazbz
- JzCzHz
- Converting 'Jzazbz' colors to 'JzCzHz' colors
- Converting JzCzHz colors to Jzazbz colors
- CtCp

Compositing SDR and HDR content

Privacy and Security Considerations

Accessibility Considerations

Conformance

- Document conventions
- Conformance classes
- Partial implementations
- Implementations of Unstable and Proprietary Features
- Non-experimental implementations

Index

- Terms defined by this specification
- Terms defined by reference

References

- Normative References
- Informative References

Issues Index

# CSS Color HDR Module Level 1

Unofficial Proposal Draft, 23 September 2020



**This version:**

<https://drafts.csswg.org/css-color-hdr/>

**Latest published version:**

<https://www.w3.org/TR/css-color-hdr/>

**Issue Tracking:**

- [CSSWG Issues Repository](#)
- [Inline In Spec](#)

**Editor:**

[Chris Lilley](#) (W3C)

**Suggest an Edit for this Spec:**

[GitHub Editor](#)

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## Abstract

This module explores additions to CSS Color 4 to enable High Dynamic Range (HDR).

CSS is a language for describing the rendering of structured documents (such as HTML and XML) on screen, on paper, etc.

## Status of this document

*This section describes the status of this document at the time of its publication. Other documents may supersede this document. A list of current W3C publications and the latest revision of this technical report can be found in the W3C technical reports index at <https://www.w3.org/TR/>.*

Please send feedback by filing issues in GitHub (preferred), including the spec code "css-color-hdr" in the title, like this: "[css-color-hdr] ...summary of comment...". All issues and comments are archived. Alternately, the track can be sent to the arr (w3c) public mailing list ([css-color-hdr@w3.org](mailto:css-color-hdr@w3.org)).

This document is governed by the 15 September 2019 W3C Process Document.

This document was produced by a group operating under the [W3C Patent Policy](#). W3C maintains a [public list of any patent disclosures](#) made in connection with the deliverables of the group; that page also includes instructions for disclosing a patent. An individual who has actual knowledge of a patent which the individual believes contains

# CSS Color HDR: high dynamic range

# CSS Color HDR (unofficial draft)

Adds BT.2100 (both HLG & PQ)

Adds  $J_z a_z b_z$  &  $J_z C_z h_z$  (PQ-like, on LMS)

Adds  $IC_T C_p$  (PQ on LMS)

Defines SDR & HDR compositing (ITU Rpt BT.2408-0)





- Business solutions
- money transfer
- net banking
- strategic planning
- statistics
- video conferencing
- e-mail, ftp
- database working

7

- Entertainment
- films
- music
- games
- e-books
- chats

5

- Internet
- websites
- hosting
- banners
- searching engines
- blogs
- chats
- applications

### world data

Finance Business Culture  
Weather Sports News Music  
Mobile Technology 7/10/10  
E-commerce Shopping Search  
Real Estate Real Estate  
Travel Travel Tech  
Entertainment Sports  
Social Media Corporate  
Image Creation Learning  
The Data Cloud Profile

# Future challenges

# CSS Compositing

Currently **gamma-encoded sRGB default**, for legacy Web/Photoshop compatibility

**Porter-Duff compositing operators**

Ideal is compositing in linear-light, such as XYZ

# CSS gradients

Currently interpolate in **alpha-premultiplied gamma-encoded sRGB** space

Ideal is alpha-premultiplied, perceptually linear, chroma-preserving (LCH or

$J_z C_z h_z$

# Canvas (2D rendering context)

Currently **gamma-encoded sRGB default**, 8bits/component

Now adding other colorspaces from CSS Color 4

Adding 16-bit and half-float sRGB for WCG (and HDR?)

# CSS Object Model

Assumes colors are 8-bit sRGB

String (serialization) based

**Huge** legacy JS codebase

CSS Color 4 extends with serialization of `color()`

CSS Typed Object Model (in development)

# Expert review

W3C **Colorweb Community Group**

*W3C joined ICC*

# W3C Workshop on WCG & HDR

Virtual, April 2021

Speaker submissions welcome

**W3C<sup>®</sup>**



**Thank you!**

- [chris@w3.org](mailto:chris@w3.org)
- [svgees.us](http://svgees.us)
- [@svgeesus](#)