IEC

IEC 61966-12-1

Edition 2.0 2020-09
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

**Multimedia systems and equipment – Colour measurement and management –
Part 12-1: Metadata for identification of colour gamut (Gamut ID)**

IEC 61966-12-1:2020-09 RLV(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 17.180.20; 33.160.40

ISBN 978-2-8322-8905-1

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 61966-12-1 has been prepared by technical area 2: Colour measurement and management, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

This second edition cancels and replaces the first edition published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) ITU-R BT.2020 colour spaces added in Clause 6;
b) ITU-R BT.2100 colour spaces added in Clause 6.

The text of this International Standard is based on the following documents:

CDV	Report on voting
100/3126/CDV	100/3375/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61966 series, published under the general title *Multimedia systems and equipment – colour measurement and management*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

New technologies in capturing and displaying wide-gamut colour images enable a new market of wide-gamut video colour content and high dynamic range video content creation. Recent video standards for wide gamut colour space encoding such as ITU-R BT.2020 (UHDTV) and IEC 61966-2-4 (xvYCC) were established in order to be able to distribute content with a colour gamut that is extended with respect to classical colour gamuts such as defined by colorimetry standards ITU-R BT.601 (standard-definition television) and ITU-R BT.709 (high-definition television). Recent video standards for high dynamic range (HDR) colour space encoding, such as ITU-R BT.2100, were established in order to be able to distribute content with a colour gamut and a dynamic range that are both extended with respect to classical colour encoding, such as that defined by ITU-R BT.709. With the increasing popularity of wide gamut and high dynamic range content and displays, the variety of colour gamuts of displays is expected to increase. This issue can be an obstacle for adopting wide-gamut video colour content in professional content creation since the compatibility of the content to the employed displays as well as the compatibility among different displays is not ensured. The term display includes here any video colour reproduction equipment, such as direct view displays and projectors. Thanks to improvements of technology, the variety of colour gamut and colour reproduction capacities of displays increases, while the colour gamut and the colour encoding rules of existing colour space encoding standards are fixed.

To address this issue, ~~the IEC standard Gamut ID (IEC 61966-12-1)~~ this document specifies a colour gamut metadata scheme for video systems including information for colour reproduction. This metadata can amend a video content or a display. More specifically, improvements can be achieved if the wide-gamut colour content is created with the knowledge of the display colour gamut as well as if the colour reproduction in the display is done with the knowledge of the colour gamut of the pictorial content.

~~This standard enables video systems defining~~ This document permits video systems to define their own colour gamut. This document defines necessary metadata that allows managing inhomogeneous video systems with different colour gamuts. This document generalizes existing colour space encoding standards having a fixed colour gamut.

MULTIMEDIA SYSTEMS AND EQUIPMENT – COLOUR MEASUREMENT AND MANAGEMENT –

Part 12-1: Metadata for identification of colour gamut (Gamut ID)

1 Scope

This part of IEC 61966 defines the colour gamut metadata scheme for video systems and similar applications.

The metadata can be associated with wide-gamut video colour content or to a piece of equipment to display the content.

When associated with content, the colour gamut metadata defines the gamut for which the content was created. It can be used by the display for controlled colour reproduction even if the display's colour gamut is different from that of the content.

When associated with a display, the colour gamut metadata defines the display colour gamut. It can be used during content creation to enable improved colour reproduction.

The colour gamut metadata ~~may~~ can cover associated colour encoding information, which includes all information required for a controlled colour reproduction, when such information is not provided by the colour encoding specification.

The colour gamut metadata scheme provides scalable solutions. For example, more flexible solutions will be used for the professional use, while much simpler solutions will be used for consumer use with easier product implementation.

This part of IEC 61966 only defines the colour gamut metadata scheme. Vendor-specific solutions for creation and end-use of this metadata are allowed.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-845~~:1987~~, *International electrochnical vocabulary – Chapter 845: Lighting*

IEC 61966-2-4:2006, *Multimedia systems and equipment – Colour measurement and management – Part 2-4: Colour management – Extended-gamut YCC colour space for video applications – xvYCC*

ISO 15076-1:~~2005~~2010, *Image technology colour management – Architecture, profile format and data structure – Part 1: Based on ICC.1:~~2004-10~~2010*

~~ISO 22028-1:2004, *Photography and graphic technology – Extended colour encodings for digital image storage, manipulation and interchange – Part 1: Architecture and requirements*~~

ITU-R BT.709~~-5:2002~~, *Parameter values for the HDTV standards for production and international programme exchange*

CIE 15:2004, *Colorimetry*

SMPTE 274M:2005, *SMPTE Standard for Television - 1920 x 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates*

ITU-R BT.2020, *Parameter values for ultra-high definition television systems for production and international programme exchange*

ITU-R BT.2100, *Image parameter values for high dynamic range television for use in production and international programme exchange*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

~~For the purposes of this document, the following terms and definitions as well as the terms and definitions of colour space, illuminance, luminance, tristimulus, and other related lighting terms of IEC 60050(845) apply.~~

For the purposes of this document, the terms and definitions given in IEC 60050-845 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
content
video content in production, post-production or consumption

3.1.2
gamut
solid in a colour space

Note 1 to entry: A solid in a colour space, such as specified by ITU-R BT.2100, can contain colours with high luminance.

3.1.3
gamut boundary description
description of the boundary of a colour gamut

3.1.4
radiometrically-linear colour space coordinates
colour space coordinates that are linear with respect to image radiance

3.2 Abbreviated terms

GBD gamut boundary description

LSB least significant bit

MSB most significant bit

GI gamut instance

GH gamut hull

GC gamut component

4 Overview

This document specifies metadata called "Gamut ID metadata" providing information on an actual colour gamut.

The Gamut ID metadata contains four parts and its format is summarized in Table 1.

Table 1 – Format of Gamut ID metadata

Byte # hex	Metadata content
0h0000	Header of Gamut ID metadata
ID_G	Description of gamut geometry
ID_E	Description of colour reproduction

Clause 5 specifies the header of Gamut ID metadata.

Clauses 6 and 7 specify the description of gamut geometry that corresponds to one of three profiles as listed below:

- full profile;
- medium profile;
- simple profile.

Clause 6 specifies the full profile of the description of gamut geometry. The medium and simple profiles are specified in Clause 7.

Clause 8 specifies the description of colour reproduction.

Annex A discusses the size of Gamut ID metadata.

Annex B gives background information.

Annex C discusses the use of simple, medium and full profiles.

5 Header of Gamut ID metadata

The Gamut ID metadata starts with the header shown in Table 2.

Table 2 – Header of Gamut ID metadata

Byte # hex	Size Bytes	Symbols	Description								Values
			7	6	5	4	3	2	1	0	
00	1	N, P	R	ID_PROFILE		ID_PRECISION		ID_GBD_SPACE			R = reserved = 0b0 (1bit) ID_PROFILE (2 bits): 0b00: Full profile 0b01: Medium profile 0b10: Simple profile 0b11: Reserved ID_PRECISION (2 bits): 0b00: 8 bits 0b01: 10 bits 0b10: 12 bits 0b11: Reserved ID_GBD_SPACE (3bits): 0b000: ITU-R BT.709 RGB 0b001: xvYCC-601 (IEC 61966-2-4 -SD) YCC 0b010: xvYCC-709 (IEC 61966-2-4 -HD) YCC 0b011: XYZ (see below) 0b100: ~~Reserved~~ ITU-R BT.2020 R'G'B' 0b101: ~~Reserved~~ ITU-R BT.2020 $Y'C'_BC'_R$ 0b110: ~~Reserved~~ ITU-R BT.2020 $Y_C'C'_{BC}C'_{RC}$ 0b111: ~~Reserved~~ ID_GBD_SPACE_EXT
01	2	ID_G	Byte # of start of the description of gamut geometry								[0h0009;0hFFFF]
03	2	ID_E	Byte # of start of the description of colour reproduction								[0;0hFFFF]
~~05~~	~~2~~		~~Reserved. Shall be zero.~~								~~0h0000~~
~~07~~	~~2~~		~~Reserved. Shall be zero.~~								~~0h0000~~

Byte # hex	Size Bytes	Symbols	Description	Values
05	1		ID_GBD_SPACE_EXT	0h00: ITU-R BT.2100 R'G'B' PQ narrow 0h01: ITU-R BT.2100 R'G'B' PQ full 0h02: ITU-R BT.2100 R'G'B' HLG narrow 0h03: ITU-R BT.2100 R'G'B' HLG full 0h04: ITU-R BT.2100 $Y'C'_BC'_R$ PQ narrow 0h05: ITU-R BT.2100 $Y'C'_BC'_R$ PQ full 0h06: ITU-R BT.2100 $Y'C'_BC'_R$ HLG narrow 0h07: ITU-R BT.2100 $Y'C'_BC'_R$ HLG full 0h08: ITU-R BT.2100 IC_TC_P PQ narrow 0h09: ITU-R BT.2100 IC_TC_P PQ full 0h0A: ITU-R BT.2100 IC_TC_P HLG narrow 0h0B: ITU-R BT.2100 IC_TC_P HLG full 0h0C – 0hFF: reserved
06	3		Reserved. Shall be zero.	0h000000

ID_PROFILE indicates the profile of the Gamut ID metadata and shall be one of

- 0b00: Full profile,
- 0b01: Medium profile,
- 0b11: Simple profile.

ID_GBD_SPACE indicates the colour space and the colour space encoding for colour vertices in the description of gamut geometry and shall be one of:

- 0b000: ITU-R BT.709, RGB space, encoding in accordance with SMPTE 274M,
- 0b001: xvYCC-601, YCbCr space, encoding in accordance with IEC 61966-2-4 – SD,
- 0b010: xvYCC-709, YCbCr space, encoding in accordance with IEC 61966-2-4 – HD,
- 0b011: XYZ; encoding shall use the XYZNumber format of ICC profiles specified in ISO 15076-1:~~2005~~2010 taking 12 bytes for one XYZ triple.
- 0b100: ITU-R BT.2020, RGB space, encoding in accordance with ITU-R BT.2020 R', G', B',
- 0b101: ITU-R BT.2020, YCbCr space', encoding in accordance with ITU-R BT.2020 Y', C'_B, C'_R,
- 0b110: ITU-R BT.2020, YCbCr space, encoding in accordance with ITU-R BT.2020 Y_C', C'_{BC}, C'_{RC},
- 0b111: colour space and colour space encoding are indicated by ID_GBD_SPACE_EXT.

If ID_GBD_SPACE equals 0b111, ID_GBD_SPACE_EXT indicates the colour space and the colour space encoding for colour vertices in the description of gamut geometry and shall be one of:

- 0h00: ITU-R BT.2100 R'G'B', PQ format, narrow range,

- 0h01: ITU-R BT.2100 R'G'B', PQ format, full range,
- 0h02: ITU-R BT.2100 R'G'B', HLG format, narrow range,
- 0h03: ITU-R BT.2100 R'G'B', HLG format, full range,
- 0h04: ITU-R BT.2100 $Y'C'_BC'_R$, PQ format, narrow range,
- 0h05: ITU-R BT.2100 $Y'C'_BC'_R$, PQ format, full range,
- 0h06: ITU-R BT.2100 $Y'C'_BC'_R$, HLG format, narrow range,
- 0h07: ITU-R BT.2100 $Y'C'_BC'_R$, HLG format, full range,
- 0h08: ITU-R BT.2100 IC_TC_P, PQ format, narrow range,
- 0h09: ITU-R BT.2100 IC_TC_P, PQ format, full range,
- 0h0A: ITU-R BT.2100 IC_TC_P, HLG format, narrow range,
- 0h0B: ITU-R BT.2100 IC_TC_P, HLG format, full range.

~~aID_PRECISION~~ ID_PRECISION, ID_GBD_SPACE and ID_GBD_SPACE_EXT specify, in accordance with Table 3, the number N of bits that are used per colour channel in order to define the coordinates of a colour in a colour space.

Table 3 – Bit depth for encoding of a colour space coordinate

~~ID_GBD_SPACE~~	~~ID_PRECISION~~	~~Bit depth N~~
~~0b000 or 0b001 or 0b010~~	~~0b00~~	~~8 bits~~
	~~0b01~~	~~10 bits~~
	~~0b10~~	~~12 bits~~
	~~0b11~~	~~Reserved~~
~~0b011~~	~~Any~~	~~32 bits~~
~~0b100 or 0b101 or 0b110 or 0b111~~	~~Any~~	~~Reserved~~

ID_GBD_SPACE	ID_PRECISION	Bit depth N
0b011	Any	32 bits
else	0b00	8 bits
	0b01	10 bits
	0b10	12 bits
	0b11	Reserved

If ID_GBD_SPACE equals 0b011 for XYZ encoding, bit depth N shall be 32 independent of ID_PRECISION.

BT.2020 and BT.2100 encodings are defined by the ITU-R for bit depths of 10 or 12, only.

ID_G indicates the offset in bytes from the beginning of Gamut ID metadata to the beginning of the description of gamut geometry.

If ID_E is different from 0h0000, the Gamut ID metadata contains a description of colour reproduction and ID_E indicates the offset in bytes from the beginning of Gamut ID metadata to the beginning of the description of colour reproduction. If ID_E has the value 0h0000, the Gamut ID metadata does not contain a description of colour reproduction.

6 Description of gamut geometry (full profile)

6.1 General

In the header of Gamut ID metadata, if ID_PROFILE equals 0b00, the description of gamut geometry shall correspond to the full profile.

6.2 Gamut geometry

The description of gamut geometry of the Gamut ID metadata describes the boundary of the actual colour gamut. The description of gamut geometry starts at byte number ID_G.

The description of gamut geometry contains five sets of different elements:

- gamut instances,
- gamut hulls,
- gamut components,
- faces, and
- vertices.

The logical structure of the Gamut ID description of colour gamut is shown in Figure 1.

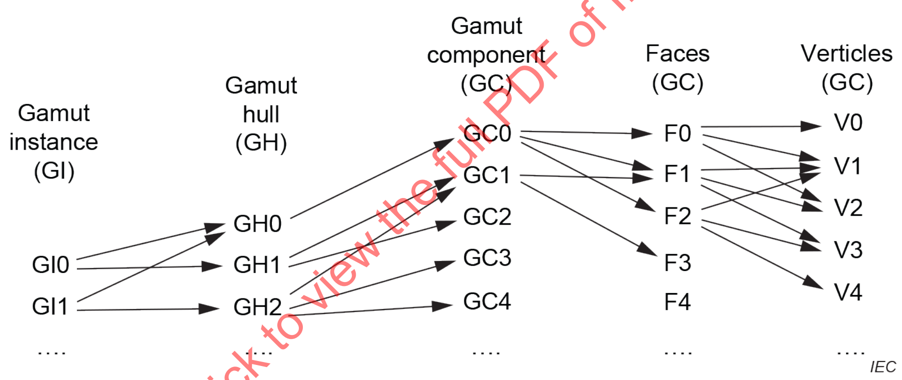

Figure 1 – Logical structure of the description of gamut geometry (full profile)

The description of gamut geometry contains one or more gamut boundary descriptions (GBD) that each describes the boundary of the same actual colour gamut. A GBD contains vertices and triangular faces. Each face is defined by the indices of three vertices.

A gamut component is a group of connex triangular faces. A GC is a part of a boundary description. A GC is defined by one or more indices of faces.

A gamut hull (GH) is a group of connex gamut components building all together a closed surface. This surface is the boundary description of a connex volume in CIEXYZ colour space. Each GH is defined by one or more indices of GCs. A GH may refer to a single GC. In this case, the GC ~~must~~ shall be a closed surface boundary description by itself. A GH may refer to a list of GCs, in that case all GCs together build a closed surface boundary description of a connex volume.

A gamut instance (GI) is a group of gamut hulls building all together a valid GBD of the actual colour gamut. A GI is defined by one or more indices of gamut hulls. A GI may refer to a single GH; in this case, the single GH describes by itself the actual colour gamut. A GI may refer to a list of GHs; in this case, the union of the volumes of the GHs describes the actual colour gamut.

The description of gamut geometry contains one or more different gamut instances. Each GI is a complete and valid GBD. Two GIs differ in at least one of the following characteristics:

- Level of detail
  → The higher the level, the higher the number of faces.
- Non-convex shape
  → A GI may allow or not allow the use of non-convex shapes.
- Percentage of gamut colours
  → GIs may contain different percentages of the colours of the actual colour gamut.

A GI may have additional, optional characteristics:

- Inverted gamut components
  → A GC is used as inverted GC if it referenced by one or more GH assuming that its surface orientation is inverted.
- Indication of gamut ridges
  → Vertices may be marked as gamut ridges if they correspond to positions on the surface of the actual colour gamut having non-continuous surface curvature.

The description of gamut geometry is summarized in Table 4.

Table 4 – Description of gamut geometry

Byte # hex	**Description**
ID_G	Header of description of gamut geometry
ID_GI	Gamut instances
ID_GH	Gamut hulls
ID_GC	Gamut components
ID_F	Faces
ID_V	Vertices

6.3 Header of description of gamut geometry

The header of the description of gamut geometry follows the header of Gamut ID metadata and is defined in accordance with Table 5.

Table 5 – Header of description of gamut geometry

Byte # hex	Size bytes	Symbol	Description	Values decimal
ID_G	2	ID_GI	Byte # of start of gamut instances	[0;0hFFFF]
ID_G + 02	2	ID_GH	Byte # of start of gamut hulls	[0;0hFFFF]
ID_G + 04	2	ID_GC	Byte # of start of gamut components	[0;0hFFFF]
ID_G + 06	2	ID_F	Byte # of start of faces	[0;0hFFFF]
ID_G + 08	2	ID_V	Byte # of start of vertices	[0;0hFFFF]
ID_G + 0A	1		Reserved	0
ID_G + 0B	1		Reserved	0
ID_G + 0C	1	K	Number of levels of detail	$1 \le K \le 255$
ID_G + 0D	2	F_{MAX}	Maximum number of faces in lowest level of detail	$1 < F_{MAX} \le F$ (F see Table 6)
ID_G + 0F	1	P	Number of levels of colour population	$0 < P \le 128/K$
ID_G + 10	1	$2Q_0$	Double of percentages of gamut colours	[0;200]
ID_G + 11	1	$2Q_1$	Double of percentages of gamut colours	[0;200]
: :				
ID_G + 10 + P-1	1	$2Q_{P-1}$	Double of percentages of gamut colours	[0;200]
ID_G + 10 + P	1	X	Convex or non-convex shape X = 1: all GIs and all GHs shall be convex X = 2: GIs and GHs may be convex or non-convex	$1 \le X \le 2$

16-bit integer or address values are encoded into 2 bytes using big endian, i.e. with the MSBs in the first byte and the LSBs in the second byte.

ID_GI, ID_GH, ID_GC, ID_F and ID_V shall give the offset in bytes from the beginning of gamut ID metadata to the beginning of gamut instances, gamut hulls, gamut components, faces and vertices data, respectively.

K indicates the number of levels of details. The Gamut ID metadata contains at least K GIs. If K = 1 there are no different level of details. Each GI is marked individually with a level of detail (0, 1,…, K – 1), see Table 7.

F_{MAX} shall indicate the maximum number of faces for a GI having the lowest level of detail (level 0). See Table 7 for definition of level of details. See Table 13 for the definition of faces.

P indicates the number of alternative GIs populated by different percentages of colours of the actual colour gamut. If P > 1, there are P alternative GIs describing the same actual colour gamut but containing different percentages of colours of the actual colour gamut. The Gamut ID metadata contains at least P GIs. Each GI is marked individually with a population level (0,1,…, P − 1), see Table 7.

$2Q_0$…$2Q_{P-1}$ are the doubles of the percentages Q_0… Q_{P-1} of colours associated with the population levels (0,1,…,P−1). A percentage shall approximately indicate how many percent of colours (0…100) of the actual colour gamut are contained in the volume described by a GI of the corresponding population level. As a matter of definition, Q_0… Q_{P-1} percentages can be defined in steps of 0,5 points.

X indicates whether the Gamut ID uses only convex shapes (X = 1) or may use convex and non-convex shapes (X = 2). When X = 1, each GI shall correspond to a convex shape and each GH shall correspond to a convex shape. When X = 2, GIs are organized into pairs. Each pair contains a first GI (marked as "convex", see Table 7) that corresponds to a convex shape and which references only GHs that correspond to a convex shape. The second GI of the pair (marked as "non convex", see Table 7) may correspond to a non-convex shape and may reference GHs that correspond to non-convex shapes. The Gamut ID metadata contains at least X GIs.

6.4 Gamut instances

The description of gamut geometry contains one or more gamut boundary descriptions of the actual colour gamut. One single GBD is called gamut instance. A user of Gamut ID metadata may use any one or any number of GIs of Gamut ID metadata. The GIs are defined by a list of GIs from byte number ID_GI in accordance with Table 6. The order in the list is arbitrary but fixed.

Table 6 – Gamut Instances

Byte # hex	**Size** bytes	**Symbol**	**Description**	**Values**
ID_GI	1	I	Total number of Gamut Instances	$I = X\,P\,K$
ID_GI + 01	6+ H_0		Definition of GI no. 0,	see Table 7
ID_GI + 01 + 6+ H_0	6+ H_1		Definition of GI no. 1	see Table 7
: :				
ID_GI + 01 + $\sum_{i=0}^{I-2}(6+H_i)$	6+ H_{I-1}		Definition of GI no. I-1	see Table 7

I is the number of GIs and shall be equal to the product of X, P and K as defined in Table 5. The ith GI, i = 0…I – 1, is defined in accordance with Table 7.

Table 7 – *i*th gamut instance

Relative byte # hex	Size bytes	Symbol	Description	Values
00	1	K_i	Level of detail of this GI	$0 \le K_i \le K-1$
01	2	F_i^{GI}	Number of faces used by this GI	$F_i^{GI} \le 2^i F_{MAX}$ (F_{MAX} see Table 5)
03	1	X_i^{GI}	This GI defines a convex shape (X_i^{GI} = 1) or may define a non-convex shape (X_i^{GI} =2)	$1 \le X_i^{GI} \le X$ (X see Table 5)
04	1	P_i	Level of colour population of this GI	$0 \le P_i \le P-1$ (P see Table 5)
05	1	H_i	Number of gamut hulls referenced by this GI	$1 \le H_i \le H$ (H see Table 8)
06	H_i		Indices of referenced GHs	[0; $H-1$] Shall be valid indices of GH

K_i is the level of detail of the ith GI. The GI is of lowest level of detail is $K_i = 0$. If K_i is larger than the level of detail K_j of a jth GI of same type ($P_i = P_j$, $X_i = X_j$) then the ith GI has a higher level of detail, i.e. a more precise geometric description, than the jth GI.

F_i^{GI} is the number of faces used by the ith GI. This number should correspond to the number of faces referenced by those gamut components (see Table 10) that are referenced by those gamut hulls (see Table 8) that are referenced by the ith GI. The number F_i^{GI} of faces should be equal or smaller than $2^{K_i} F_{MAX}$ (F_{MAX} see Table 6).

X_i^{GI} is an indicator of convex or non-convex shape. If X_i^{GI} = 1, the ith GI defines a convex shape and each GH referenced by the ith GI defines a convex shape by itself. If X_i^{GI} = 2, the ith GI may define a convex or a non-convex shape and each of the GHs referenced by the ith GI may define a convex or a non-convex shape by itself.

P_i is the population level of the ith GI. The ith GI shall contain approximately Q_{P_i} percent of colours of the actual colour gamut. Different GIs with same population level shall contain approximately the same percentage of colours of the actual colour gamut. A GI with population level P_i shall contain at least all colours of another GI with population level P_j if $P_j > P_i$, $K_j = K_i$ and $X_j = X_i$.

H_i is the number of gamut hulls that are referenced by the ith GI. If an ith GI references one gamut hull, then H_i = 1 and the gamut hull describes the actual colour gamut. If an ith GI references more than one gamut hull, then H_i > 1 and the union of the volumes of all referenced gamut hulls describes the actual colour gamut.

The H_i indices of GHs have each one byte.

6.5 Gamut hulls

The description of gamut geometry contains one or more gamut hulls. Each GH is the closed surface boundary description defining a connex, closed volume in colour space. A GH may be referenced by one or more GIs. A GI may reference one or more GHs. A GH may describe by itself the actual colour gamut or just a part of it. The GHs are defined by a list of GHs from byte number ID_GH in accordance with Table 8. The order in the list is arbitrary but fixed.

H is the total number of GHs contained in the Gamut ID metadata. The hth GH, $h = 0 \ldots H - 1$, is defined according to Table 9.

Table 8 – Gamut hulls

Byte # hex	Size bytes	Symbol	Description	Values
ID_GH	1	H	Total number of Gamut Hulls	$0 \leq H \leq 255$
ID_GH + 01	$3+ C_0 + \overline{C_0}$		Definition of GH no. 0	see Table 9
ID_GH + 01 $+ 2+ C_0 + \overline{C_0}$	$3+ C_1 + \overline{C_1}$		Definition of GH no. 1	see Table 9
: :				
ID_GH + 01 $+ \sum_{h=0}^{H-2} (3+C_h+\overline{C}_h)$	$3+ C_{H-1} + \overline{C}_{H-1}$		Definition of GH no. $H - 1$	see Table 9

Table 9 – hth Gamut hull

Relative byte # hex	Size bytes	Symbol	Description	Values
00	1	X_h^{GH}	Indication whether this GH defines a convex shape or any shape (convex or non-convex)	$1 \le X_h^{GH} \le X$ (X see Table 5) X_h^{GH} =1: convex shape X_h^{GH} =2: convex or non-convex shape
01	1	C_h	Number referenced Gamut Components that are used non-inverted by this GH	$1 \le C_k + \overline{C}_k \le C$ (C see Table 10)
02	1	$\overline{C}_h$	Number of referenced Gamut Components that are used inverted by this GH	
03	C_h		Indices of referenced Gamut Components	[0; C − 1] shall be valid indices of GCs
03 + C_h	$\overline{C}_h$		Indices of referenced Gamut Components used in an inverted manner	

$C_h + \overline{C}_h$ is the number of gamut components that are referenced by the hth GH. If a hth GH references one GC, then $C_h + \overline{C}_h = 1$ and the GC defines by itself the closed surface of the GH. If a hth GH references more than one GC, then $C_h + \overline{C}_h > 1$ and all referenced GCs build together the closed surface of the GH. When a GC is used inverted, the surface normals of the faces referenced by this GC are used in the inverse sense. For referenced faces, see Table 10. For surface normals, see 6.7.

6.6 Gamut component

6.6.1 General

The description of gamut geometry contains one or more gamut components that each defines a connex piece of a boundary description of a surface in CIEXYZ colour space. A GC may be referenced by one or more GHs. A GH may reference one or more GCs. A GC may be the boundary description of a closed surface in 3D colour space or a piece of it. The GCs are defined by a list of GCs from byte number ID_GC in accordance with Table 10. The order in the list is arbitrary, but fixed.

Table 10 – Definition of gamut components

Byte # hex	Size bytes	Symbol	Description	Values
ID_GC	1	C	Total number of Gamut Components	0 ≤ C ≤ 255
ID_GC + 01	2 + $\lceil F_0 ld(F)/8 \rceil$		Definition of GC no. 0	see Table 11
ID_GC + 01 + 02 + $\lceil F_0 \lceil ld(F) \rceil / 8 \rceil$	2 + $\lceil F_1 ld(F)/8 \rceil$		Definition of GC no. 1	see Table 11
: :				
ID_GC + 01 + $\sum_{c=0}^{C-2}(02 + \lceil F_c \lceil ld(F) \rceil / 8 \rceil$	2 + $\lceil F_{C-1} ld(F)/8 \rceil$		Definition of GC no. C – 1	see Table 11

C is the total number of GCs contained in the Gamut ID metadata. In Table 11, $\lceil \bullet \rceil$ is the operation that rounds to the next upper integer if the operand is not an integer and $ld(\bullet)$ is the logarithm to the base of 2.

The cth GC, c = 0…C − 1, is defined in accordance with Table 11.

Table 11 – cth gamut component

Relative byte # hex	Size bytes	Symbol	Description	Values
00	2	F_c	Number faces referenced by this GC	$1 \leq F_c \leq F$ (F see Table 13)
02	$\lceil F_c \lceil ld(F) \rceil / 8 \rceil$		Indices of referenced faces	[0; F − 1] shall be valid indices of faces, F see Table 13

6.6.2 Packing of face indices

The indices of the faces are packed into bytes. Each index of a face takes $ld(F)$ bits. Packing is organized GC wise, i.e. the first face index of a GC always starts at the beginning of a byte.

An example of packing is given for the case of C = 2 gamut components each using F_0 = F_1 = 4 faces from a total of F = 8 faces. Each GC takes $\lceil N \cdot ld(F) \cdot F_c / 8 \rceil$ = $\lceil (\lceil ld 8 \rceil 4)/8 \rceil$ = 2 bytes for the indices of the faces. The definition of the GCs requires in total $1 + 2C + \sum_{c=0}^{C-1} \lceil ld(F) F_c / 8 \rceil = 5 + \sum_{c=0}^{1} \lceil (\lceil ld(8) \rceil 4)/8 \rceil = 5 + 2\lceil 12/8 \rceil = 9$ bytes. Packing is as shown in Table 12.

Table 12 – Example for packing of gamut components

Byte # hex	Size	Value binary							
		7	6	5	4	3	2	1	0
ID_GC	1	0b00000010							
ID_GC + 01	1	0 (MSB)							
ID_GC + 02	1	0b100 (LSB)							
ID_GC + 03	1	1. index			2. index			3. index MSBs	
ID_GC + 04	1	3. i. LSB	4. index			Unused			
ID_GC + 05	1	0 (MSB)							
ID_GC + 06	1	0b100 (LSB)							
ID_GC + 07	1	1. index			2. index			3. index MSBs	
ID_GC + 08	1	3. i. LSB	4. index			Unused			
LSB are the Least Significant Bits; MSB are the Most Significant Bits.									

6.7 Faces

6.7.1 General

The faces are defined by a list of faces from byte number ID_F in accordance with Table ~~11~~13. The order in the list is arbitrary but fixed.

Table 13 – Definition of faces

Byte # hex	Size	Symbol	Description	Values
ID_F	2	F	Total number of faces	$6 \leq F < 65\,535$
ID_F+02	$\lceil 3F \lceil ld(V) \rceil / 8 \rceil$		$3F$ indices of vertices	$[0; V - 1]$ ~~Must~~ Shall be valid indices of vertices

F is the total number of faces of the description of gamut geometry and shall be at least 6 or shall equal zero (see Clause 7). For each face, three indices of vertexes are indicated, in total $3F$ indices.

If a sample face is defined by three indices index of three vertices V_0, V_1, V_2, respectively, in CIEXYZ space, the surface normal of the face is defined as follows:

$$v = \frac{(V_2 - V_0) \times (V_1 - V_0)}{|V_2 - V_0| \cdot |V_1 - V_0|}$$

where

× is the vector cross product,

$|\bullet|$ is the vector length operator, and

v is the surface normal.

6.7.2 Packing of vertex indices

The indices of the vertices of all faces are packed into bytes. Each index of a face takes $ld(V)$ bits; for V see Table 15.

An example of packing is given for the case of F = 6 faces and V = 5 vertices. Each index of a vertex takes $ld(V) = 3$ bits. All indices take $\lceil 3F \lceil ld(V) \rceil / 8 \rceil$ = 7 bytes.

Packing is as shown in Table 14.

Table 14 – Example for packing of faces

Byte # hex	**Size**	**Value**							
		Bits							
		7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
ID_F	2	0h0006							
ID_F + 02	1	F0 index0			F0 index1			F0 index2 MSBs	
ID_F + 03	1	F0 i.2 LSB	F1 index0			F1 index1			F1 i.2 MSB
ID_F + 04	1	F1 i.2 LSBs		F2 index0			F2 index1		
ID_F + 05	1	F2 index2			F3 index0			F3 index1 MSBs	
ID_F + 06	1	F3 i.1 LSB	F3 index2			F4 index0			F4 i.1 MSB
ID_F + 07	1	F4 I.1 LSBs		F4 index2			F5 index0		
ID_F + 08	1	F5 index1			F5 index2			0b00	

6.8 Vertices

6.8.1 General

The vertices are defined by a list of vertices from byte number ID_V on; see Table 15.

The order in the list is arbitrary, but fixed.

Table 15 – Vertices

Byte # hex	Size	Symbol	Description	Values
ID_V	2	V	Total number of vertices	$5 \leq V < 65\,535$
ID_V+02	2	R	Number of vertices belonging to gamut ridges	$0 \leq R \leq V$
ID_V+04	$\lceil 3VN/8 \rceil$		$3V$ encoded colour space coordinates defining V vertices	Encoded colour space coordinates
ID_V+04+ $\lceil 3VN/8 \rceil$	$\lceil R \lceil ld(V) \rceil /8 \rceil$		R indices of vertices belonging to gamut ridges	$[0;\ V-1]$ ~~Must~~ Shall be a valid indices of vertices

~~Hereby~~ In Table 15, $\lceil \bullet \rceil$ is the operation that rounds to the next upper integer. V is the total number of vertices of the description of gamut geometry.

The vertices belonging to gamut ridges are a subset of all vertices. Gamut ridges are positions on the surface of the actual colour gamut having non-continuous surface curvature such as ridges or summits.

6.8.2 Packing of colour space coordinates for vertices

For 8-bit encoding, the 12 colour space coordinates are directly coded into 12 bytes. For 10-bit encoding, the vertices are packed in accordance with Table 16. For 12-bit encoding, the vertices are packed in accordance with Table 17.

Table 16 – Packing of 10-bit colour space coordinates

Relative byte # hex	Size bytes	Description							
		7	6	5	4	3	2	1	0
00	1	A_high							
01	1	A_low		B_high					
02	1	B_low				C_high			
03	1	C_low						D_high	
04	1	D_low							

Table 17 – Packing of 12-bit colour space coordinates

Relative byte # hex	Size bytes	Description							
		7	6	5	4	3	2	1	0
00	1	A_high							
01	1	A_low				B_high			
02	1	B_low							
03	1	C_high							
04	1	C_low				D_high			
05	1	D_low							

7 Description of gamut geometry (medium and simple profiles)

7.1 General

This clause specifies the simple and medium profile of the description of gamut geometry. See Clause 6 for the full profile.

7.2 Medium profile

In the header of Gamut ID metadata, if ID_PROFILE equals 0b01, the description of gamut geometry shall correspond to the medium profile.

For the description of gamut geometry, the medium profile is identical to the full profile except for the following specifications.

In the medium profile, the header of the description of gamut geometry is defined in accordance with Table 5, except:

- the number of levels of colour population shall always be P = 1;
- the number of levels of details shall be K = 1 or K = 2.

The Gamut Hulls are defined in accordance with Table 8 except:

- the total number H of Gamut Hulls shall be smaller than or equal to 4.

Each Gamut Hull is defined in accordance with Table 9 except:

- the number of referenced Gamut Components that are used inverted by the hth GH shall be $\bar{C}_h = 0$.

The Gamut Components are defined in accordance with Table 10 except:

- the total number C of Gamut Components shall be smaller than or equal to 4.

7.3 Simple profile

If ID_PROFILE (see Table 2) equals 0b10, the description of gamut geometry shall correspond to the simple profile.

In the simple profile, ID_GBD_SPACE (see Table 2) shall be 0b011.

In the simple profile, the format of the description of gamut geometry is summarized in Table 18.

Table 18 – Description of gamut geometry (simple profile)

Byte # hex	Description
ID_G	Header of description of gamut geometry
ID_V	Vertices

The header of the description of gamut geometry follows the Gamut ID header and is defined in accordance with Table 19.

Table 19 – Header of description of gamut geometry (simple profile)

Byte # hex	Size bytes	Symbol	Description	Values
ID_G	2	ID_V	Bite # of start of vertices	ID_G + 04
ID_G + 02	1		Reserved	0
ID_G + 03	1		Reserved	0

The vertices are defined by a list of vertices from byte number ID_V on. In the simple profile, ID_V equals ID_G + 0h04. There are V = 5 vertices, one each for white, black, red, green and blue, respectively, in accordance with Table 20:

Table 20 – Definition of vertices (simple profile)

Byte # hex	Size	Symbol	Description	Values
ID_V	2	V	Total number of vertices	Shall be 5
ID_V+02	2	R	Shall be zero	0
ID_V+04	$\lceil 3VN/8 \rceil$		$3V$ encoded colour space coordinates defining V vertices	Encoded colour space coordinates

Hereby is $\lceil \bullet \rceil$, the operation that rounds to the next upper integer.

An example for the description of gamut geometry using the simple profile is given in Annex D.

8 Description of colour reproduction

If the ID_E field in the header of the Gamut ID metadata is not 0h0000, the description of colour reproduction shall follow from byte number ID_E on. The description of colour reproduction determines the link between encoded colour space coordinates and radiometrically-linear CIEXYZ colour space coordinates, as defined in CIE 15, of reproduced colours. When using the description of colour reproduction, the image state of the encoded colour space coordinates shall be output-referred as defined in ISO 22028-1.

The header of the description of colour reproduction shall be in accordance with Table 21. Gamut ID metadata may contain Q distinct colour reproduction models E_0 to E_{Q-1}. With increasing index, the colour reproduction profiles shall have increasing precision and usually have increasing memory footprint. E_0 should have lowest precision and smallest memory footprint.

Table 21 – Header of description of colour reproduction

Byte # hex	Size bytes	Symbol	Description	Values decimal
ID_E	1	Q	Number of levels of detail (number of colour reproduction profiles)	$1 \leq Q \leq 255$
ID_E + 01	SE_0	E_0	First colour reproduction profile	
: :				
ID_E + 01 + $\sum_{q=1...Q-1} SE_m$	SE_{Q-1}	E_{Q-1}	Qth colour reproduction profile	

Each Gamut ID colour reproduction model shall be binary encoded using the ICC profile format specified in ISO 15076-1:~~2005~~2010, except that only the following tags are required:

- profileDescriptionTag;
- copyrightTag;
- mediaWhitePointTag;
- chromaticAdaptationTag – when the colour space indicated by ID_GBD_SPACE assumes adaptation to a white with a chromaticity different from that of CIE Illuminant D50;
- At least one of the following tag groups:
  - N-Component LUT-based display profiles tags: AtoB1Tag and BtoA1Tag;
  - three-component matrix-based display profile tags: redMatrixColumnTag, greenMatrixColumnTag, blueMatrixColumnTag, redTRCTag, greenTRCTag, blueTRCTag.

A Gamut ID colour reproduction model shall not contain one of the following tags from ISO 15076-1:~~2005~~2010:

- outputResponseTag.

A Gamut ID colour reproduction model shall have the following characteristics:

- the rendering intent indicated in the ICC profile header shall be either the ICC-absolute colorimetric intent or the media-relative colorimetric intent;
- the Profile Connection Space (PCS) shall be XYZData;
- if the colour space indicated by ID_GBD_SPACE assumes adaptation to a white with a chromaticity different from that of D50, the ICC chromaticAdaptationTag should contain a linearized Bradford transform in accordance with ISO 15076-1:~~2005~~2010, Annex E as the chromatic adaptation transform (CAT) that transforms CIEXYZ colour space coordinates under the native illumination and with the native adopted white into PCS CIEXYZ colour space coordinates that are adapted to the D50 PCS adopted white.

NOTE The mediaWhitePointTag provides the media white point tristimulus values after chromatic adaptation to the PCS D50 adopted white. All PCS XYZ colour space coordinates, including the mediaWhitePointTag values, are adapted to this white point.

If any of the following ICC profile tags are present in a colour reproduction model, they shall not be used to obtain gamut information:

- gamutTag,
- AtoB0Tag,
- BtoA0Tag,
- AtoB2Tag,
- BtoA2Tag,
- DtoB0Tag,
- BtoD0Tag,
- DtoB2Tag,
- BtoD2Tag.

Annex A
(informative)

Size of Gamut ID metadata

This annex gives information on the size of the following Gamut ID metadata parts:

- the header of Gamut ID metadata;
- the description of gamut geometry.

The size of the header of Gamut ID metadata is 9 bytes.

For medium and full profiles, the size in bytes of the description of gamut geometry is referred to as ~~*GSIZE*~~ S_G and is given by

$$S_G = 26 + P + 6I + EH + 2C + \sum_I H_i + \sum_H \left(C_h + \bar{C}_h\right) + \sum_C \lceil F_c ld(F) \rceil / 8 \rceil$$
$$+ \lceil 3F \lceil ld(V) \rceil / 8 \rceil + \lceil 3VN / 8 \rceil + \lceil R \lceil ld(V) \rceil / 8 \rceil$$

where

I is the number of gamut instances;

H is the number of gamut hulls;

C is the number of gamut components;

F is the number of faces;

V is the number of vertices;

H_i is the number of GH used by the ith GI;

C_h is the number of GC used by the hth GH;

$\bar{C}_h$ is the number of inverted GC used by the hth GH;

F_c is the number of faces used by the cth GC;

N is the number of bits per colour channel;

R is the number of vertices belonging to gamut ridges.

For the simple profile, ~~*GSIZE*~~ S_G is 77.

Annex B
(informative)

Motivation and requirements

B.1 History

In 2006, the IEC published the International Standard IEC 61966-2-4. It defines a wide-gamut colour space encoding and is referenced in HDMI 1.3 [1][1] and in other documents. At the same time, a gamut metadata packet was adopted for HDMI 1.3 describing the video content colour gamut.

This document specifies an extended, generalized and scalable gamut metadata format.

B.2 Motivation

In order to allow correct colorimetric colour reproduction of video content by a video sink, three conditions have to be satisfied.

1) The encoding of colours of the content has to be correctly understood by the display.
2) Differences between content and sink colour gamuts have to be identified and processed in a controlled manner.
3) Differences between display viewing conditions and reference viewing conditions have to be compensated for.

The Gamut ID metadata focuses on the second condition. However, in order to satisfy the second condition, the first and third conditions need to be addressed as well.

A typical example of differences in gamuts is content colours out of the sink gamut. Out-of-gamut colours are usually processed by gamut mapping algorithms. Out-of-gamut colours can never be correctly reproduced, it is a question of colour appearance and artistic intent to know by which valid colour an out-of-gamut colour is to be replaced.

The main motivation for the Gamut ID standard is to offer a unified format in order to define the gamut of the video content that will be gamut mapped by the video sink [2].

A second motivation for the Gamut ID standard is to offer a unified format in order to define the gamut of the video sink in the case that gamut mapping is not applied by the display, but elsewhere.

If the video sink does not know the actual colour gamut of the video content, it needs to map all incoming colours in some way into the sink's gamut. In order to keep image details, a video sink may use some kind of gamut mapping that is more sophisticated than just gamut clipping. The possible colours are defined by the employed colour space encoding and colour reproduction rules (for example SMPTE S274M). We call these possible colours the colour encoding gamut. The content gamut is always identical or smaller than the colour encoding gamut. If there is no description of the actual colour gamut of the content, gamut mapping will use this colour encoding gamut as the content gamut. Gamut mapping will then not be well-adapted to the content and may cause loss or over-shooting of contrast and saturation. As an example, such a result is least acceptable when the actual content gamut is close to the sink gamut, but the encoding gamut is larger than the sink gamut. The Gamut ID metadata solves this problem by associating a description of the actual content gamut to the content.

[1] Numbers in square brackets refer to the Bibliography.

B.3 Scope of Gamut ID metadata

Figure B.1 shows the scope of the Gamut ID metadata. The metadata is usually associated with video content and/or with video equipment. It contains metadata describing the colour gamut of the video content or the colour gamut of the video equipment and associated colour reproduction information. The video content may be a single frame, a series of frames, just a visible object, or any other pictorial content. The equipment can be a video source (camera, set-top box) or a video sink (display, printer).

This document specifies the format of the Gamut ID metadata. The Gamut ID metadata can be associated with content or with a display. The standard is open to any method that generates the Gamut ID metadata. Metadata generation is an open field for the content creator to add value to the content, or for the equipment manufacturer to add value to the equipment, or for the service provider to add value to the service. The Gamut ID metadata standard may be used in a variety of ways, for example to facilitate gamut mapping. This is an open field for content creators, equipment manufacturers and service providers to create added value. Gamut mapping is a well-known topic in the scientific literature [3] and a survey of methods was prepared by the CIE [4].

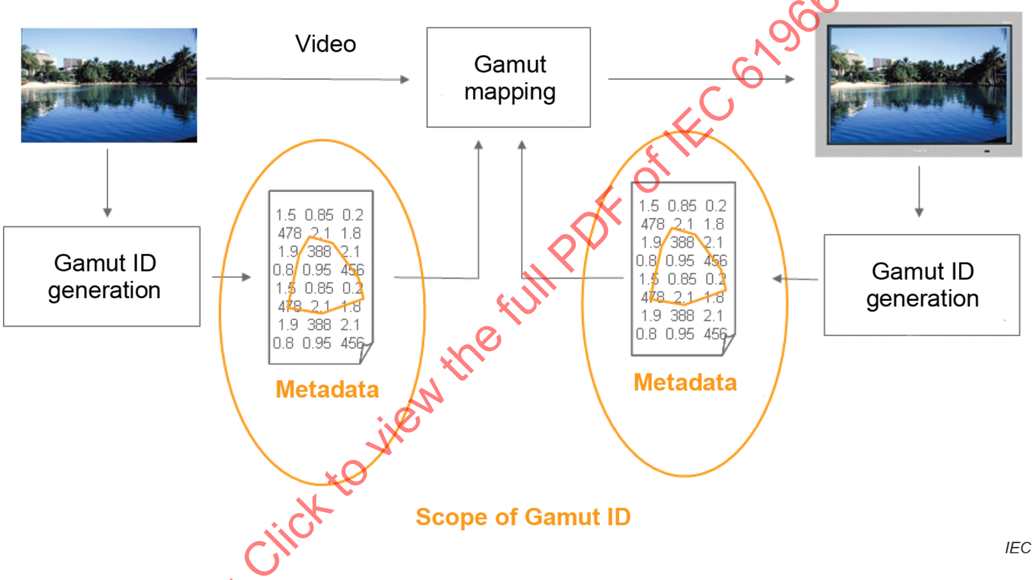

Figure B.1 – Scope of Gamut ID – Generation and use of metadata are not specified

B.4 Requirements

First, the description of an actual colour gamut in the framework of this document should use encoded colour space coordinates with an output referred image state [5]. Second, the Gamut ID metadata should support scalability and complexity reduction for implementation with lower computational complexity. Furthermore, the Gamut ID metadata has to consider the physical features of colour spaces and needs to support creative processes in content production in order to enable high-quality applications.

The requirements for the Gamut ID metadata include:

- Addressing colour reproduction
  – Use a colour encoding with an output-referred image state interpretation provided for gamut description
- Scalability
  – Allow different levels of gamut precision
  – Allow different levels of precision of colour reproduction

- Low computational complexity
  - Support existing graphics standards
  - Allow simple gamut geometry using convex shapes
  - Allow gamut decomposition into sub-gamut modules
- Small memory footprint
  - Allow multiple re-use of sub-gamut modules
- Physics-based
  - Consider gamut ridges due to colorant channels
- Creative
  - Consider importance and population of colours in gamuts

These requirements are not met by the HDMI 1.3 gamut metadata packet [1].

B.5 Structure

The description of gamut geometry in the Gamut ID metadata makes use of gamut boundary descriptions (GBD). A GBD describes the two-dimensional bounding surface of an actual three-dimensional colour gamut in a colour space. A GBD is based on an indexed face set. Faces are triangular surface elements. Figure B.2 shows an example of a gamut that could be contained in the Gamut ID description of gamut geometry.

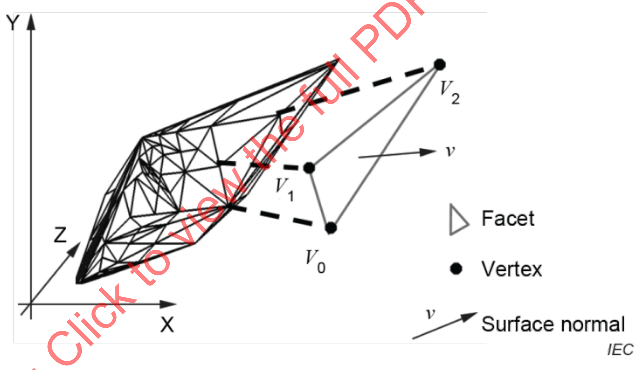

Figure B.2 – Example of a description of gamut geometry in CIEXYZ colour space consisting of a set of triangular faces

The description of gamut geometry corresponding to the sample gamut shown in Figure B.2 contains a set of vertices (V_0, V_1, V_2, V_3, …). Each vertex is defined by three colour-space coordinates in accordance with a chosen colour space and a chosen rule for colour encoding. Colour space coordinates have to be in an output-referred image state. The link between the encoded colour space coordinates and reproduced, radiometrically-linear CIEXYZ colour space coordinates depends on the adopted rule for colour reproduction. Gamut ID data may contain an optional, explicit, ICC-like description of colour reproduction.

The description of gamut geometry corresponding to the sample gamut shown in Figure B.2 also contains a set of faces (F_0, F_1, F_2, F_3, …). Let F_0 being the sample face shown in Figure B.2. Face F_0 is defined by three indices 0,1,2 of its three vertices V_0, V_1, V_2. A set of such faces is called indexed face set. The surface normal of a face always points outside the gamut. According to the order of indices 0, 1, 2, the surface normal of F_0 is defined as follows:

$$v = \frac{(V_2 - V_0) \times (V_1 - V_0)}{|V_2 - V_0| \bullet |V_1 - V_0|}$$

where

× is the vector cross product,

$|\bullet|$ is the vector length operator, and

v is the surface normal.

The description of gamut geometry is organized in a hierarchical manner such as shown in Figure 1. The description of gamut geometry contains a set of each of the following elements:

- **Vertices**: each defined by its three colour coordinates;
- **Faces**: each defined by exactly three indices of three corresponding vertices of the set of vertices;
- **Gamut components**: each being a connex 3D surface, each defined by a list of at least one face;
- **Gamut hulls**: each being the closed surface of a connex volume in colour space, each defined by a list of at least one gamut component;
- **Gamut instance:** each being a valid gamut boundary description each defined by a list of at least one gamut hull.

Table B.1 shows how the hierarchical structure of the Gamut ID metadata satisfies the mentioned requirements.

Table B.1 – Requirements and Gamut ID features

Requirement	Gamut ID feature	Advantage
Addressing colour reproduction: Use colour encoding based on output-referred image state for gamut description	The Gamut ID contains an optional description of colour reproduction assuming output-referred image state	Gamut ID metadata can be used to enhance colour reproduction accuracy
Scalability: Allow different levels of precision for gamut description	A Gamut ID may contain K levels of detail. It therefore may contain K different, alternative gamut instances.	The video sink can choose the level of detail according to its capabilities.
Scalability: Allow different levels of precision for colour reproduction	A Gamut ID may contain Q levels of detail for the description of colour reproduction.	The video sink can choose the level of detail according to its capabilities.
Low computational complexity: Allow simple geometry using convex shapes	A Gamut ID allows for geometry with convex and/or non-convex shapes. It may contain more than one, alternative gamut instances, at least one using only convex shapes.	The video sink may choose the GI using only convex shapes in order speed up geometrical operations.
Low computational complexity: Support of existing graphics standards	The Gamut ID is based on an indexed face set.	Accelerated operations in OpenGL and graphics hardware
Low computational complexity: Allow gamut decomposition into sub-gamut modules	The Gamut ID may contain modular GIs, each of those defined by one or more gamut hulls, the union of the volumes of these GHs is then the volume of the GI.	The video is able to handle non-convex gamuts while speeding up geometrical operations using convex GHs.
Small memory footprint: Allow multiple re-use of sub-gamut modules	The Gamut ID may contain modular GHs defined by one or more gamut components; all these GCs together build a GH. A GC may be used by more than one GH.	Parts of gamut shape that are common to different GIs are defined only one time; memory footprint is reduced.
Physics-based: Consider gamut ridges due to colorant channels	A vertex may contain a flag indicating that it represents a summit or a ridge with non-continuous gamut surface curvature.	The video sink is able to avoid smoothing at ridges and summits when manipulating gamuts.
Creative: Consider colour population	A Gamut ID may contain $P > 1$ alternative Gamut Instances each describing alternative gamuts containing different percentages of colours of the actual colour gamut.	The video sink can differentiate between frequent colours and rare colours.

B.6 Specific features

An example for the physics-based requirement to consider gamut ridges in the description of gamut geometry due to colorant channels is shown in Figure B.3. Vertices belonging to a gamut ridge or a gamut summit are marked as such. Ridges can be lines on the gamut surface linking two or more summits of a gamut. Summits can be primary colours, secondary colours, black point, or white point, for example.

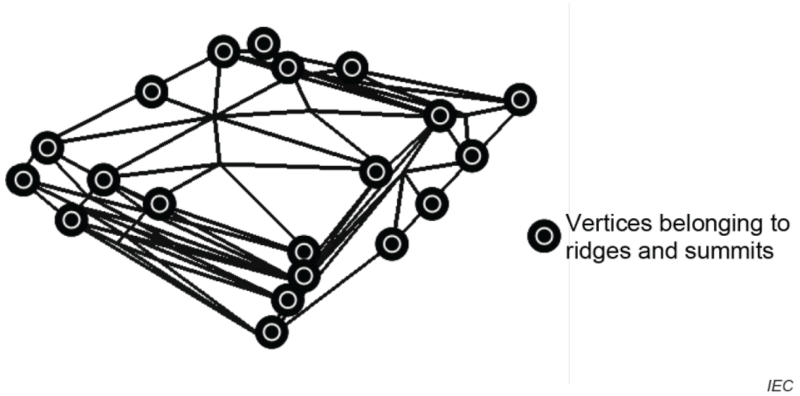

Figure B.3 – Example of a gamut with identified ridge due to colorant channels

An example of a description of gamut geometry that decomposes the colour gamut into modules is shown in Figure B.4. The colour gamut is the union of the volumes of all gamut hulls. In this example, both two gamut hulls are convex while the overall gamut is not convex. When using this description of gamut geometry, geometrical operations such as line-gamut intersection can make use of simple geometry with convex hulls.

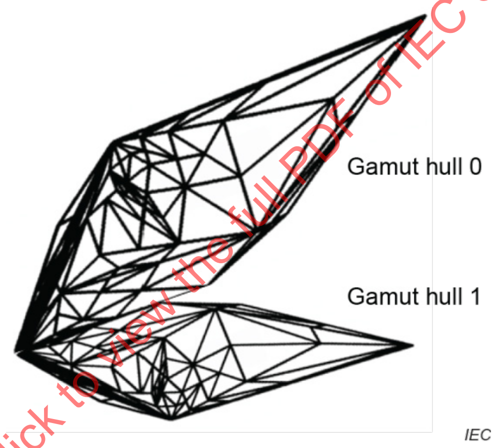

Figure B.4 – Example of a non-convex gamut with two convex Gamut Hulls

An example of a gamut hull using a gamut component in an inverted way is explained in the following. GCs are normally defined in a way that the surface normals of the faces go into outside direction of the gamut. If a GC is used inverted, the surface normals are supposed to go into the inside direction of the gamut. By this procedure, a single GC can be used by two GHs and defines the separating face between the GHs. In the first GH, the GC is used non-inverted, and in the second GH, the GC is used inverted.

Annex C
(informative)

Use of profiles

C.1 Gamut ID profiles

The description of gamut geometry corresponds to one of three profiles:

- full profile;
- medium profile;
- simple profile.

The profiles are summarized in Table C.1.

Table C.1 – Profiles for the description of gamut geometry

<table>
<tr><th>Feature of the description of gamut geometry</th><th>Gamut ID simple profile</th><th>Gamut ID medium profile</th><th>Gamut ID full profile</th></tr>
<tr><td>ID_PROFILE in Gamut ID header</td><td>0b10</td><td>0b01</td><td>0b00</td></tr>
<tr><td>Colour vertices</td><td>5 predefined vertices in known order:
white, black, red, green, blue</td><td rowspan="2">any</td><td rowspan="2">any</td></tr>
<tr><td>Colour faces</td><td>not allowed</td></tr>
<tr><td>Number of gamut components</td><td>not allowed</td><td>≤ 4</td><td rowspan="4">any</td></tr>
<tr><td>Number of gamut hulls</td><td>not allowed</td><td>≤ 4</td></tr>
<tr><td>Number of gamut instances</td><td>not allowed</td><td>≤ 2</td></tr>
<tr><td>Levels of detail</td><td>not allowed</td><td>≤ 2</td></tr>
<tr><td>Non-convex shape</td><td>not allowed</td><td>allowed</td><td rowspan="4">allowed</td></tr>
<tr><td>Indication of gamut ridges</td><td>not allowed</td><td>allowed</td></tr>
<tr><td>Percentage of gamut colours</td><td>not allowed</td><td>not allowed</td></tr>
<tr><td>Inverted gamut components</td><td>not allowed</td><td>not allowed</td></tr>
</table>

C.2 Medium profile

The medium profile has the following limitations with respect to the full profile:

- the description of gamut geometry shall not use percentage of gamut colours;
- the description of gamut geometry shall not use inverted gamut components;
- the number of gamut components shall not be larger than four;
- the number of gamut hulls shall not be larger than four;
- the number of gamut instances shall not be larger than two;
- the number of levels of details shall not be larger than two.

C.3 Simple profile

The simple profile has the following limitations with respect to the full profile:

- the description of colour consists of 5 vertices for white, black, red, green, blue, respectively, and thus V = 5 (see Table 15);
- there is no description of colour reproduction;
- there is no GI, I = K = P = 0, X = 1 and ID_GI equals 0h0000 (see Table 5);
- there is no GH, H = 0 and ID_GH equals 0h0000 (see Table 5);
- there is no GC, C = 0 and ID_GC equals 0h0000 (see Table 5);
- there are no faces, F = 0 and ID_F equals 0h0000 (see Table 5);
- colour space is XYZ and ID_GBD_SPACE equals 0b011 (see Table 2).

An example is given in Annex D.

Annex D
(informative)

Example of Gamut ID metadata in simple profile

This annex provides an example of Gamut ID metadata using the simple profile. In this example, the Gamut ID metadata describes the actual colour gamut of a video content that is prepared for projection in accordance with the nominal image parameters of the digital cinema system specification [6] in Table D.1:

Table D.1 – Colour gamut for digital cinema

Colour	CIE x	CIE y	CIE X	CIE Y	CIE Z
white	0,314	0,351	42,940	48,000	45,812
black	0,314	0,351	0,021	0,024	0,023
red	0,680	0,320	21,463	10,100	0,000
green	0,265	0,690	13,288	34,600	2,257
blue	0,150	0,060	8,275	3,310	43,582

The Gamut ID metadata contains one single Gamut Boundary Description describing an actual colour gamut that is defined by five colour vertices: white, black, red, green and blue, in accordance with Table D.1.

The Gamut ID metadata starts with the header in accordance with Table D.2.

Table D.2 – Example for the header

<table>
<tr><th>Byte #
hex</th><th>Size
bytes</th><th>Symbols</th><th colspan="8">Description</th><th>Values</th></tr>
<tr><td></td><td></td><td></td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td><td></td></tr>
<tr><td>00</td><td>1</td><td>N, P</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>R</td><td colspan="2">ID_PROFILE</td><td colspan="2">ID_PRECISION</td><td colspan="3">ID_GBD_SPACE</td><td></td></tr>
<tr><td>01</td><td>1</td><td rowspan="2">ID_G</td><td colspan="8" rowspan="2">Byte # of start of the description of gamut geometry</td><td>0h00</td></tr>
<tr><td>02</td><td>1</td><td>0h09</td></tr>
<tr><td>03</td><td>1</td><td rowspan="2">ID_E</td><td colspan="8" rowspan="2">Byte # of start of the description of colour reproduction</td><td>0h00</td></tr>
<tr><td>04</td><td>1</td><td>0h00</td></tr>
<tr><td>05</td><td>1</td><td rowspan="2"></td><td colspan="8" rowspan="2">Reserved. Shall be zero.</td><td>0h00</td></tr>
<tr><td>06</td><td>1</td><td>0h00</td></tr>
<tr><td>07</td><td>1</td><td rowspan="2"></td><td colspan="8" rowspan="2">Reserved. Shall be zero.</td><td>0h00</td></tr>
<tr><td>08</td><td>1</td><td>0h00</td></tr>
</table>

ID_PROFILE is set to 0b10 (simple profile). ID_PRECISISON is set to 0b00. ID_GBD_SPACE is set to 0b011 (XYZ). ID_G equals 0h009. In this example, ID_E is set to 0h0000 and the Gamut ID metadata does not contain a description of colour reproduction.

16-bit integer or address values are encoded into 2 bytes using big endian, i.e. with the MSBs in the first byte and the LSBs in the second byte.

The header of the description of gamut geometry is built in accordance with Table D.3.

Table D.3 – Example for the header of description of gamut geometry

Byte # hex	Size bytes	Symbol	Description	Values
09	1	ID_V	Byte # of start of vertices	0h00
0A	1			~~0h1A~~ 0h0D
0B	1		Reserved	0h00
0C	1		Reserved	0h00

There are no GI, no GH, no GC and no faces.

There are 5 vertices in accordance with Table D.4.

Table D.4 – Example of definition of vertices

Byte # hex	Size	Symbol	Description	Values
0D	1	V	Total number of vertices	0h00
0E	1			0h05
0F	1	R	Shall be zero	0h00
10	1			0h00
11	$\lceil 3VN/8 \rceil$ =60		3V encoded colour space coordinates defining V vertices	See Table D.5

The vertices represent the primary colours white, black, red, green and blue~~, respectively,~~ of the actual colour gamut. For each vertex, the corresponding colour is encoded as an XYZ number (see ICC profiles in ISO 15076-1:~~2005~~2010) and requires 12 bytes. Each colour space coordinate (X, Y or Z) is encoded as s15Fixed16Number (see ICC profiles in ISO 15076-1:~~2005~~2010) and requires N = 32 bits. There are 60 bytes of vertex data, representing 5 times 12 bytes. The encoded colour coordinates are shown in Table D.5.

Table D.5 – Encoded colour space coordinates for vertices

Byte # hex	Value hex	Description
11	00	White X
12	2A	
13	F0	
14	AF	
15	00	White Y
16	30	
17	00	
18	00	

Byte # hex	**Value** hex	**Description**
19	00	White Z
1A	2D	
1B	CF	
1C	DC	
1D	00	Black X
1E	00	
1F	05	
20	7F	
21	00	Black Y
22	00	
23	06	
24	24	
25	00	Black Z
26	00	
27	05	
28	DD	
29	00	Red X
2A	15	
2B	76	
2C	66	
2D	00	Red Y
2E	0A	
2F	19	
30	99	
31	00	Red Z
32	00	
33	00	
34	00	
35	00	Green X
36	0D	
37	49	
38	D4	
39	00	Green Y
3A	22	
3B	99	
3C	99	
3D	00	Green Z
3E	02	
3F	41	
40	AB	

Byte # hex	Value hex	Description
41	00	Blue X
42	08	
43	46	
44	66	
45	00	Blue Y
46	03	
47	4F	
48	5C	
49	00	Blue Z
4A	2B	
4B	94	
4C	E8	

The Gamut ID described in this example has a length of 77 bytes.

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[3] N. Katoh, Corresponding Colour Reproduction from Softcopy Images to Hardcopy Images, PhD thesis, Chiba University, Japan, 2002.

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[5] ISO 22028-1:2004, *Photography and graphic technology – Extended colour encodings for digital image storage, manipulation and interchange – Part 1: Architecture and requirements*

~~[6] ITU-R BT.601-5:1995, *Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios*~~

[6] Digital Cinema Initiatives, LLC, Digital Cinema System Specification, Version 1.1, April 12, 2007.

IEC 61966-12-1

Edition 2.0 2020-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Multimedia systems and equipment – Colour measurement and management – Part 12-1: Metadata for identification of colour gamut (Gamut ID)

Systèmes et appareils multimédias – Mesure et gestion de la couleur – Partie 12-1: Métadonnées d'identification des gammes de couleurs (Gamut ID)

IEC 61966-12-1:2020-09(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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MULTIMEDIA SYSTEMS AND EQUIPMENT –
COLOUR MEASUREMENT AND MANAGEMENT –

Part 12-1: Metadata for identification of colour gamut (Gamut ID)

FOREWORD

International Standard IEC 61966-12-1 has been prepared by technical area 2: Colour measurement and management, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

This second edition cancels and replaces the first edition published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) ITU-R BT.2020 colour spaces added in Clause 6;

b) ITU-R BT.2100 colour spaces added in Clause 6.

The text of this International Standard is based on the following documents:

CDV	Report on voting
100/3126/CDV	100/3375/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61966 series, published under the general title *Multimedia systems and equipment – colour measurement and management*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

New technologies in capturing and displaying wide-gamut colour images enable a new market of wide-gamut video colour content and high dynamic range video content creation. Recent video standards for wide gamut colour space encoding such as ITU-R BT.2020 (UHDTV) and IEC 61966-2-4 (xvYCC) were established in order to be able to distribute content with a colour gamut that is extended with respect to classical colour gamuts such as defined by colorimetry standards ITU-R BT.601 (standard-definition television) and ITU-R BT.709 (high-definition television). Recent video standards for high dynamic range (HDR) colour space encoding, such as ITU-R BT.2100, were established in order to be able to distribute content with a colour gamut and a dynamic range that are both extended with respect to classical colour encoding, such as that defined by ITU-R BT.709. With the increasing popularity of wide gamut and high dynamic range content and displays, the variety of colour gamuts of displays is expected to increase. This issue can be an obstacle for adopting wide-gamut video colour content in professional content creation since the compatibility of the content to the employed displays as well as the compatibility among different displays is not ensured. The term display includes here any video colour reproduction equipment, such as direct view displays and projectors. Thanks to improvements of technology, the variety of colour gamut and colour reproduction capacities of displays increases, while the colour gamut and the colour encoding rules of existing colour space encoding standards are fixed.

To address this issue, this document specifies a colour gamut metadata scheme for video systems including information for colour reproduction. This metadata can amend a video content or a display. More specifically, improvements can be achieved if the wide-gamut colour content is created with the knowledge of the display colour gamut as well as if the colour reproduction in the display is done with the knowledge of the colour gamut of the pictorial content.

This document permits video systems to define their own colour gamut. This document defines necessary metadata that allows managing inhomogeneous video systems with different colour gamuts. This document generalizes existing colour space encoding standards having a fixed colour gamut.

MULTIMEDIA SYSTEMS AND EQUIPMENT – COLOUR MEASUREMENT AND MANAGEMENT –

Part 12-1: Metadata for identification of colour gamut (Gamut ID)

1 Scope

This part of IEC 61966 defines the colour gamut metadata scheme for video systems and similar applications.

The metadata can be associated with wide-gamut video colour content or to a piece of equipment to display the content.

When associated with content, the colour gamut metadata defines the gamut for which the content was created. It can be used by the display for controlled colour reproduction even if the display's colour gamut is different from that of the content.

When associated with a display, the colour gamut metadata defines the display colour gamut. It can be used during content creation to enable improved colour reproduction.

The colour gamut metadata can cover associated colour encoding information, which includes all information required for a controlled colour reproduction, when such information is not provided by the colour encoding specification.

The colour gamut metadata scheme provides scalable solutions. For example, more flexible solutions will be used for the professional use, while much simpler solutions will be used for consumer use with easier product implementation.

This part of IEC 61966 only defines the colour gamut metadata scheme. Vendor-specific solutions for creation and end-use of this metadata are allowed.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-845, *International electrochnical vocabulary – Chapter 845: Lighting*

IEC 61966-2-4:2006, *Multimedia systems and equipment – Colour measurement and management – Part 2-4: Colour management – Extended-gamut YCC colour space for video applications – xvYCC*

ISO 15076-1:2010, *Image technology colour management – Architecture, profile format and data structure – Part 1: Based on ICC.1:2010*

ITU-R BT.709, *Parameter values for the HDTV standards for production and international programme exchange*

CIE 15:2004, *Colorimetry*

SMPTE 274M:2005, *SMPTE Standard for Television - 1920 x 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates*

ITU-R BT.2020, *Parameter values for ultra-high definition television systems for production and international programme exchange*

ITU-R BT.2100, *Image parameter values for high dynamic range television for use in production and international programme exchange*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-845 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
content
video content in production, post-production or consumption

3.1.2
gamut
solid in a colour space

Note 1 to entry: A solid in a colour space, such as specified by ITU-R BT.2100, can contain colours with high luminance.

3.1.3
gamut boundary description
description of the boundary of a colour gamut

3.1.4
radiometrically-linear colour space coordinates
colour space coordinates that are linear with respect to image radiance

3.2 Abbreviated terms

GBD gamut boundary description

LSB least significant bit

MSB most significant bit

GI gamut instance

GH gamut hull

GC gamut component

4 Overview

This document specifies metadata called "Gamut ID metadata" providing information on an actual colour gamut.

The Gamut ID metadata contains four parts and its format is summarized in Table 1.

Table 1 – Format of Gamut ID metadata

Byte # hex	Metadata content
0h0000	Header of Gamut ID metadata
ID_G	Description of gamut geometry
ID_E	Description of colour reproduction

Clause 5 specifies the header of Gamut ID metadata.

Clauses 6 and 7 specify the description of gamut geometry that corresponds to one of three profiles as listed below:

- full profile;
- medium profile;
- simple profile.

Clause 6 specifies the full profile of the description of gamut geometry. The medium and simple profiles are specified in Clause 7.

Clause 8 specifies the description of colour reproduction.

Annex A discusses the size of Gamut ID metadata.

Annex B gives background information.

Annex C discusses the use of simple, medium and full profiles.

5 Header of Gamut ID metadata

The Gamut ID metadata starts with the header shown in Table 2.

Table 2 – Header of Gamut ID metadata

Byte # hex	Size Bytes	Symbols	Description 7	6	5	4	3	2	1	0	Values
00	1	N, P	R	ID_PROFILE		ID_PRECISION		ID_GBD_SPACE			R = reserved = 0b0 (1bit) ID_PROFILE (2 bits): 0b00: Full profile 0b01: Medium profile 0b10: Simple profile 0b11: Reserved ID_PRECISION (2 bits): 0b00: 8 bits 0b01: 10 bits 0b10: 12 bits 0b11: Reserved ID_GBD_SPACE (3bits): 0b000: ITU-R BT.709 RGB 0b001: xvYCC-601 (IEC 61966-2-4 -SD) YCC 0b010: xvYCC-709 (IEC 61966-2-4 -HD) YCC 0b011: XYZ (see below) 0b100: ITU-R BT.2020 R'G'B' 0b101: ITU-R BT.2020 $Y'C'_{B}C'_{R}$ 0b110: ITU-R BT.2020 $Y_{C}'C'_{BC}C'_{RC}$ 0b111: ID_GBD_SPACE_EXT
01	2	ID_G	Byte # of start of the description of gamut geometry								[0h0009;0hFFFF]
03	2	ID_E	Byte # of start of the description of colour reproduction								[0;0hFFFF]
05	1		ID_GBD_SPACE_EXT								0h00: ITU-R BT.2100 R'G'B' PQ narrow 0h01: ITU-R BT.2100 R'G'B' PQ full 0h02: ITU-R BT.2100 R'G'B' HLG narrow 0h03: ITU-R BT.2100 R'G'B' HLG full 0h04: ITU-R BT.2100 $Y'C'_{B}C'_{R}$ PQ narrow 0h05: ITU-R BT.2100 $Y'C'_{B}C'_{R}$ PQ full 0h06: ITU-R BT.2100 $Y'C'_{B}C'_{R}$ HLG narrow 0h07: ITU-R BT.2100 $Y'C'_{B}C'_{R}$ HLG full 0h08: ITU-R BT.2100 $IC_{T}C_{P}$ PQ narrow 0h09: ITU-R BT.2100 $IC_{T}C_{P}$ PQ full 0h0A: ITU-R BT.2100 $IC_{T}C_{P}$ HLG narrow 0h0B: ITU-R BT.2100 $IC_{T}C_{P}$ HLG full 0h0C – 0hFF: reserved
06	3		Reserved. Shall be zero.								0h000000

ID_PROFILE indicates the profile of the Gamut ID metadata and shall be one of

- 0b00: Full profile,
- 0b01: Medium profile,
- 0b11: Simple profile.

ID_GBD_SPACE indicates the colour space and the colour space encoding for colour vertices in the description of gamut geometry and shall be one of:

- 0b000: ITU-R BT.709, RGB space, encoding in accordance with SMPTE 274M,
- 0b001: xvYCC-601, YCbCr space, encoding in accordance with IEC 61966-2-4 – SD,
- 0b010: xvYCC-709, YCbCr space, encoding in accordance with IEC 61966-2-4 – HD,
- 0b011: XYZ; encoding shall use the XYZNumber format of ICC profiles specified in ISO 15076-1:2010 taking 12 bytes for one XYZ triple.
- 0b100: ITU-R BT.2020, RGB space, encoding in accordance with ITU-R BT.2020 R', G', B',
- 0b101: ITU-R BT.2020, YCbCr space', encoding in accordance with ITU-R BT.2020 Y', C'_B, C'_R,
- 0b110: ITU-R BT.2020, YCbCr space, encoding in accordance with ITU-R BT.2020 Y_C', C'_{BC}, C'_{RC},
- 0b111: colour space and colour space encoding are indicated by ID_GBD_SPACE_EXT.

If ID_GBD_SPACE equals 0b111, ID_GBD_SPACE_EXT indicates the colour space and the colour space encoding for colour vertices in the description of gamut geometry and shall be one of:

- 0h00: ITU-R BT.2100 R'G'B', PQ format, narrow range,
- 0h01: ITU-R BT.2100 R'G'B', PQ format, full range,
- 0h02: ITU-R BT.2100 R'G'B', HLG format, narrow range,
- 0h03: ITU-R BT.2100 R'G'B', HLG format, full range,
- 0h04: ITU-R BT.2100 $Y'C'_BC'_R$, PQ format, narrow range,
- 0h05: ITU-R BT.2100 $Y'C'_BC'_R$, PQ format, full range,
- 0h06: ITU-R BT.2100 $Y'C'_BC'_R$, HLG format, narrow range,
- 0h07: ITU-R BT.2100 $Y'C'_BC'_R$, HLG format, full range,
- 0h08: ITU-R BT.2100 IC_TC_P, PQ format, narrow range,
- 0h09: ITU-R BT.2100 IC_TC_P, PQ format, full range,
- 0h0A: ITU-R BT.2100 IC_TC_P, HLG format, narrow range,
- 0h0B: ITU-R BT.2100 IC_TC_P, HLG format, full range.

ID_PRECISION, ID_GBD_SPACE and ID_GBD_SPACE_EXT specify, in accordance with Table 3, the number N of bits that are used per colour channel in order to define the coordinates of a colour in a colour space.

Table 3 – Bit depth for encoding of a colour space coordinate

ID_GBD_SPACE	ID_PRECISION	Bit depth N
0b011	Any	32 bits
else	0b00	8 bits
	0b01	10 bits
	0b10	12 bits
	0b11	Reserved

If ID_GBD_SPACE equals 0b011 for XYZ encoding, bit depth N shall be 32 independent of ID_PRECISION.

BT.2020 and BT.2100 encodings are defined by the ITU-R for bit depths of 10 or 12, only.

ID_G indicates the offset in bytes from the beginning of Gamut ID metadata to the beginning of the description of gamut geometry.

If ID_E is different from 0h0000, the Gamut ID metadata contains a description of colour reproduction and ID_E indicates the offset in bytes from the beginning of Gamut ID metadata to the beginning of the description of colour reproduction. If ID_E has the value 0h0000, the Gamut ID metadata does not contain a description of colour reproduction.

6 Description of gamut geometry (full profile)

6.1 General

In the header of Gamut ID metadata, if ID_PROFILE equals 0b00, the description of gamut geometry shall correspond to the full profile.

6.2 Gamut geometry

The description of gamut geometry of the Gamut ID metadata describes the boundary of the actual colour gamut. The description of gamut geometry starts at byte number ID_G.

The description of gamut geometry contains five sets of different elements:

- gamut instances,
- gamut hulls,
- gamut components,
- faces, and
- vertices.

The logical structure of the Gamut ID description of colour gamut is shown in Figure 1.

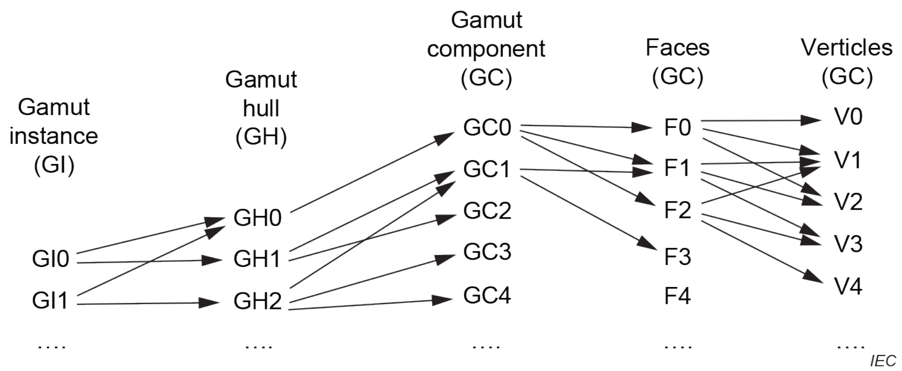

Figure 1 – Logical structure of the description of gamut geometry (full profile)

The description of gamut geometry contains one or more gamut boundary descriptions (GBD) that each describes the boundary of the same actual colour gamut. A GBD contains vertices and triangular faces. Each face is defined by the indices of three vertices.

A gamut component is a group of connex triangular faces. A GC is a part of a boundary description. A GC is defined by one or more indices of faces.

A gamut hull (GH) is a group of connex gamut components building all together a closed surface. This surface is the boundary description of a connex volume in CIEXYZ colour space. Each GH is defined by one or more indices of GCs. A GH may refer to a single GC. In this case, the GC shall be a closed surface boundary description by itself. A GH may refer to a list of GCs, in that case all GCs together build a closed surface boundary description of a connex volume.

A gamut instance (GI) is a group of gamut hulls building all together a valid GBD of the actual colour gamut. A GI is defined by one or more indices of gamut hulls. A GI may refer to a single GH; in this case, the single GH describes by itself the actual colour gamut. A GI may refer to a list of GHs; in this case, the union of the volumes of the GHs describes the actual colour gamut.

The description of gamut geometry contains one or more different gamut instances. Each GI is a complete and valid GBD. Two GIs differ in at least one of the following characteristics:

- Level of detail
  → The higher the level, the higher the number of faces.
- Non-convex shape
  → A GI may allow or not allow the use of non-convex shapes.
- Percentage of gamut colours
  → GIs may contain different percentages of the colours of the actual colour gamut.

A GI may have additional, optional characteristics:

- Inverted gamut components
  → A GC is used as inverted GC if it referenced by one or more GH assuming that its surface orientation is inverted.
- Indication of gamut ridges
  → Vertices may be marked as gamut ridges if they correspond to positions on the surface of the actual colour gamut having non-continuous surface curvature.

The description of gamut geometry is summarized in Table 4.

Table 4 – Description of gamut geometry

Byte # hex	Description
ID_G	Header of description of gamut geometry
ID_GI	Gamut instances
ID_GH	Gamut hulls
ID_GC	Gamut components
ID_F	Faces
ID_V	Vertices

6.3 Header of description of gamut geometry

The header of the description of gamut geometry follows the header of Gamut ID metadata and is defined in accordance with Table 5.

Table 5 – Header of description of gamut geometry

Byte # hex	Size bytes	Symbol	Description	Values decimal
ID_G	2	ID_GI	Byte # of start of gamut instances	[0;0hFFFF]
ID_G + 02	2	ID_GH	Byte # of start of gamut hulls	[0;0hFFFF]
ID_G + 04	2	ID_GC	Byte # of start of gamut components	[0;0hFFFF]
ID_G + 06	2	ID_F	Byte # of start of faces	[0;0hFFFF]
ID_G + 08	2	ID_V	Byte # of start of vertices	[0;0hFFFF]
ID_G + 0A	1		Reserved	0
ID_G + 0B	1		Reserved	0
ID_G + 0C	1	K	Number of levels of detail	$1 \leq K \leq 255$
ID_G + 0D	2	F_{MAX}	Maximum number of faces in lowest level of detail	$1 < F_{MAX} \leq F$ (F see Table 6)
ID_G + 0F	1	P	Number of levels of colour population	$0 < P \leq 128/K$
ID_G + 10	1	$2Q_0$	Double of percentages of gamut colours	[0;200]
ID_G + 11	1	$2Q_1$	Double of percentages of gamut colours	[0;200]
: :				
ID_G + 10 + P-1	1	$2Q_{P-1}$	Double of percentages of gamut colours	[0;200]
ID_G + 10 + P	1	X	Convex or non-convex shape X = 1: all GIs and all GHs shall be convex X = 2: GIs and GHs may be convex or non-convex	$1 \leq X \leq 2$

16-bit integer or address values are encoded into 2 bytes using big endian, i.e. with the MSBs in the first byte and the LSBs in the second byte.

ID_GI, ID_GH, ID_GC, ID_F and ID_V shall give the offset in bytes from the beginning of gamut ID metadata to the beginning of gamut instances, gamut hulls, gamut components, faces and vertices data, respectively.

K indicates the number of levels of details. The Gamut ID metadata contains at least K GIs. If K = 1 there are no different level of details. Each GI is marked individually with a level of detail (0, 1,…, $K - 1$), see Table 7.

F_{MAX} shall indicate the maximum number of faces for a GI having the lowest level of detail (level 0). See Table 7 for definition of level of details. See Table 13 for the definition of faces.

P indicates the number of alternative GIs populated by different percentages of colours of the actual colour gamut. If P > 1, there are P alternative GIs describing the same actual colour gamut but containing different percentages of colours of the actual colour gamut. The Gamut ID metadata contains at least P GIs. Each GI is marked individually with a population level (0,1,…, $P - 1$), see Table 7.

$2Q_0 \ldots 2Q_{P-1}$ are the doubles of the percentages $Q_0 \ldots Q_{P-1}$ of colours associated with the population levels (0,1,…,$P-1$). A percentage shall approximately indicate how many percent of colours (0…100) of the actual colour gamut are contained in the volume described by a GI of the corresponding population level. As a matter of definition, $Q_0 \ldots Q_{P-1}$ percentages can be defined in steps of 0,5 points.

X indicates whether the Gamut ID uses only convex shapes (X = 1) or may use convex and non-convex shapes (X = 2). When X = 1, each GI shall correspond to a convex shape and each GH shall correspond to a convex shape. When X = 2, GIs are organized into pairs. Each pair contains a first GI (marked as "convex", see Table 7) that corresponds to a convex shape and which references only GHs that correspond to a convex shape. The second GI of the pair (marked as "non convex", see Table 7) may correspond to a non-convex shape and may reference GHs that correspond to non-convex shapes. The Gamut ID metadata contains at least X GIs.

6.4 Gamut instances

The description of gamut geometry contains one or more gamut boundary descriptions of the actual colour gamut. One single GBD is called gamut instance. A user of Gamut ID metadata may use any one or any number of GIs of Gamut ID metadata. The GIs are defined by a list of GIs from byte number ID_GI in accordance with Table 6. The order in the list is arbitrary but fixed.

Table 6 – Gamut Instances

Byte # hex	Size bytes	Symbol	Description	Values
ID_GI	1	I	Total number of Gamut Instances	$I = X\,P\,K$
ID_GI + 01	6+ H_0		Definition of GI no. 0,	see Table 7
ID_GI + 01 + 6+ H_0	6+ H_1		Definition of GI no. 1	see Table 7
: :				
ID_GI + 01 + $\sum_{i=0}^{I-2}(6+H_i)$	6+ H_{I-1}		Definition of GI no. I-1	see Table 7

I is the number of GIs and shall be equal to the product of X, P and K as defined in Table 5. The ith GI, i = 0…I − 1, is defined in accordance with Table 7.

Table 7 – ith gamut instance

Relative byte # hex	Size bytes	Symbol	Description	Values
00	1	K_i	Level of detail of this GI	$0 \le K_i \le K-1$
01	2	F_i^{GI}	Number of faces used by this GI	$F_i^{GI} \le 2^i F_{\mathrm{MAX}}$ (F_{MAX}see Table 5)
03	1	X_i^{GI}	This GI defines a convex shape (X_i^{GI} = 1) or may define a non-convex shape (X_i^{GI} =2)	$1 \le X_i^{GI} \le X$ (X see Table 5)
04	1	P_i	Level of colour population of this GI	$0 \le P_i \le P-1$ (P see Table 5)
05	1	H_i	Number of gamut hulls referenced by this GI	$1 \le H_i \le H$ (H see Table 8)
06	H_i		Indices of referenced GHs	[0; H − 1] Shall be valid indices of GH

K_i is the level of detail of the ith GI. The GI is of lowest level of detail is K_i = 0. If K_i is larger than the level of detail K_j of a jth GI of same type (P_i = P_j, X_i = X_j) then the ith GI has a higher level of detail, i.e. a more precise geometric description, than the jth GI.

F_i^{GI} is the number of faces used by the ith GI. This number should correspond to the number of faces referenced by those gamut components (see Table 10) that are referenced by those gamut hulls (see Table 8) that are referenced by the ith GI. The number F_i^{GI} of faces should be equal or smaller than $2^{K_i} F_{\mathrm{MAX}}$ (F_{MAX} see Table 6).

X_i^{GI} is an indicator of convex or non-convex shape. If X_i^{GI} = 1, the ith GI defines a convex shape and each GH referenced by the ith GI defines a convex shape by itself. If X_i^{GI} = 2, the ith GI may define a convex or a non-convex shape and each of the GHs referenced by the ith GI may define a convex or a non-convex shape by itself.

P_i is the population level of the ith GI. The ith GI shall contain approximately Q_{P_i} percent of colours of the actual colour gamut. Different GIs with same population level shall contain approximately the same percentage of colours of the actual colour gamut. A GI with population level P_i shall contain at least all colours of another GI with population level P_j if $P_j > P_i$, $K_j = K_i$ and $X_j = X_i$.

H_i is the number of gamut hulls that are referenced by the ith GI. If an ith GI references one gamut hull, then H_i = 1 and the gamut hull describes the actual colour gamut. If an ith GI references more than one gamut hull, then H_i > 1 and the union of the volumes of all referenced gamut hulls describes the actual colour gamut.

The H_i indices of GHs have each one byte.

6.5 Gamut hulls

The description of gamut geometry contains one or more gamut hulls. Each GH is the closed surface boundary description defining a connex, closed volume in colour space. A GH may be referenced by one or more GIs. A GI may reference one or more GHs. A GH may describe by itself the actual colour gamut or just a part of it. The GHs are defined by a list of GHs from byte number ID_GH in accordance with Table 8. The order in the list is arbitrary but fixed.

H is the total number of GHs contained in the Gamut ID metadata. The hth GH, $h = 0...H - 1$, is defined according to Table 9.

Table 8 – Gamut hulls

Byte # hex	Size bytes	Symbol	Description	Values
ID_GH	1	H	Total number of Gamut Hulls	$0 \le H \le 255$
ID_GH + 01	$3 + C_0 + \overline{C}_0$		Definition of GH no. 0	see Table 9
ID_GH + 01 + $2 + C_0 + \overline{C}_0$	$3 + C_1 + \overline{C}_1$		Definition of GH no. 1	see Table 9
: :				
ID_GH + 01 + $\sum_{h=0}^{H-2}(3 + C_h + \overline{C}_h)$	$3 + C_{H-1} + \overline{C}_{H-1}$		Definition of GH no. $H - 1$	see Table 9

Table 9 – *h*th Gamut hull

Relative byte # hex	Size bytes	Symbol	Description	Values
00	1	X_h^{GH}	Indication whether this GH defines a convex shape or any shape (convex or non-convex)	$1 \le X_h^{GH} \le X$ (X see Table 5) X_h^{GH} =1: convex shape X_h^{GH} =2: convex or non-convex shape
01	1	C_h	Number referenced Gamut Components that are used non-inverted by this GH	$1 \le C_k + \overline{C}_k \le C$ (C see Table 10)
02	1	$\overline{C}_h$	Number of referenced Gamut Components that are used inverted by this GH	
03	C_h		Indices of referenced Gamut Components	[0; C − 1] shall be valid indices of GCs
03 + C_h	$\overline{C}_h$		Indices of referenced Gamut Components used in an inverted manner	

$C_h + \overline{C}_h$ is the number of gamut components that are referenced by the hth GH. If a hth GH references one GC, then $C_h + \overline{C}_h = 1$ and the GC defines by itself the closed surface of the GH. If a hth GH references more than one GC, then $C_h + \overline{C}_h > 1$ and all referenced GCs build together the closed surface of the GH. When a GC is used inverted, the surface normals of the faces referenced by this GC are used in the inverse sense. For referenced faces, see Table 10. For surface normals, see 6.7.

6.6 Gamut component

6.6.1 General

The description of gamut geometry contains one or more gamut components that each defines a connex piece of a boundary description of a surface in CIEXYZ colour space. A GC may be referenced by one or more GHs. A GH may reference one or more GCs. A GC may be the boundary description of a closed surface in 3D colour space or a piece of it. The GCs are defined by a list of GCs from byte number ID_GC in accordance with Table 10. The order in the list is arbitrary, but fixed.

Table 10 – Definition of gamut components

Byte # hex	Size bytes	Symbol	Description	Values
ID_GC	1	C	Total number of Gamut Components	$0 \le C \le 255$
ID_GC + 01	2 + $\lceil F_0 ld(F)/8 \rceil$		Definition of GC no. 0	see Table 11
ID_GC + 01 + 02 + $\lceil F_0 \lceil ld(F) \rceil /8 \rceil$	2 + $\lceil F_1 ld(F)/8 \rceil$		Definition of GC no. 1	see Table 11
: :				
ID_GC + 01 + $\sum_{c=0}^{C-2} \left(02 + \lceil F_c \lceil ld(F) \rceil /8 \rceil \right)$	2 + $\lceil F_{C-1} ld(F)/8 \rceil$		Definition of GC no. $C - 1$	see Table 11

C is the total number of GCs contained in the Gamut ID metadata. In Table 11, $\lceil \bullet \rceil$ is the operation that rounds to the next upper integer if the operand is not an integer and $ld(\bullet)$ is the logarithm to the base of 2.

The cth GC, $c = 0 \ldots C - 1$, is defined in accordance with Table 11.

Table 11 – cth gamut component

Relative byte # hex	Size bytes	Symbol	Description	Values
00	2	F_c	Number faces referenced by this GC	$1 \le F_c \le F$ (F see Table 13)
02	$\lceil F_c \lceil ld(F) \rceil /8 \rceil$		Indices of referenced faces	[0; $F - 1$] shall be valid indices of faces, F see Table 13

6.6.2 Packing of face indices

The indices of the faces are packed into bytes. Each index of a face takes $ld(F)$ bits. Packing is organized GC wise, i.e. the first face index of a GC always starts at the beginning of a byte.

An example of packing is given for the case of $C = 2$ gamut components each using $F_0 = F_1 = 4$ faces from a total of $F = 8$ faces. Each GC takes $\lceil N \cdot ld(F) \cdot F_c / 8 \rceil = \lceil (\lceil ld 8 \rceil 4)/8 \rceil = 2$ bytes for the indices of the faces. The definition of the GCs requires in total $1 + 2C + \sum_{c=0}^{C-1} \lceil ld(F) F_c / 8 \rceil = 5 + \sum_{c=0}^{1} \lceil (\lceil ld(8) \rceil 4) / 8 \rceil = 5 + 2 \lceil 12/8 \rceil = 9$ bytes. Packing is as shown in Table 12.

Table 12 – Example for packing of gamut components

Byte # hex	Size	Value binary							
		7	6	5	4	3	2	1	0
ID_GC	1	0b00000010							
ID_GC + 01	1	0 (MSB)							
ID_GC + 02	1	0b100 (LSB)							
ID_GC + 03	1	1. index			2. index			3. index MSBs	
ID_GC + 04	1	3. i. LSB	4. index			Unused			
ID_GC + 05	1	0 (MSB)							
ID_GC + 06	1	0b100 (LSB)							
ID_GC + 07	1	1. index			2. index			3. index MSBs	
ID_GC + 08	1	3. i. LSB	4. index			Unused			
LSB are the Least Significant Bits; MSB are the Most Significant Bits.									

6.7 Faces

6.7.1 General

The faces are defined by a list of faces from byte number ID_F in accordance with Table 13. The order in the list is arbitrary but fixed.

Table 13 – Definition of faces

Byte # hex	Size	Symbol	Description	Values
ID_F	2	F	Total number of faces	$6 \le F < 65\,535$
ID_F+02	$\lceil 3F \lceil ld(V) \rceil / 8 \rceil$		$3F$ indices of vertices	$[0; V-1]$ Shall be valid indices of vertices

F is the total number of faces of the description of gamut geometry and shall be at least 6 or shall equal zero (see Clause 7). For each face, three indices of vertexes are indicated, in total $3F$ indices.

If a sample face is defined by three indices index of three vertices V_0, V_1, V_2, respectively, in CIEXYZ space, the surface normal of the face is defined as follows:

$$v = \frac{(V_2 - V_0) \times (V_1 - V_0)}{|V_2 - V_0| \cdot |V_1 - V_0|}$$

where

× is the vector cross product,

$|\cdot|$ is the vector length operator, and

v is the surface normal.

6.7.2 Packing of vertex indices

The indices of the vertices of all faces are packed into bytes. Each index of a face takes $ld(V)$ bits; for V see Table 15.

An example of packing is given for the case of F = 6 faces and V = 5 vertices. Each index of a vertex takes $ld(V) = 3$ bits. All indices take $\lceil 3F \lceil ld(V) \rceil / 8 \rceil$ = 7 bytes.

Packing is as shown in Table 14.

Table 14 – Example for packing of faces

<table>
<tr><th>Byte #
hex</th><th>Size</th><th colspan="8">Value</th></tr>
<tr><td></td><td></td><td colspan="8">Bits</td></tr>
<tr><td></td><td></td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>ID_F</td><td>2</td><td colspan="8">0h0006</td></tr>
<tr><td>ID_F + 02</td><td>1</td><td colspan="3">F0 index0</td><td colspan="3">F0 index1</td><td colspan="2">F0 index2 MSBs</td></tr>
<tr><td>ID_F + 03</td><td>1</td><td>F0 i.2 LSB</td><td colspan="3">F1 index0</td><td colspan="3">F1 index1</td><td>F1 i.2 MSB</td></tr>
<tr><td>ID_F + 04</td><td>1</td><td colspan="2">F1 i.2 LSBs</td><td colspan="3">F2 index0</td><td colspan="3">F2 index1</td></tr>
<tr><td>ID_F + 05</td><td>1</td><td colspan="3">F2 index2</td><td colspan="3">F3 index0</td><td colspan="2">F3 index1 MSBs</td></tr>
<tr><td>ID_F + 06</td><td>1</td><td>F3 i.1 LSB</td><td colspan="3">F3 index2</td><td colspan="3">F4 index0</td><td>F4 i.1 MSB</td></tr>
<tr><td>ID_F + 07</td><td>1</td><td colspan="2">F4 i.1 LSBs</td><td colspan="3">F4 index2</td><td colspan="3">F5 index0</td></tr>
<tr><td>ID_F + 08</td><td>1</td><td colspan="3">F5 index1</td><td colspan="3">F5 index2</td><td colspan="2">0b00</td></tr>
</table>

6.8 Vertices

6.8.1 General

The vertices are defined by a list of vertices from byte number ID_V on; see Table 15.

The order in the list is arbitrary, but fixed.

Table 15 – Vertices

Byte # hex	Size	Symbol	Description	Values
ID_V	2	V	Total number of vertices	$5 \leq V < 65\ 535$
ID_V+02	2	R	Number of vertices belonging to gamut ridges	$0 \leq R \leq V$
ID_V+04	$\lceil 3VN/8 \rceil$		$3V$ encoded colour space coordinates defining V vertices	Encoded colour space coordinates
ID_V+04+ $\lceil 3VN/8 \rceil$	$\lceil R\lceil ld(V) \rceil /8 \rceil$		R indices of vertices belonging to gamut ridges	[0; V − 1] Shall be a valid indices of vertices

In Table 15, $\lceil \bullet \rceil$ is the operation that rounds to the next upper integer. V is the total number of vertices of the description of gamut geometry.

The vertices belonging to gamut ridges are a subset of all vertices. Gamut ridges are positions on the surface of the actual colour gamut having non-continuous surface curvature such as ridges or summits.

6.8.2 Packing of colour space coordinates for vertices

For 8-bit encoding, the 12 colour space coordinates are directly coded into 12 bytes. For 10-bit encoding, the vertices are packed in accordance with Table 16. For 12-bit encoding, the vertices are packed in accordance with Table 17.

Table 16 – Packing of 10-bit colour space coordinates

Relative byte # hex	Size bytes	Description							
		7	6	5	4	3	2	1	0
00	1	A_high							
01	1	A_low		B_high					
02	1	B_low				C_high			
03	1	C_low						D_high	
04	1	D_low							

Table 17 – Packing of 12-bit colour space coordinates

Relative byte # hex	Size bytes	Description							
		7	6	5	4	3	2	1	0
00	1	A_high							
01	1	A_low				B_high			
02	1	B_low							
03	1	C_high							
04	1	C_low				D_high			
05	1	D_low							

7 Description of gamut geometry (medium and simple profiles)

7.1 General

This clause specifies the simple and medium profile of the description of gamut geometry. See Clause 6 for the full profile.

7.2 Medium profile

In the header of Gamut ID metadata, if ID_PROFILE equals 0b01, the description of gamut geometry shall correspond to the medium profile.

For the description of gamut geometry, the medium profile is identical to the full profile except for the following specifications.

In the medium profile, the header of the description of gamut geometry is defined in accordance with Table 5, except:

- the number of levels of colour population shall always be P = 1;
- the number of levels of details shall be K = 1 or K = 2.

The Gamut Hulls are defined in accordance with Table 8 except:

- the total number H of Gamut Hulls shall be smaller than or equal to 4.

Each Gamut Hull is defined in accordance with Table 9 except:

- the number of referenced Gamut Components that are used inverted by the hth GH shall be $\bar{C}_h = 0$.

The Gamut Components are defined in accordance with Table 10 except:

- the total number C of Gamut Components shall be smaller than or equal to 4.

7.3 Simple profile

If ID_PROFILE (see Table 2) equals 0b10, the description of gamut geometry shall correspond to the simple profile.

In the simple profile, ID_GBD_SPACE (see Table 2) shall be 0b011.

In the simple profile, the format of the description of gamut geometry is summarized in Table 18.

Table 18 – Description of gamut geometry (simple profile)

Byte # hex	Description
ID_G	Header of description of gamut geometry
ID_V	Vertices

The header of the description of gamut geometry follows the Gamut ID header and is defined in accordance with Table 19.

Table 19 – Header of description of gamut geometry (simple profile)

Byte # hex	Size bytes	Symbol	Description	Values
ID_G	2	ID_V	Bite # of start of vertices	ID_G + 04
ID_G + 02	1		Reserved	0
ID_G + 03	1		Reserved	0

The vertices are defined by a list of vertices from byte number ID_V on. In the simple profile, ID_V equals ID_G + 0h04. There are V = 5 vertices, one each for white, black, red, green and blue, respectively, in accordance with Table 20:

Table 20 – Definition of vertices (simple profile)

Byte # hex	Size	Symbol	Description	Values
ID_V	2	V	Total number of vertices	Shall be 5
ID_V+02	2	R	Shall be zero	0
ID_V+04	$\lceil 3VN/8 \rceil$		3V encoded colour space coordinates defining V vertices	Encoded colour space coordinates

Hereby is $\lceil \bullet \rceil$, the operation that rounds to the next upper integer.

An example for the description of gamut geometry using the simple profile is given in Annex D.

8 Description of colour reproduction

If the ID_E field in the header of the Gamut ID metadata is not 0h0000, the description of colour reproduction shall follow from byte number ID_E on. The description of colour reproduction determines the link between encoded colour space coordinates and radiometrically-linear CIEXYZ colour space coordinates, as defined in CIE 15, of reproduced colours. When using the description of colour reproduction, the image state of the encoded colour space coordinates shall be output-referred as defined in ISO 22028-1.

The header of the description of colour reproduction shall be in accordance with Table 21. Gamut ID metadata may contain Q distinct colour reproduction models E_0 to E_{Q-1}. With increasing index, the colour reproduction profiles shall have increasing precision and usually have increasing memory footprint. E_0 should have lowest precision and smallest memory footprint.

Table 21 – Header of description of colour reproduction

Byte # hex	**Size** bytes	**Symbol**	**Description**	**Values decimal**
ID_E	1	Q	Number of levels of detail (number of colour reproduction profiles)	$1 \le Q \le 255$
ID_E + 01	SE_0	E_0	First colour reproduction profile	
: :				
ID_E + 01 + $\sum_{q=1...Q-1} SE_m$	SE_{Q-1}	E_{Q-1}	Qth colour reproduction profile	

Each Gamut ID colour reproduction model shall be binary encoded using the ICC profile format specified in ISO 15076-1:2010, except that only the following tags are required:

- profileDescriptionTag;
- copyrightTag;
- mediaWhitePointTag;
- chromaticAdaptationTag – when the colour space indicated by ID_GBD_SPACE assumes adaptation to a white with a chromaticity different from that of CIE Illuminant D50;
- At least one of the following tag groups:
  - N-Component LUT-based display profiles tags: AtoB1Tag and BtoA1Tag;
  - three-component matrix-based display profile tags: redMatrixColumnTag, greenMatrixColumnTag, blueMatrixColumnTag, redTRCTag, greenTRCTag, blueTRCTag.

A Gamut ID colour reproduction model shall not contain one of the following tags from ISO 15076-1:2010:

- outputResponseTag.

A Gamut ID colour reproduction model shall have the following characteristics:

- the rendering intent indicated in the ICC profile header shall be either the ICC-absolute colorimetric intent or the media-relative colorimetric intent;
- the Profile Connection Space (PCS) shall be XYZData;
- if the colour space indicated by ID_GBD_SPACE assumes adaptation to a white with a chromaticity different from that of D50, the ICC chromaticAdaptationTag should contain a linearized Bradford transform in accordance with ISO 15076-1:2010, Annex E as the chromatic adaptation transform (CAT) that transforms CIEXYZ colour space coordinates under the native illumination and with the native adopted white into PCS CIEXYZ colour space coordinates that are adapted to the D50 PCS adopted white.

NOTE The mediaWhitePointTag provides the media white point tristimulus values after chromatic adaptation to the PCS D50 adopted white. All PCS XYZ colour space coordinates, including the mediaWhitePointTag values, are adapted to this white point.

If any of the following ICC profile tags are present in a colour reproduction model, they shall not be used to obtain gamut information:

- gamutTag,
- AtoB0Tag,
- BtoA0Tag,
- AtoB2Tag,
- BtoA2Tag,
- DtoB0Tag,
- BtoD0Tag,
- DtoB2Tag,
- BtoD2Tag.

Annex A
(informative)

Size of Gamut ID metadata

This annex gives information on the size of the following Gamut ID metadata parts:

- the header of Gamut ID metadata;
- the description of gamut geometry.

The size of the header of Gamut ID metadata is 9 bytes.

For medium and full profiles, the size in bytes of the description of gamut geometry is referred to as S_G and is given by

$$S_G = 26 + P + 6I + EH + 2C + \sum_I H_i + \sum_H \left(C_h + \bar{C}_h\right) + \sum_C \lceil F_c ld(F) \rceil / 8 \rceil$$
$$+ \lceil 3F \lceil ld(V) \rceil / 8 \rceil + \lceil 3VN / 8 \rceil + \lceil R \lceil ld(V) \rceil / 8 \rceil$$

where

I is the number of gamut instances;

H is the number of gamut hulls;

C is the number of gamut components;

F is the number of faces;

V is the number of vertices;

H_i is the number of GH used by the ith GI;

C_h is the number of GC used by the hth GH;

$\overline{C_h}$ is the number of inverted GC used by the hth GH;

F_c is the number of faces used by the cth GC;

N is the number of bits per colour channel;

R is the number of vertices belonging to gamut ridges.

For the simple profile, S_G is 77.

Annex B
(informative)

Motivation and requirements

B.1 History

In 2006, the IEC published the International Standard IEC 61966-2-4. It defines a wide-gamut colour space encoding and is referenced in HDMI 1.3 [1][1] and in other documents. At the same time, a gamut metadata packet was adopted for HDMI 1.3 describing the video content colour gamut.

This document specifies an extended, generalized and scalable gamut metadata format.

B.2 Motivation

In order to allow correct colorimetric colour reproduction of video content by a video sink, three conditions have to be satisfied.

1) The encoding of colours of the content has to be correctly understood by the display.
2) Differences between content and sink colour gamuts have to be identified and processed in a controlled manner.
3) Differences between display viewing conditions and reference viewing conditions have to be compensated for.

The Gamut ID metadata focuses on the second condition. However, in order to satisfy the second condition, the first and third conditions need to be addressed as well.

A typical example of differences in gamuts is content colours out of the sink gamut. Out-of-gamut colours are usually processed by gamut mapping algorithms. Out-of-gamut colours can never be correctly reproduced, it is a question of colour appearance and artistic intent to know by which valid colour an out-of-gamut colour is to be replaced.

The main motivation for the Gamut ID standard is to offer a unified format in order to define the gamut of the video content that will be gamut mapped by the video sink [2].

A second motivation for the Gamut ID standard is to offer a unified format in order to define the gamut of the video sink in the case that gamut mapping is not applied by the display, but elsewhere.

If the video sink does not know the actual colour gamut of the video content, it needs to map all incoming colours in some way into the sink's gamut. In order to keep image details, a video sink may use some kind of gamut mapping that is more sophisticated than just gamut clipping. The possible colours are defined by the employed colour space encoding and colour reproduction rules (for example SMPTE S274M). We call these possible colours the colour encoding gamut. The content gamut is always identical or smaller than the colour encoding gamut. If there is no description of the actual colour gamut of the content, gamut mapping will use this colour encoding gamut as the content gamut. Gamut mapping will then not be well-adapted to the content and may cause loss or over-shooting of contrast and saturation. As an example, such a result is least acceptable when the actual content gamut is close to the sink gamut, but the encoding gamut is larger than the sink gamut. The Gamut ID metadata solves this problem by associating a description of the actual content gamut to the content.

---

[1] Numbers in square brackets refer to the Bibliography.

B.3 Scope of Gamut ID metadata

Figure B.1 shows the scope of the Gamut ID metadata. The metadata is usually associated with video content and/or with video equipment. It contains metadata describing the colour gamut of the video content or the colour gamut of the video equipment and associated colour reproduction information. The video content may be a single frame, a series of frames, just a visible object, or any other pictorial content. The equipment can be a video source (camera, set-top box) or a video sink (display, printer).

This document specifies the format of the Gamut ID metadata. The Gamut ID metadata can be associated with content or with a display. The standard is open to any method that generates the Gamut ID metadata. Metadata generation is an open field for the content creator to add value to the content, or for the equipment manufacturer to add value to the equipment, or for the service provider to add value to the service. The Gamut ID metadata standard may be used in a variety of ways, for example to facilitate gamut mapping. This is an open field for content creators, equipment manufacturers and service providers to create added value. Gamut mapping is a well-known topic in the scientific literature [3] and a survey of methods was prepared by the CIE [4].

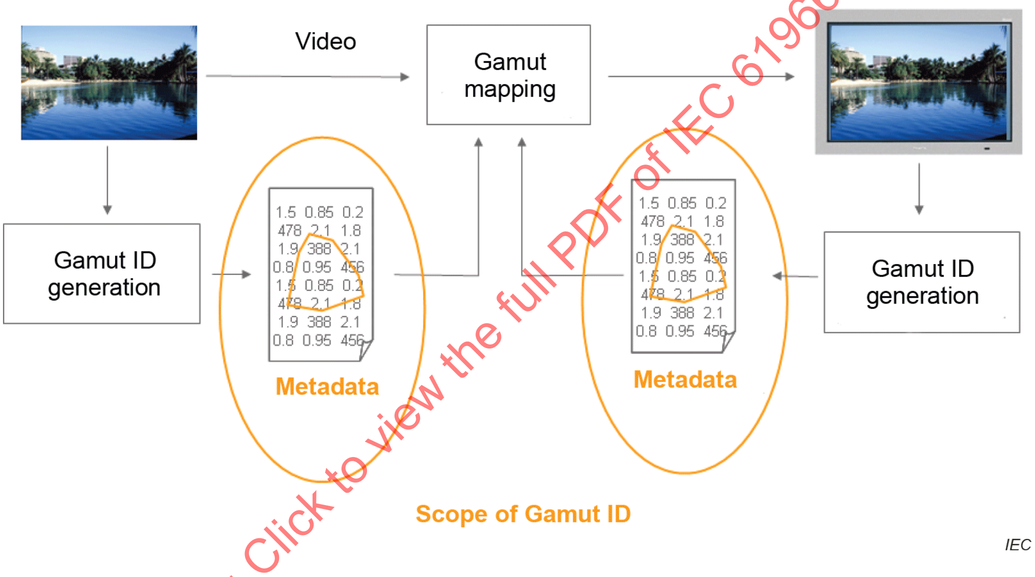

Figure B.1 – Scope of Gamut ID – Generation and use of metadata are not specified

B.4 Requirements

First, the description of an actual colour gamut in the framework of this document should use encoded colour space coordinates with an output referred image state [5]. Second, the Gamut ID metadata should support scalability and complexity reduction for implementation with lower computational complexity. Furthermore, the Gamut ID metadata has to consider the physical features of colour spaces and needs to support creative processes in content production in order to enable high-quality applications.

The requirements for the Gamut ID metadata include:

- Addressing colour reproduction
  - Use a colour encoding with an output-referred image state interpretation provided for gamut description
- Scalability
  - Allow different levels of gamut precision
  - Allow different levels of precision of colour reproduction

- Low computational complexity
  - Support existing graphics standards
  - Allow simple gamut geometry using convex shapes
  - Allow gamut decomposition into sub-gamut modules
- Small memory footprint
  - Allow multiple re-use of sub-gamut modules
- Physics-based
  - Consider gamut ridges due to colorant channels
- Creative
  - Consider importance and population of colours in gamuts

These requirements are not met by the HDMI 1.3 gamut metadata packet [1].

B.5 Structure

The description of gamut geometry in the Gamut ID metadata makes use of gamut boundary descriptions (GBD). A GBD describes the two-dimensional bounding surface of an actual three-dimensional colour gamut in a colour space. A GBD is based on an indexed face set. Faces are triangular surface elements. Figure B.2 shows an example of a gamut that could be contained in the Gamut ID description of gamut geometry.

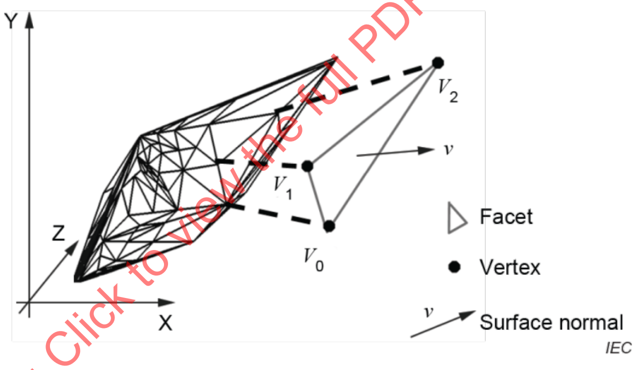

Figure B.2 – Example of a description of gamut geometry in CIEXYZ colour space consisting of a set of triangular faces

The description of gamut geometry corresponding to the sample gamut shown in Figure B.2 contains a set of vertices (V_0, V_1, V_2, V_3, …). Each vertex is defined by three colour-space coordinates in accordance with a chosen colour space and a chosen rule for colour encoding. Colour space coordinates have to be in an output-referred image state. The link between the encoded colour space coordinates and reproduced, radiometrically-linear CIEXYZ colour space coordinates depends on the adopted rule for colour reproduction. Gamut ID data may contain an optional, explicit, ICC-like description of colour reproduction.

The description of gamut geometry corresponding to the sample gamut shown in Figure B.2 also contains a set of faces (F_0, F_1, F_2, F_3, …). Let F_0 being the sample face shown in Figure B.2. Face F_0 is defined by three indices 0,1,2 of its three vertices V_0, V_1, V_2. A set of such faces is called indexed face set. The surface normal of a face always points outside the gamut. According to the order of indices 0, 1, 2, the surface normal of F_0 is defined as follows:

$$v = \frac{(V_2 - V_0) \times (V_1 - V_0)}{|V_2 - V_0| \bullet |V_1 - V_0|}$$

where

$\times$ is the vector cross product,

$|\bullet|$ is the vector length operator, and

v is the surface normal.

The description of gamut geometry is organized in a hierarchical manner such as shown in Figure 1. The description of gamut geometry contains a set of each of the following elements:

- **Vertices**: each defined by its three colour coordinates;
- **Faces**: each defined by exactly three indices of three corresponding vertices of the set of vertices;
- **Gamut components**: each being a connex 3D surface, each defined by a list of at least one face;
- **Gamut hulls**: each being the closed surface of a connex volume in colour space, each defined by a list of at least one gamut component;
- **Gamut instance:** each being a valid gamut boundary description each defined by a list of at least one gamut hull.

Table B.1 shows how the hierarchical structure of the Gamut ID metadata satisfies the mentioned requirements.

Table B.1 – Requirements and Gamut ID features

Requirement	Gamut ID feature	Advantage
Addressing colour reproduction: Use colour encoding based on output-referred image state for gamut description	The Gamut ID contains an optional description of colour reproduction assuming output-referred image state	Gamut ID metadata can be used to enhance colour reproduction accuracy
Scalability: Allow different levels of precision for gamut description	A Gamut ID may contain K levels of detail. It therefore may contain K different, alternative gamut instances.	The video sink can choose the level of detail according to its capabilities.
Scalability: Allow different levels of precision for colour reproduction	A Gamut ID may contain Q levels of detail for the description of colour reproduction.	The video sink can choose the level of detail according to its capabilities.
Low computational complexity: Allow simple geometry using convex shapes	A Gamut ID allows for geometry with convex and/or non-convex shapes. It may contain more than one, alternative gamut instances, at least one using only convex shapes.	The video sink may choose the GI using only convex shapes in order speed up geometrical operations.
Low computational complexity: Support of existing graphics standards	The Gamut ID is based on an indexed face set.	Accelerated operations in OpenGL and graphics hardware
Low computational complexity: Allow gamut decomposition into sub-gamut modules	The Gamut ID may contain modular GIs, each of those defined by one or more gamut hulls, the union of the volumes of these GHs is then the volume of the GI.	The video is able to handle non-convex gamuts while speeding up geometrical operations using convex GHs.
Small memory footprint: Allow multiple re-use of sub-gamut modules	The Gamut ID may contain modular GHs defined by one or more gamut components; all these GCs together build a GH. A GC may be used by more than one GH.	Parts of gamut shape that are common to different GIs are defined only one time; memory footprint is reduced.
Physics-based: Consider gamut ridges due to colorant channels	A vertex may contain a flag indicating that it represents a summit or a ridge with non-continuous gamut surface curvature.	The video sink is able to avoid smoothing at ridges and summits when manipulating gamuts.
Creative: Consider colour population	A Gamut ID may contain $P > 1$ alternative Gamut Instances each describing alternative gamuts containing different percentages of colours of the actual colour gamut.	The video sink can differentiate between frequent colours and rare colours.

B.6 Specific features

An example for the physics-based requirement to consider gamut ridges in the description of gamut geometry due to colorant channels is shown in Figure B.3. Vertices belonging to a gamut ridge or a gamut summit are marked as such. Ridges can be lines on the gamut surface linking two or more summits of a gamut. Summits can be primary colours, secondary colours, black point, or white point, for example.

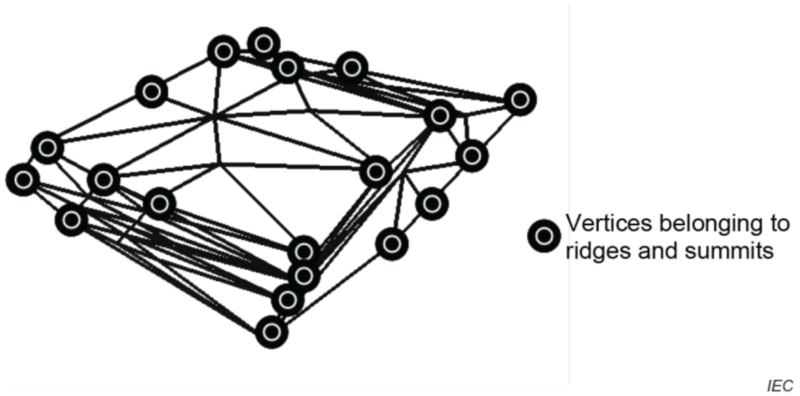

Figure B.3 – Example of a gamut with identified ridge due to colorant channels

An example of a description of gamut geometry that decomposes the colour gamut into modules is shown in Figure B.4. The colour gamut is the union of the volumes of all gamut hulls. In this example, both two gamut hulls are convex while the overall gamut is not convex. When using this description of gamut geometry, geometrical operations such as line-gamut intersection can make use of simple geometry with convex hulls.

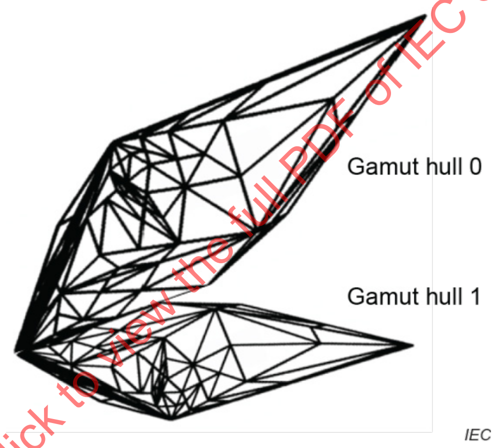

Figure B.4 – Example of a non-convex gamut with two convex Gamut Hulls

An example of a gamut hull using a gamut component in an inverted way is explained in the following. GCs are normally defined in a way that the surface normals of the faces go into outside direction of the gamut. If a GC is used inverted, the surface normals are supposed to go into the inside direction of the gamut. By this procedure, a single GC can be used by two GHs and defines the separating face between the GHs. In the first GH, the GC is used non-inverted, and in the second GH, the GC is used inverted.

Annex C
(informative)

Use of profiles

C.1 Gamut ID profiles

The description of gamut geometry corresponds to one of three profiles:

- full profile;
- medium profile;
- simple profile.

The profiles are summarized in Table C.1.

Table C.1 – Profiles for the description of gamut geometry

<table>
<tr><th>Feature of the description of gamut geometry</th><th>Gamut ID simple profile</th><th>Gamut ID medium profile</th><th>Gamut ID full profile</th></tr>
<tr><td>ID_PROFILE in Gamut ID header</td><td>0b10</td><td>0b01</td><td>0b00</td></tr>
<tr><td>Colour vertices</td><td>5 predefined vertices in known order:
white, black, red, green, blue</td><td rowspan="2">any</td><td rowspan="2">any</td></tr>
<tr><td>Colour faces</td><td>not allowed</td></tr>
<tr><td>Number of gamut components</td><td>not allowed</td><td>≤ 4</td><td rowspan="4">any</td></tr>
<tr><td>Number of gamut hulls</td><td>not allowed</td><td>≤ 4</td></tr>
<tr><td>Number of gamut instances</td><td>not allowed</td><td>≤ 2</td></tr>
<tr><td>Levels of detail</td><td>not allowed</td><td>≤ 2</td></tr>
<tr><td>Non-convex shape</td><td>not allowed</td><td>allowed</td><td rowspan="4">allowed</td></tr>
<tr><td>Indication of gamut ridges</td><td>not allowed</td><td>allowed</td></tr>
<tr><td>Percentage of gamut colours</td><td>not allowed</td><td>not allowed</td></tr>
<tr><td>Inverted gamut components</td><td>not allowed</td><td>not allowed</td></tr>
</table>

C.2 Medium profile

The medium profile has the following limitations with respect to the full profile:

- the description of gamut geometry shall not use percentage of gamut colours;
- the description of gamut geometry shall not use inverted gamut components;
- the number of gamut components shall not be larger than four;
- the number of gamut hulls shall not be larger than four;
- the number of gamut instances shall not be larger than two;
- the number of levels of details shall not be larger than two.

C.3 Simple profile

The simple profile has the following limitations with respect to the full profile:

- the description of colour consists of 5 vertices for white, black, red, green, blue, thus $V = 5$ (see Table 15);
- there is no description of colour reproduction;
- there is no GI, $I = K = P = 0$, $X = 1$ and ID_GI equals 0h0000 (see Table 5);
- there is no GH, $H = 0$ and ID_GH equals 0h0000 (see Table 5);
- there is no GC, $C = 0$ and ID_GC equals 0h0000 (see Table 5);
- there are no faces, $F = 0$ and ID_F equals 0h0000 (see Table 5);
- colour space is XYZ and ID_GBD_SPACE equals 0b011 (see Table 2).

An example is given in Annex D.

Annex D
(informative)

Example of Gamut ID metadata in simple profile

This annex provides an example of Gamut ID metadata using the simple profile. In this example, the Gamut ID metadata describes the actual colour gamut of a video content that is prepared for projection in accordance with the nominal image parameters of the digital cinema system specification [6] in Table D.1:

Table D.1 – Colour gamut for digital cinema

Colour	CIE x	CIE y	CIE X	CIE Y	CIE Z
white	0,314	0,351	42,940	48,000	45,812
black	0,314	0,351	0,021	0,024	0,023
red	0,680	0,320	21,463	10,100	0,000
green	0,265	0,690	13,288	34,600	2,257
blue	0,150	0,060	8,275	3,310	43,582

The Gamut ID metadata contains one single Gamut Boundary Description describing an actual colour gamut that is defined by five colour vertices: white, black, red, green and blue, in accordance with Table D.1.

The Gamut ID metadata starts with the header in accordance with Table D.2.

Table D.2 – Example for the header

Byte # hex	Size bytes	Symbols	Description								Values
			7	6	5	4	3	2	1	0	
00	1	N, P	0	1	0	0	0	0	1	1	
			R	ID_PROFILE		ID_PRECISION		ID_GBD_SPACE			
01	1	ID_G	Byte # of start of the description of gamut geometry								0h00
02	1										0h09
03	1	ID_E	Byte # of start of the description of colour reproduction								0h00
04	1										0h00
05	1		Reserved. Shall be zero.								0h00
06	1										0h00
07	1		Reserved. Shall be zero.								0h00
08	1										0h00

ID_PROFILE is set to 0b10 (simple profile). ID_PRECISISON is set to 0b00. ID_GBD_SPACE is set to 0b011 (XYZ). ID_G equals 0h009. In this example, ID_E is set to 0h0000 and the Gamut ID metadata does not contain a description of colour reproduction.

16-bit integer or address values are encoded into 2 bytes using big endian, i.e. with the MSBs in the first byte and the LSBs in the second byte.

The header of the description of gamut geometry is built in accordance with Table D.3.

Table D.3 – Example for the header of description of gamut geometry

Byte # hex	Size bytes	Symbol	Description	Values
09	1	ID_V	Byte # of start of vertices	0h00
0A	1			0h0D
0B	1		Reserved	0h00
0C	1		Reserved	0h00

There are no GI, no GH, no GC and no faces.

There are 5 vertices in accordance with Table D.4.

Table D.4 – Example of definition of vertices

Byte # hex	Size	Symbol	Description	Values
0D	1	V	Total number of vertices	0h00
0E	1			0h05
0F	1	R	Shall be zero	0h00
10	1			0h00
11	$\lceil 3VN/8 \rceil$ =60		$3V$ encoded colour space coordinates defining V vertices	See Table D.5

The vertices represent the primary colours white, black, red, green and blue of the actual colour gamut. For each vertex, the corresponding colour is encoded as an XYZ number (see ICC profiles in ISO 15076-1:2010) and requires 12 bytes. Each colour space coordinate (X, Y or Z) is encoded as s15Fixed16Number (see ICC profiles in ISO 15076-1:2010) and requires N = 32 bits. There are 60 bytes of vertex data, representing 5 times 12 bytes. The encoded colour coordinates are shown in Table D.5.

Table D.5 – Encoded colour space coordinates for vertices

Byte # hex	Value hex	Description
11	00	White X
12	2A	
13	F0	
14	AF	
15	00	White Y
16	30	
17	00	
18	00	

Byte # hex	**Value** hex	**Description**
19	00	White Z
1A	2D	
1B	CF	
1C	DC	
1D	00	Black X
1E	00	
1F	05	
20	7F	
21	00	Black Y
22	00	
23	06	
24	24	
25	00	Black Z
26	00	
27	05	
28	DD	
29	00	Red X
2A	15	
2B	76	
2C	66	
2D	00	Red Y
2E	0A	
2F	19	
30	99	
31	00	Red Z
32	00	
33	00	
34	00	
35	00	Green X
36	0D	
37	49	
38	D4	
39	00	Green Y
3A	22	
3B	99	
3C	99	
3D	00	Green Z
3E	02	
3F	41	
40	AB	

Byte # hex	Value hex	Description
41	00	Blue X
42	08	
43	46	
44	66	
45	00	Blue Y
46	03	
47	4F	
48	5C	
49	00	Blue Z
4A	2B	
4B	94	
4C	E8	

The Gamut ID described in this example has a length of 77 bytes.

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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SYSTÈMES ET APPAREILS MULTIMÉDIAS – MESURE ET GESTION DE LA COULEUR –

Partie 12-1: Métadonnées d'identification des gammes de couleurs (Gamut ID)

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La Norme internationale IEC 61966-12-1 a été établie par le domaine technique 2: Gestion et mesure des couleurs, du comité d'études 100 de l'IEC: Systèmes et équipements audio, vidéo et services de données.

Cette deuxième édition annule et remplace la première édition parue en 2011. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) ajout des espaces de couleurs UIT-R BT.2020 à l'Article 6;
b) ajout des espaces de couleurs UIT-R BT.2100 à l'Article 6.

Le texte de cette Norme internationale est issu des documents suivants:

CDV	Rapport de vote
100/3126/CDV	100/3375/RVC

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 61966, publiées sous le titre général *Systèmes et appareils multimédias – Mesure et gestion de la couleur*, peut être consultée sur le site web de l'IEC.

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INTRODUCTION

De nouvelles technologies de capture et d'affichage d'images à gamme de couleurs étendue ouvrent un nouveau marché, celui de la création de contenus vidéo à gamme de couleurs étendue et de contenus vidéo à grande plage dynamique. Des normes vidéo récentes pour le codage de l'espace des couleurs à gamme de couleurs étendue, comme l'UIT-R BT.2020 (UHDTV) et l'IEC 61966-2-4 (xvYCC), ont été établies pour permettre de distribuer des contenus avec une gamme de couleurs plus grande que les gammes classiques, définies par les normes de colorimétrie UIT-R BT.601 (télévision de définition normale) et UIT-R BT.709 (télévision à haute définition). Des normes vidéo récentes pour le codage de l'espace des couleurs à grande plage dynamique (HDR, *High Dynamic Range*), comme l'UIT-R BT.2100, ont été établies pour permettre de distribuer des contenus avec une gamme de couleurs et une plage dynamique plus grandes que le codage classique des couleurs, défini par l'UIT-R BT.709. La popularité grandissante des contenus et des écrans à gamme de couleurs étendue et à plage dynamique rend probable une diversification des gammes de couleurs des écrans. L'adoption par les professionnels de la création de contenus d'une vidéo couleur à gamme étendue peut poser problème tant que la compatibilité de ces contenus avec les écrans n'est pas assurée, de même que la compatibilité entre les différents écrans. Le terme "écran" inclut ici tout appareil de reproduction vidéo couleur, tel que les afficheurs à vision directe et les projecteurs. Du fait des améliorations technologiques, la diversité des gammes de couleurs et des capacités de reproduction des couleurs par les écrans s'accroît, alors que dans les normes existantes la gamme des couleurs et les règles de codage de la couleur qui régissent le codage de l'espace des couleurs sont figées.

Pour traiter ce problème, le présent document spécifie un agencement des métadonnées des gammes de couleurs pour systèmes vidéo, y compris l'information pour la reproduction des couleurs. Ces métadonnées peuvent apporter des améliorations à un contenu vidéo ou à un écran. Plus spécifiquement, des améliorations peuvent être obtenues si le contenu à gamme de couleurs étendue est créé avec la connaissance de la gamme de couleurs de l'écran, ou si la reproduction des couleurs par l'écran s'effectue en toute connaissance de la gamme de couleurs du contenu fait d'images.

Le présent document permet aux systèmes vidéo de définir leur propre gamme de couleurs. Le présent document définit les métadonnées nécessaires pour gérer des systèmes vidéo non homogènes avec des gammes de couleurs différentes. Le présent document généralise les normes existantes de codage de l'espace des couleurs, dont la gamme de couleurs est figée.

SYSTÈMES ET APPAREILS MULTIMÉDIAS – MESURE ET GESTION DE LA COULEUR –

Partie 12-1: Métadonnées d'identification des gammes de couleurs (Gamut ID)

1 Domaine d'application

La présente partie de l'IEC 61966 définit l'agencement des métadonnées des gammes de couleurs destiné aux systèmes vidéo et applications similaires.

Les métadonnées peuvent être associées à un contenu vidéo à gamme de couleurs étendue ou à un appareil qui sert à afficher ce contenu.

Lorsqu'elles sont associées au contenu, les métadonnées de gamme de couleurs définissent la gamme de couleurs pour laquelle le contenu a été créé. Elles peuvent être utilisées par l'écran pour piloter la reproduction des couleurs, même si la gamme de couleurs de l'écran est différente de celle du contenu.

Lorsqu'elles sont associées à un écran, les métadonnées de gamme de couleurs définissent la gamme des couleurs de l'écran. Elles peuvent servir pendant la création du contenu, pour permettre une meilleure reproduction des couleurs.

Les métadonnées de gammes de couleurs peuvent intégrer des informations associées de codage des couleurs, dont toutes celles nécessaires à une reproduction contrôlée des couleurs, lorsque ces informations ne sont pas fournies par la spécification du codage des couleurs.

L'agencement des métadonnées des gammes de couleurs apporte des solutions évolutives. Par exemple, des solutions plus souples servent à un usage professionnel, alors que des solutions beaucoup plus simples servent au grand public, avec une mise en œuvre plus facile du produit.

La présente partie de l'IEC 61966 ne définit que l'agencement des métadonnées des gammes de couleurs. Des solutions spécifiques à un fournisseur, pour la création et l'usage final de ces métadonnées, sont admises.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050-845, *Vocabulaire Electrotechnique International – Chapitre 845: Eclairage*

IEC 61966-2-4:2006, *Systèmes et appareils multimédia – Mesure et gestion de la couleur – Partie 2-4: Gestion de la couleur – Extension de gamme de l'espace chromatique YCC pour applications vidéo – xvYCC*

ISO 15076-1:2010, *Image technology colour management – Architecture, profile format and data structure – Part 1: Based on ICC.1:2010* (disponible en anglais seulement)

UIT-R BT.709, *Valeurs des paramètres des normes de TVHD pour la production et l'échange international des programmes*

CIE 15:2004, *Colorimétrie*

SMPTE 274M:2005, *SMPTE Standard for Television - 1920 x 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates* (disponible en anglais seulement)

UIT-R BT.2020, *Valeurs de paramètres des systèmes de télévision à ultra haute définition pour la production et l'échange international de programmes*

UIT-R BT.2100, *Valeurs des paramètres de l'image dans le cas de systèmes de télévision à grande plage dynamique à utiliser pour la production et l'échange international de programmes*

3 Termes, définitions et termes abrégés

3.1 Termes et définitions

Pour les besoins du présent document, les termes et définitions donnés dans l'IEC 60050-845 ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1.1
contenu
contenu vidéo en production, en postproduction ou en consommation

3.1.2
gamme de couleurs (*Gamut*)
solide dans un espace des couleurs

Note 1 à l'article: Un solide dans un espace des couleurs, comme spécifié par l'UIT-R BT.2100, peut contenir des couleurs à haute luminance.

3.1.3
description de la frontière d'une gamme de couleurs (*gamut boundary description*)
description de la frontière d'une gamme de couleurs

3.1.4
coordonnées de l'espace des couleurs radiométriquement linéaires
coordonnées de l'espace des couleurs linéaires par rapport à l'illumination de l'image

3.2 Termes abrégés

GBD gamut boundary description (description de la frontière d'une gamme de couleurs)

LSB least significant bit (bit de poids faible)

MSB most significant bit (bit de poids fort)

GI gamut instance (réalisation (ou instanciation) d'une gamme de couleurs)

GH gamut hull (enveloppe d'une gamme de couleurs)

GC gamut component (composant d'une gamme de couleurs)

4 Présentation générale

Le présent document spécifie des métadonnées appelées "métadonnées d'identification des gammes de couleurs" qui donnent des informations sur une gamme de couleurs réelle.

Les métadonnées d'identification des gammes de couleurs comprennent quatre parties et leur format est résumé par le Tableau 1.

Tableau 1 – Format des métadonnées d'identification des gammes de couleurs

Numéro d'octet hexadécimal	**Contenu des métadonnées**
0h0000	En-tête des métadonnées d'identification des gammes de couleurs
ID_G	Description de la géométrie d'une gamme de couleurs
ID_E	Description de la reproduction des couleurs

L'Article 5 spécifie l'en-tête des métadonnées d'identification des gammes de couleurs.

Les Articles 6 et 7 spécifient la description de la géométrie d'une gamme de couleurs qui correspond à l'un des trois profils énumérés ci-après:

- profil complet;
- profil moyen;
- profil simple.

L'Article 6 spécifie le profil complet de la description de la géométrie d'une gamme de couleurs. Les profils moyen et simple sont spécifiés à l'Article 7.

L'Article 8 spécifie la description de la reproduction des couleurs.

L'Annexe A traite de la taille des métadonnées d'identification d'une gamme de couleurs.

L'Annexe B fournit des informations contextuelles.

L'Annexe C concerne l'utilisation des profils simple, moyen et complet.

5 En-tête des métadonnées d'identification des gammes de couleurs

Les métadonnées d'identification des gammes de couleurs commencent par l'en-tête indiqué dans le Tableau 2.

Tableau 2 – En-tête des métadonnées d'identification des gammes de couleurs

Numéro de l'octet hexadécimal	**Taille** Octets	**Symboles**	**Description**								**Valeurs**
			7	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
00	1	N, P	R	ID_PROFILE		ID_PRECISION		ID_GBD_SPACE			R = réservé = 0b0 (1 bit) ID_PROFILE (2 bits): 0b00: Profil complet 0b01: Profil moyen 0b10: Profil simple 0b11: Réservé ID_PRECISION (2 bits): 0b00: 8 bits 0b01: 10 bits 0b10: 12 bits 0b11: réservé ID_GBD_SPACE (3 bits): 0b000: UIT-R BT.709 RVB 0b001: xvYCC-601 (IEC 61966-2-4 -DS) YCC 0b010: xvYCC-709 (IEC 61966-2-4 -HD) YCC 0b011: XYZ (voir ci-dessous) 0b100: UIT-R BT.2020 R'V'B' 0b101: UIT-R BT.2020 $Y'C'_BC'_R$ 0b110: UIT-R BT.2020 $Y_C'C'_{BC}C'_{RC}$ 0b111: ID_GBD_SPACE_EXT
01	2	ID_G	Numéro d'octet du début de la description de la géométrie d'une gamme de couleurs								[0h0009; 0hFFFF]
03	2	ID_E	Numéro d'octet du début de la description de la reproduction des couleurs								[0; 0hFFFF]

Numéro de l'octet hexadécimal	Taille Octets	Symboles	Description	Valeurs
05	1		ID_GBD_SPACE_EXT	0h00: UIT-R BT.2100 R'V'B' PQ restreint 0h01: UIT-R BT.2100 R'V'B' PQ complet 0h02: UIT-R BT.2100 R'V'B' HLG restreint 0h03: UIT-R BT.2100 R'V'B' HLG complet 0h04: UIT-R BT.2100 $Y'C'_BC'_R$ PQ restreint 0h05: UIT-R BT.2100 $Y'C'_BC'_R$ PQ complet 0h06: UIT-R BT.2100 $Y'C'_BC'_R$ HLG restreint 0h07: UIT-R BT.2100 $Y'C'_BC'_R$ HLG complet 0h08: UIT-R BT.2100 IC_TC_P PQ restreint 0h09: UIT-R BT.2100 IC_TC_P PQ complet 0h0A: UIT-R BT.2100 IC_TC_P HLG restreint 0h0B: UIT-R BT.2100 IC_TC_P HLG complet 0h0C – 0hFF: réservé
06	3		Réservé. Doit être zéro.	0h000000

ID_PROFILE indique le profil des métadonnées d'identification des gammes de couleurs et doit être l'un des suivants:

- 0b00: profil complet;
- 0b01: profil moyen;
- 0b11: profil simple.

ID_GBD_SPACE indique l'espace des couleurs et le codage dans l'espace des couleurs des sommets de couleur de la description de la géométrie d'une gamme de couleurs et doit être l'un des suivants:

- 0b000: UIT-R BT.709, espace RVB, codage conforme au SMPTE 274M,
- 0b001: xvYCC-601, espace YCbCr, codage conforme à l'IEC 61966-2-4 – DS,
- 0b010: xvYCC-709, espace YCbCr, codage conforme à l'IEC 61966-2-4 – HD,
- 0b011: XYZ; le codage doit utiliser le format XYZNumber des profils ICC, spécifié dans l'ISO 15076-1:2010, qui prend 12 octets pour un triplet XYZ,
- 0b100: UIT-R BT.2020, espace RVB, codage conforme à l'UIT-R BT.2020 R', V', B',
- 0b101: UIT-R BT.2020, espace YCbCr, codage conforme à l'UIT-R BT.2020 Y', C'_B, C'_R,
- 0b110: UIT-R BT.2020, espace YCbCr, codage conforme à l'UIT-R BT.2020 Y_C', C'_{BC}, C'_{RC},
- 0b111: l'espace des couleurs et le codage dans l'espace des couleurs sont indiqués par ID_GBD_SPACE_EXT.

Si ID_GBD_SPACE est égal à 0b111, ID_GBD_SPACE_EXT indique l'espace des couleurs et le codage dans l'espace des couleurs des sommets de couleur de la description de la géométrie d'une gamme de couleurs et doit être l'un des suivants:

- 0h00: UIT-R BT.2100 R'G'B', format PQ, gamme restreinte,
- 0h01: UIT-R BT.2100 R'G'B', format PQ, gamme complète,
- 0h02: UIT-R BT.2100 R'G'B', format HLG, gamme restreinte,
- 0h03: UIT-R BT.2100 R'G'B', format HLG, gamme complète,
- 0h04: UIT-R BT.2100 $Y'C'_BC'_R$, format PQ, gamme restreinte,
- 0h05: UIT-R BT.2100 $Y'C'_BC'_R$, format PQ, gamme complète,
- 0h06: UIT-R BT.2100 $Y'C'_BC'_R$, format HLG, gamme restreinte,
- 0h07: UIT-R BT.2100 $Y'C'_BC'_R$, format HLG, gamme complète,
- 0h08: UIT-R BT.2100 IC_TC_P, format PQ, gamme restreinte,
- 0h09: UIT-R BT.2100 IC_TC_P, format PQ, gamme complète,
- 0h0A: UIT-R BT.2100 IC_TC_P, format HLG, gamme restreinte,
- 0h0B: UIT-R BT.2100 IC_TC_P, format HLG, gamme complète.

ID_PRECISION, ID_GBD_SPACE et ID_GBD_SPACE_EXT spécifient, conformément au Tableau 3, le nombre N de bits utilisés par voie de couleur, afin de définir les coordonnées d'une couleur dans un espace des couleurs.

Tableau 3 – Profondeur des couleurs relative au codage d'une coordonnée de l'espace des couleurs

ID_GBD_SPACE	ID_PRECISION	Profondeur des couleurs N
0b011	Quelconque	32 bits
sinon	0b00	8 bits
	0b01	10 bits
	0b10	12 bits
	0b11	Réservé

Si ID_GBD_SPACE est égal à 0b011 pour le codage XYZ, la profondeur des couleurs N doit être égale à 32, quel que soit ID_PRECISION.

Les codages BT.2020 et BT.2100 sont définis par l'UIT-R pour les profondeurs de couleurs égales à 10 ou 12 uniquement.

ID_G indique le décalage, en octets, du début des métadonnées d'identification d'une gamme de couleurs jusqu'au début de la description de la géométrie de la gamme de couleurs.

Si ID_E est différent de 0h0000, les métadonnées d'identification d'une gamme de couleurs contiennent une description de la reproduction des couleurs et ID_E indique le décalage, en octets, du début des métadonnées jusqu'au début de la description de la reproduction des couleurs. Si ID_E a la valeur 0h0000, les métadonnées ne contiennent pas de description de la reproduction des couleurs.

6 Description de la géométrie d'une gamme de couleurs (profil complet)

6.1 Généralités

Dans l'en-tête des métadonnées d'identification d'une gamme de couleurs, si ID_PROFILE est égal à 0b00, la description de la géométrie de la gamme de couleurs doit correspondre au profil complet.

6.2 Géométrie d'une gamme de couleurs

La description de la géométrie dans les métadonnées d'identification des gammes de couleurs détermine la frontière de la gamme réelle des couleurs. La description de la géométrie d'une gamme de couleurs commence au numéro d'octet ID_G.

La description de la géométrie d'une gamme de couleurs contient cinq jeux d'éléments différents:

- réalisations ou instanciations d'une gamme de couleurs;
- enveloppes d'une gamme de couleurs;
- composants d'une gamme de couleurs;
- faces; et
- sommets.

La structure logique de la description de l'identification d'une gamme de couleurs est représentée à la Figure 1.

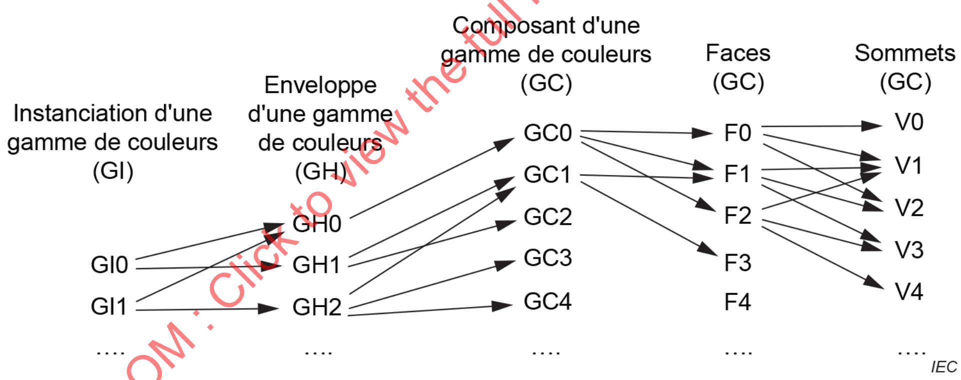

Figure 1 – Structure logique de la description de la géométrie d'une gamme de couleurs (profil complet)

La description de la géométrie d'une gamme de couleurs contient une ou plusieurs descriptions de la frontière de cette gamme, qui décrivent chacune la frontière de la même gamme réelle. Une description de la frontière d'une gamme (GBD) contient des sommets et des faces triangulaires. Chaque face est définie par les indices des trois sommets.

Un composant d'une gamme est un groupe de faces triangulaires connexes. Un composant d'une gamme (GC) est une partie d'une description d'une frontière. Un GC est défini par un ou plusieurs indices de faces.

Une enveloppe d'une gamme de couleurs (GH) est un groupe de composants connexes d'une gamme de couleurs, qui forment ensemble une surface fermée. Cette surface est la description de la frontière d'un volume connexe dans l'espace des couleurs CIEXYZ. Chaque GH est définie par un ou plusieurs indices de GC. Une GH peut se rapporter à un GC unique. Dans ce cas, le GC doit être par lui-même une description d'une surface fermée. Une GH peut se rapporter à une liste de GC; dans ce cas, ces GC constituent tous ensemble une description de la surface fermée qui forme la frontière d'un volume connexe.

Une réalisation ou instanciation d'une gamme de couleurs (GI) est un groupe d'enveloppes d'une gamme de couleurs qui forment ensemble une description de la frontière d'une gamme de couleurs (GBD) valide de la gamme réelle des couleurs. Une GI est définie par un ou plusieurs indices de GH. Une GI peut se rapporter à une GH unique; dans ce cas, la GH décrit à elle seule la gamme réelle des couleurs. Une GI peut se rapporter à une liste de GH; dans ce cas, l'union des volumes des GH décrit la gamme réelle des couleurs.

La description de la géométrie d'une gamme de couleurs contient une ou plusieurs instanciations différentes de la gamme de couleurs. Chaque GI est une GBD complète et valide. Deux GI diffèrent par au moins une des caractéristiques suivantes:

- Niveau des détails
  → Plus le niveau des détails est élevé, plus le nombre de faces est important.
- Forme non convexe
  → Une GI peut permettre ou non l'utilisation de formes non convexes.
- Pourcentage des couleurs de la gamme de couleurs
  → Les GI peuvent contenir différents pourcentages des couleurs de la gamme réelle des couleurs.

Une GI peut avoir des caractéristiques supplémentaires optionnelles:

- Composants inversés d'une gamme de couleurs
  → Un GC est utilisé en tant que GC inversé s'il est référencé par une ou par plusieurs GH, en prenant pour hypothèse que l'orientation de sa surface est inversée.
- Indication des arêtes d'une gamme de couleurs
  → Des sommets peuvent être identifiés comme arêtes d'une gamme de couleurs s'ils correspondent aux points et lignes de discontinuité de la courbure de la surface de la gamme réelle des couleurs.

La description de la géométrie d'une gamme de couleurs est résumée dans le Tableau 4.

Tableau 4 – Description de la géométrie d'une gamme de couleurs

Numéro d'octet hexadécimal	**Description**
ID_G	En-tête de la description de la géométrie d'une gamme de couleurs
ID_GI	Réalisations ou instanciations d'une gamme de couleurs
ID_GH	Enveloppes d'une gamme de couleurs
ID_GC	Composants d'une gamme de couleurs
ID_F	Faces
ID_V	Sommets

6.3 En-tête de la description de la géométrie d'une gamme de couleurs

L'en-tête de la description de la géométrie d'une gamme de couleurs suit l'en-tête des métadonnées d'identification d'une gamme de couleurs (Gamut ID) et est défini conformément au Tableau 5.

Tableau 5 – En-tête de description de la géométrie d'une gamme de couleurs

Numéro d'octet hexadécimal	**Taille** octets	**Symbole**	**Description**	**Valeurs** décimales
ID_G	2	ID_GI	Numéro d'octet du début des instanciations d'une gamme de couleurs	[0; 0hFFFF]
ID_G + 02	2	ID_GH	Numéro d'octet du début des enveloppes d'une gamme de couleurs	[0; 0hFFFF]
ID_G + 04	2	ID_GC	Numéro d'octet du début des composants d'une gamme de couleurs	[0; 0hFFFF]
ID_G + 06	2	ID_F	Numéro d'octet du début des faces	[0; 0hFFFF]
ID_G + 08	2	ID_V	Numéro d'octet du début des sommets	[0; 0hFFFF]
ID_G + 0A	1		Réservé	0
ID_G + 0B	1		Réservé	0
ID_G + 0C	1	K	Nombre de niveaux des détails	$1 \le K \le 255$
ID_G + 0D	2	F_{MAX}	Nombre maximal de faces du plus faible niveau de détails	$1 < F_{MAX} \le F$ (F voir Tableau 6)
ID_G + 0F	1	P	Nombre de niveaux de la population de couleurs	$0 < P \le 128/K$
ID_G + 10	1	$2Q_0$	Double du pourcentage des couleurs de la gamme de couleurs	[0; 200]
ID_G + 11	1	$2Q_1$	Double du pourcentage des couleurs de la gamme de couleurs	[0; 200]
: :				
ID_G + 10 + P-1	1	$2Q_{P-1}$	Double du pourcentage des couleurs de la gamme de couleurs	[0; 200]
ID_G + 10 + P	1	X	Forme convexe ou non convexe X = 1: toutes les GI et toutes les GH doivent être convexes X = 2: les GI et les GH peuvent être convexes ou non convexes	$1 \le X \le 2$

Les nombres entiers de 16 bits ou les valeurs des adresses sont codés en 2 octets, en mode gros-boutiste, c'est-à-dire avec les MSB dans le premier octet et les LSB dans le deuxième octet.

ID_GI, ID_GH, ID_GC, ID_F et ID_V doivent donner le décalage, en octets, depuis le début des métadonnées Gamut ID jusqu'au début des données des GI, des données des GH, des données des GC, des données des faces et des données des sommets, respectivement.

K indique le nombre de niveaux des détails. Les métadonnées Gamut ID contiennent au moins K GI. Si K = 1, il n'y a qu'un niveau des détails. Chaque GI est marquée individuellement avec un niveau des détails (0, 1,..., $K - 1$), selon le Tableau 7.

F_{MAX} doit indiquer le nombre maximal des faces pour une GI de niveau des détails le plus faible (niveau 0). Voir Tableau 7 pour la définition du niveau des détails. Voir Tableau 13 pour la définition des faces.

P indique le nombre de GI différentes qui contiennent différents pourcentages des couleurs de la gamme réelle des couleurs. Si P > 1, il y a P GI différentes qui décrivent la même gamme réelle des couleurs, mais qui contiennent différents pourcentages des couleurs de cette gamme.

Les métadonnées Gamut ID contiennent au moins P GI. Chaque GI est marquée individuellement avec un niveau de population (0,1,..., P − 1), selon le Tableau 7.

$2Q_0 \ldots 2Q_{P-1}$ sont les doubles des pourcentages $Q_0 \ldots Q_{P-1}$ des couleurs associées aux niveaux de population (0,1,...,P−1). Un pourcentage doit indiquer approximativement le pourcentage des couleurs (0..100) de la gamme réelle des couleurs contenu dans le volume décrit par une GI du niveau correspondant de population. En vue d'une définition, les pourcentages $Q_0 \ldots Q_{P-1}$ peuvent être calculés par pas de 0,5 point.

X indique si l'identifiant d'une gamme de couleurs (Gamut ID) n'utilise que des formes convexes (X = 1) ou peut utiliser des formes convexes et non convexes (X = 2). Lorsque X = 1, chaque GI doit correspondre à une forme convexe et chaque GH doit correspondre à une forme convexe. Lorsque X = 2, les GI sont organisées en paires. Chaque paire contient une première GI (identifiée comme "convexe", voir Tableau 7) qui correspond à une forme convexe et qui ne fait référence qu'à des GH qui correspondent à une forme convexe. La deuxième GI de la paire (identifiée comme "non convexe", voir Tableau 7) peut correspondre à une forme non convexe et peut faire référence à des GH qui correspondent à des formes non convexes. Les métadonnées d'identification des gammes de couleurs contiennent au moins X GI.

6.4 Instanciations d'une gamme de couleurs

La description de la géométrie d'une gamme de couleurs contient une ou plusieurs descriptions de la frontière de la gamme réelle des couleurs. Une GBD individuelle est appelée "réalisation" ou "instanciation" d'une gamme de couleurs. Un utilisateur des métadonnées Gamut ID peut utiliser une GI quelconque ou un nombre quelconque de GI des métadonnées Gamut ID. Les GI sont définies par une liste de GI à partir du numéro d'octet ID_GI, conformément au Tableau 6. L'ordre dans la liste est arbitraire, mais fixe.

Tableau 6 – Instanciations d'une gamme de couleurs

Numéro d'octet hexadécimal	**Taille** octets	**Symbole**	**Description**	**Valeurs**
ID_GI	1	I	Nombre total d'instanciations d'une gamme de couleurs	$I = X\,P\,K$
ID_GI + 01	6+ H_0		Définition de la GI n° 0	voir Tableau 7
ID_GI + 01 + 6+ H_0	6+ H_1		Définition de la GI n° 1	voir Tableau 7
: :				
ID_GI + 01 + $\sum_{i=0}^{I-2}(6+H_i)$	6+ H_{I-1}		Définition de la GI n° I-1	voir Tableau 7

I est le nombre de GI et doit être égal au produit de X, de P et de K, comme cela est défini dans le Tableau 5. La i^e GI, i = 0...I − 1, est définie conformément au Tableau 7.

Tableau 7 – i^e instanciation d'une gamme de couleurs

Numéro d'octet relatif hexadécimal	**Taille** octets	**Symbole**	**Description**	**Valeurs**
00	1	K_i	Niveau de détails de cette GI	$0 \leq K_i \leq K-1$
01	2	F_i^{GI}	Nombre de faces utilisées par cette GI	$F_i^{GI} \leq 2^i F_{MAX}$ (F_{MAX} voir Tableau 5)
03	1	X_i^{GI}	Cette GI définit une forme convexe (X_i^{GI} = 1) ou peut définir une forme non convexe (X_i^{GI} =2)	$1 \leq X_i^{GI} \leq X$ (X voir Tableau 5)
04	1	P_i	Niveau de population de couleurs de cette GI	$0 \leq P_i \leq P-1$ (P voir Tableau 5)
05	1	H_i	Nombre d'enveloppes d'une gamme de couleurs référencées par cette GI	$1 \leq H_i \leq H$ (H voir Tableau 8)
06	H_i		Indices des GH référencées	[0; $H-1$] Doivent être des indices valides de GH

K_i est le niveau des détails de la i^e GI. La GI est au niveau de détails le plus faible si K_i = 0. Si K_i est supérieur au niveau de détails K_j d'une j^e GI du même type ($P_i = P_j$, $X_i = X_j$), alors la i^e GI a un niveau de détails plus élevé, c'est-à-dire une description géométrique plus précise, que la j^e GI.

F_i^{GI} est le nombre de faces utilisées par la i^e GI. Il convient que ce nombre corresponde au nombre de faces référencées par les composants de gamme de couleurs (voir Tableau 10) qui sont référencés par les enveloppes de gamme de couleurs (voir Tableau 8) qui sont référencées par la i^e GI. Il convient que le nombre de faces F_i^{GI} soit inférieur ou égal à $2^{K_i} F_{MAX}$ (F_{MAX}, voir Tableau 6).

X_i^{GI} est un indicateur relatif à la forme convexe ou non convexe. Si X_i^{GI} = 1, la i^e GI définit une forme convexe et chacune des GH référencées par cette i^e GI définit aussi une forme convexe. Si X_i^{GI} = 2, la i^e GI peut définir une forme convexe ou une forme non convexe et chacune des GH référencées par cette i^e GI peut définir aussi une forme convexe ou une forme non convexe.

P_i est le niveau de population de la i^e GI. La i^e GI doit contenir approximativement Q_{P_i} pour cent des couleurs de la gamme réelle des couleurs. Différentes GI de même niveau de population doivent contenir approximativement le même pourcentage des couleurs de la gamme réelle des couleurs. Une GI de niveau de population P_i doit contenir au moins toutes les couleurs d'une autre GI de niveau de population P_j si $P_j > P_i$, $K_j = K_i$ et $X_j = X_i$.

H_i est le nombre d'enveloppes d'une gamme de couleurs référencées par la i^e GI. Si une i^e GI référence une enveloppe d'une gamme de couleurs, alors H_i = 1 et l'enveloppe de gamme de couleurs décrit la gamme réelle des couleurs. Si une i^e GI référence plusieurs enveloppes de gamme de couleurs, alors H_i > 1 et l'union des volumes de toutes les enveloppes de gamme de couleurs référencées décrit la gamme réelle des couleurs.

Les indices H_i des GH ont chacun un octet.

6.5 Enveloppes de gamme de couleurs

La description de la géométrie d'une gamme de couleurs contient une ou plusieurs enveloppes de gamme de couleurs. Chaque GH est la description comme surface fermée de la frontière d'un volume connexe fermé de l'espace des couleurs. Une GH peut être référencée par une ou plusieurs GI. Une GI peut référencer une ou plusieurs GH. Une GH peut décrire par elle-même la gamme réelle des couleurs ou juste une partie de celle-ci. Les GH sont définies par une liste de GH à partir du numéro d'octet ID_GH, conformément au Tableau 8. L'ordre dans la liste est arbitraire, mais fixe.

H est le nombre total de GH contenues dans les métadonnées Gamut ID. La he GH, $h = 0 \ldots H - 1$, est définie conformément au Tableau 9.

Tableau 8 – Enveloppes de gamme de couleurs

Numéro d'octet hexadécimal	Taille octets	Symbole	Description	Valeurs
ID_GH	1	H	Nombre total d'enveloppes d'une gamme de couleurs	$0 \le H \le 255$
ID_GH + 01	$3 + C_0 + \overline{C_0}$		Définition de la GH n° 0	voir Tableau 9
ID_GH + 01 $+ 2 + C_0 + \overline{C_0}$	$3 + C_1 + \overline{C_1}$		Définition de la GH n° 1	voir Tableau 9
: :				
ID_GH + 01 $+ \sum_{h=0}^{H-2} (3 + C_h + \overline{C}_h)$	$3 + C_{H-1} + \overline{C}_{H-1}$		Définition de la GH n° $H - 1$	voir Tableau 9