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Standard

ISO/IEC 23090-18

**Information technology — Coded
representation of immersive
media —**

**Part 18:
Carriage of geometry-based point
cloud compression data**

*Technologies de l'information — Représentation codée de média
immersifs —*

*Partie 18: Transport des données de compression des nuages de
points basée sur la géométrie*

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Foreword

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Introduction

Advances in 3D capturing and rendering technologies have unleashed a new wave of innovation in Virtual/Augmented/Mixed reality (VR/AR/MR) content creation and communication. Point clouds have arisen as one of the main representations for such applications. Geometry-based point cloud compression data is used for representing sparse dynamically varying point clouds such as those used in vehicular LiDAR or 3D mapping, as well as dense static point clouds used in cultural heritage, and industrial applications.

This document addresses technologies defining the carriage of geometry-based point cloud compression data for storage and delivery purposes. This document includes (but is not limited to):

- Storage of geometry-based point cloud compression data and the associated metadata using the ISO Base Media File Format (ISO/BMFF) as specified in ISO/IEC 14496-12;
- Storage of non-timed geometry-based point cloud compression data and the associated metadata using HEVC Image File Format (HEIF) as specified in ISO/IEC 23008-12;
- Encapsulation, signalling, and streaming of geometry-based compression data in a media streaming system, for example, dynamic adaptive streaming over HTTP (DASH) as specified in ISO/IEC 23009-1 or MPEG media transport (MMT) as specified in ISO/IEC 23008-1.

Information technology — Coded representation of immersive media —

Part 18: Carriage of geometry-based point cloud compression data

1 Scope

This document specifies a media format that enables the storage and delivery of geometry-based point cloud compression data. The geometry-based point cloud compression data can be timed or non-timed. It supports flexible extraction of geometry-based point cloud compression data at delivery or decoding time.

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.

ISO/IEC 9834-1, (Rec. ITU-T X.660), *Information technology — Procedures for the operation of object identifier registration authorities — Part 1: General procedures and top arcs of the international object identifier tree*

ISO/IEC 9834-8, (Rec. ITU-T X.667), *Information technology — Procedures for the operation of object identifier registration authorities — Part 8: Generation of universally unique identifiers (UUIDs) and their use in object identifiers*

ISO/IEC 14496-12, *Information technology — Coding of audio-visual objects — Part 12: ISO base media file format*

ISO/IEC 23008-1:2023, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 1: MPEG media transport (MMT)*

ISO/IEC 23008-12:2022, *Information technology — MPEG systems technologies — Part 12: Image File Format*

ISO/IEC 23009-1:2022, *Information technology — Dynamic adaptive streaming over HTTP (DASH) — Part 1: Media presentation description and segment formats*

ISO/IEC 23090-9:2023, *Information technology — Coded representation of immersive media (MPEG-I) — Part 9: Geometry-based point cloud compression*

IEEE 754-2019, *IEEE Standard for Floating-Point Arithmetic*.

W3C Recommendation, *XML schema part 1: Structures*

W3C Recommendation, *XML schema part 2: Datatypes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 23090-9 and the following apply.

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

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <https://www.electropedia.org/>

3.1

attribute track

volumetric visual track which carries ADUs of one instance of a particular attribute component of coded point cloud frames

3.2

attribute tile track

G-PCC tile track (3.10) which carries ADUs of one instance of a particular attribute component corresponding to one or more G-PCC tiles

3.3

G-PCC bitstream

sequence of bits of the coded point cloud sequence

Note 1 to entry: G-PCC bitstream is specified in ISO/IEC 23090-9.

3.4

G-PCC bitstream track

volumetric visual track which carries the entire coded point cloud sequence

3.5

G-PCC content

volumetric visual media that consists of one or more point cloud frames

Note 1 to entry: Each point cloud frame includes a number of points, identified by their positions in 3D space, and the associated attributes (e.g. colour) at a particular time instance.

3.6

G-PCC component track

volumetric visual track which carries DUs of one instance of a particular G-PCC component

Note 1 to entry: There are two types of G-PCC component tracks: one is *geometry track* (3.7) and the other is *attribute track* (3.1).

3.7

geometry track

volumetric visual track which carries GDUs of the coded point cloud frames

3.8

geometry tile track

G-PCC tile track (3.10) which carries GDUs of one or more G-PCC tiles

3.9

G-PCC player

application responsible for receiving files/segments or accessing files locally, decapsulating files/segments, decoding the G-PCC bitstream, reconstructing point cloud frames from the decoded G-PCC bitstream, and rendering the point cloud frames

3.10

G-PCC tile track

volumetric visual track which carries either any of DUs corresponding to one or more G-PCC tiles

3.11

G-PCC tile base track

volumetric visual track which carries DUs which can be applied across the associated *G-PCC tile tracks* (3.10)

4 Abbreviated terms

ADU	attribute data unit (specified in ISO/IEC 23090-9)
APS	attribute parameter set (specified in ISO/IEC 23090-9)
DASH	dynamic adaptive streaming over HTTP (specified in ISO/IEC 23009-1)
DU	data unit (specified in ISO/IEC 23090-9)
FBDU	frame boundary marker data unit (specified in ISO/IEC 23090-9)
FSAP	frame-specific attribute properties (specified in ISO/IEC 23090-9)
GDU	geometry data unit (specified in ISO/IEC 23090-9)
GPS	geometry parameter set (specified in ISO/IEC 23090-9)
HTTP	Hyper-text transfer protocol
HEIF	HEVC image format (specified in ISO/IEC 23008-12)
ISOBMFF	ISO base media file format (specified in ISO/IEC 14496-12)
MMT	MPEG media transport (specified in ISO/IEC 23008-1)
SPS	sequence parameter set (specified in ISO/IEC 23090-9)

5 Overview

5.1 Overall architecture for carriage of geometry-based point cloud compression data

Geometry-based point cloud compression (G-PCC) provides the method for efficiently compressing the point cloud sequence which consists of one or more point cloud frames. Each point cloud frame consists of a number of points and each point is a tuple of a three-dimensional position and attribute values for every attribute present in the point cloud.

The coded point cloud sequence forms a G-PCC bitstream comprising of data represents a volumetric encoding of point clouds consisting of a sequence of point cloud frames. Each point cloud frame includes a number of points, identified by their positions in 3D space, and their associated attributes at a particular time instance. The number of points can vary from one frame to another.

parameter sets and slices of coded point cloud frames. Every slice includes a GDU which codes the slice geometry and ADUs or defaulted attribute DUs which code the slice attributes. The group of slices may be associated with spatial regions in a point cloud to aid spatial access.

[Figure 1](#) shows the overall architecture for a typical content flow process for carriage of G-PCC data and it is applicable to both live and on-demand use cases.

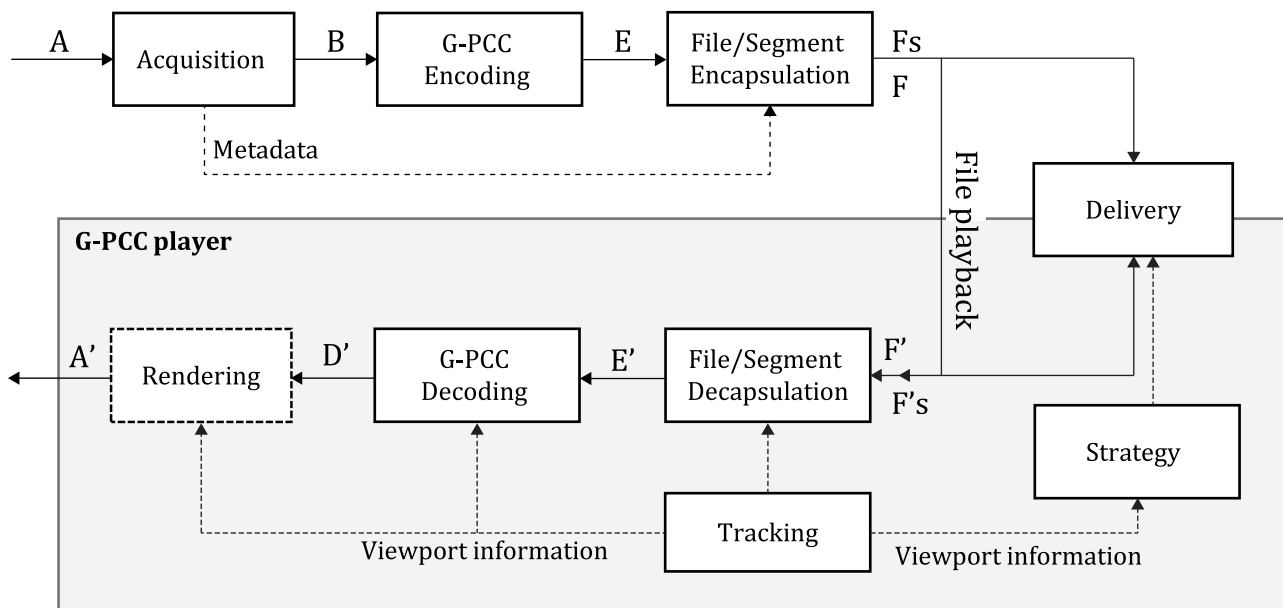


Figure 1 — Overall architecture flow process of for carriage of G-PCC data

A real-world visual scene (A) is captured by a set of cameras or a camera device with multiple lenses and sensors. A virtual visual scene (A) is also captured by virtual camera. The acquisition results in a point cloud sequence comprising of one or more point cloud frames (B). The point cloud sequence can be timed or non-timed. Each point cloud frame includes a set of points, identified by their positions in a three-dimensional Cartesian coordinate system, and associated attributes at a particular time instance. All points in the same point cloud frame have the same number of attributes. The number of points may vary from one frame to another. Each point cloud frame is coded as a sequence of slices and each slice comprises a sequence of encapsulated DUs. One or multiple point cloud frames are multiplexed into a G-PCC bitstream (E). The G-PCC bitstream are then encapsulated into a media file for file playback (F) or a sequence of an initialization segment and media segments for streaming (F_s), according to a particular media container file format. The metadata which can contribute to interpret and to consume the point cloud frames is encapsulated into the file or the segments. The point cloud metadata can describe, for example, the mapping between points to spatial regions within a point cloud. The segments F_s are delivered using a delivery mechanism to a G-PCC player.

The file that the file encapsulator outputs (F) is identical to the file that the file decapsulator inputs (F').

The G-PCC player processes the file (F') or the received segments (F'_s) and extracts the G-PCC bitstream (E') and parses the metadata. The G-PCC bitstream is then decoded into one or multiple point cloud frames (D') and the point clouds are reconstructed from the decoded point cloud frames (D'). The reconstructed point clouds are rendered and displayed onto the screen of a head-mounted display or any other display device based on the viewport information, such as the current viewing position, viewing orientation, or the field of view information, which is determined by various types of sensors. Besides being used by the G-PCC player to access the appropriate part of the point clouds, the viewport information can also be used for determining which tracks are extracted from the file. In viewport-dependent delivery, the viewport information is also passed to the strategy module, which determines the segments to be received based on the current viewport.

This process is applicable to both live and on-demand use cases.

The following interfaces are specified in this document:

- F/F': media file including the specification of the track formats in [Clause 7](#) for timed G-PCC data, in [Clause 8](#) for non-timed G-PCC data, and in [Clause 9](#) for metadata in ISOBMFF.
- [Clause 10](#) specifies the delivery related interfaces for DASH delivery.
- [Clause 11](#) specifies the delivery related interfaces for MMT delivery.

The other interfaces in [Figure 1](#) are not specified in this document.

5.2 Referenceable code points

5.2.1 Brands

The brands are used in this document to indicate conformance points to an encapsulation mode and a specific set of tools that are defined in this document. It may be indicated in the `FileTypeBox`.

The brands specified in this document are listed in [Table 1](#) and defined in [Annex A](#).

Table 1 — Brands specified in this document

Brand identifier	Subclause in this document	Description
gpst	A.2.1	Single track encapsulation
gpmt	A.2.2	Multiple track encapsulation
gppa	A.2.3	Encapsulation with partial access support
gpci	A.3	Non-timed G-PCC encapsulation

5.2.2 Sample entry type

The sample entry type specified in this document are listed in [Table 2](#).

Table 2 — Sample entry types specified in this document

Sample entry type	Subclause in this document	Description
gpe1	7.3.2	For use with the single track encapsulation with all parameter set data units carrying SPS, GPS, and APS carried in decoder configuration record
gpeg	7.3.2	For use with the single track encapsulation with all parameter set data units carrying SPS, GPS, and APS carried in decoder configuration record and in track samples
gpc1	7.4.2	For use with the multiple track encapsulation with all parameter set data units carrying SPS, GPS, and APS carried in decoder configuration record
gpcg	7.4.2	For use with the multiple track encapsulation with all parameter set data units carrying SPS, GPS, and APS carried in decoder configuration record and in track samples
gpeb	7.5.2.1	For use with a tile base track with G-PCC tile track(s) containing DUs of all components
gpcb	7.5.2.1	For use with a tile base track with G-PCC tile track(s) containing DUs of one instance of a particular component
gpt1	7.5.3.1	For use with a G-PCC tile track
gpdr	9.1.3.2	For use with a timed metadata track indicating the dynamic spatial regions that are dynamically changing over time
gpdv	9.2.4.2	For use with a timed metadata track indicating viewport information that are dynamically changing over time

5.2.3 Box types

The box types specified in this document are listed in bold in [Table 3](#). Mandatory boxes are marked with an asterisk. Box types without a four-character code are marked with ‘-’ in the structure.

Table 3 — Box types specified in this document and their relation to boxes not specified in this document

Box types, structure, and cross-reference												
moov										*	ISOBMFF	container for all the metadata
	trak									*	ISOBMFF	container for an individual track or stream
		mdia								*	ISOBMFF	container for the media information in a track
			minf							*	ISOBMFF	media information container
				stbl						*	ISOBMFF	sample table box, container for the time/space map
					stsd					*	ISOBMFF	sample descriptions (codec types, initialization etc.)
						-					ISOBMFF	visual sample entry
											6.1.3	volumetric visual sample entry
							gpcC				7.2.2	G-PCC decoder configuration box
							ginf				7.2.3	G-PCC component information box
							gptC				7.5.3.1	G-PCC tile configuration box
							gpsr				8.3.3	Static spatial region information box
							gvpC				9.2.3	Viewport information Configuration Box
							gpdr				9.1.3.2	Dynamic spatial region timed metadata sample entry
							gpsr				8.3.3	Static spatial region information box
							gpdv				9.2.4.2	Viewport information timed metadata sample entry
							gvpC				9.2.3	Viewport information Configuration Box
meta											ISOBMFF	Metadata
	grpl										ISOBMFF	group list box
		vpta									8.4.1	Viewport association box
	iprp										ISOBMFF	item properties box
		ipco									ISOBMFF	item property container box
			gpcC								8.3.1	G-PCC configuration item property
			ginf								8.3.2	G-PCC component information item property
			gpsr								8.3.3	G-PCC spatial region item property
			gpti								8.3.4	G-PCC tile information item property

5.2.4 Track reference types

The track reference types specified in this document are listed in [Table 4](#).

Table 4 — Track reference types specified in this document

Track reference type	Subclause in this document	Description
gpca	7.4.4	Referenced track is an attribute track
gpbT	7.5.5	Referenced track is a G-PCC tile track

5.2.5 Entity grouping types

The entity grouping types specified in this document are listed in [Table 5](#).

Table 5 — Entity grouping types specified in this document

Entity grouping type	Subclause in this document	Description
vpta	8.4.1	Viewport association between G-PCC items and the viewport information timed metadata track

5.2.6 Sample grouping types

The sample grouping types specified in this document are listed in [Table 6](#).

Table 6 — sample grouping types specified in this document

Sample grouping type	Subclause in this document	Description
gtii	7.2.4	Tile inventory sample group

5.2.7 Uniform resource names

The URNs specified in this document are listed in [Table 7](#).

Table 7 — URNs specified in this document

URN	Subclause in this document	Description
urn:mpeg:mpegI:gpcc:2023	10.2.2.1	Namespace for the XML elements and attributes specified in this document
urn:mpeg:mpegI:gpcc:2023:component	10.2.2.2	Scheme identifier for the G-PCC component DASH MPD descriptor
urn:mpeg:mpegI:gpcc:2023:gpc	10.2.2.3	Scheme identifier for the G-PCC content DASH MPD descriptor
urn:mpeg:mpegI:gpcc:2023:gpsr	10.3.1	Scheme identifier for the G-PCC static spatial region DASH MPD descriptor
urn:mpeg:mpegI:gpcc:2023:tileID	10.3.3.1	Scheme identifier for the G-PCC tile id DASH MPD descriptor
urn:mpeg:mpegI:gpcc:2023:rv	10.4.1	Scheme identifier for the static recommended viewports DASH MPD descriptor
urn:mpeg:mmt:app:gpcc:2023	11.3.1	Scheme identifier for the MMT G-PCC specific signalling messages

6 Volumetric media

6.1 Volumetric visual media

6.1.1 General

A volumetric visual track shall be identified by the volumetric visual media handler type 'volv' in the `HandlerBox` of the `MediaBox`, as defined in ISO/IEC 14496-12, and by a volumetric visual media header as defined in [subclause 6.1.2](#).

Multiple volumetric visual tracks can be present in the file.

6.1.2 Volumetric visual media header

6.1.2.1 Definition

Box Type: 'vvhd'
 Container: `MediaInformationBox`
 Mandatory: Yes
 Quantity: Exactly one

Volumetric visual tracks shall use a `VolumetricVisualMediaHeaderBox` in the `MediaInformationBox` as defined in ISO/IEC 14496-12.

6.1.2.2 Syntax

```
aligned(8) class VolumetricVisualMediaHeaderBox
    extends FullBox('vvhd', version = 0, 1) {
}
```

6.1.2.3 Semantics

`version` is an integer that specifies the version of this box.

6.1.3 Volumetric visual sample entry

6.1.3.1 Definition

Volumetric visual tracks shall use a `VolumetricVisualSampleEntry`.

6.1.3.2 Syntax

```
class VolumetricVisualSampleEntry(codingname)
    extends SampleEntry (codingname){
    unsigned int(8)[32] compressorname;
    // other boxes from derived specifications
}
```

6.1.3.3 Semantics

`compressorname` is a name, for informative purposes. It is formatted in a fixed 32-byte field, with the first byte set to the number of bytes to be displayed, followed by that number of bytes of displayable data encoded using UTF-8, and then padding to complete 32 bytes total (including the size byte). The field may be set to 0.

6.1.4 Volumetric visual sample group entry

```
abstract class VolumetricVisualSampleGroupEntry (unsigned int(32) grouping_type)
    extends SampleGroupDescriptionEntry (grouping_type)
{
}
```

6.1.5 Volumetric visual samples

The format of a volumetric visual sample is defined by the coding system.

7 Timed G-PCC data storage in ISOBMFF

7.1 General

This clause specifies the below encapsulation of G-PCC bitstream in tracks within a file, and only one of the below encapsulations shall be used at the same time.

- Single track encapsulation of G-PCC bitstream, where one track carries the entire coded point cloud sequence, as specified in [subclause 7.3](#).
- Multiple track encapsulation, where the coded bitstream of single G-PCC component of the point cloud sequence is encapsulated into a separate track, as specified in [subclause 7.4](#).
- Encapsulation with G-PCC tile tracks, where DUs of one or more G-PCC tiles are encapsulated into a separate track, as specified in [subclause 7.5](#).

The order of G-PCC slices and DUs of the output G-PCC bitstream after decapsulation should be maintained as the order of G-PCC slices and DUs of the original G-PCC bitstream.

[Annex D](#) provides a summary of the sample entry types and sample formats for tracks defined in this document.

7.2 Common boxes and data structures

7.2.1 G-PCC decoder configuration record

7.2.1.1 Definition

This subclause specifies the G-PCC decoder configuration information for ISO/IEC 23090-9 content.

This G-PCC decoder configuration record contains the information for configuration and initialization of G-PCC decoder. It contains a `configurationVersion` field. This edition of this document defines version 1 of this record. Incompatible changes to the record will be indicated by a change of configuration version number. Compatible extensions to this record will extend it and will not change the configuration version number. The G-PCC player shall not attempt to decode this record or the G-PCC bitstreams to which it applies if the value of `configurationVersion` is not supported or recognized.

The values for `simple_profile_compliant`, `dense_profile_compliant`, `predictive_profile_compliant`, and `main_profile_compliant` shall indicate a profile to which the G-PCC bitstream associated with this configuration record conforms. The value for `level_idc` shall indicate a level of capability equal to or greater than the highest level indicated for the highest tier in all the parameter sets. These values to indicate the conformance to a certain profile and `level_idc` shall be valid for all parameter sets that are activated when the G-PCC bitstream described by this record is decoded (referred to as "all parameter sets" below). The G-PCC player ignores the G-PCC bitstream if the indicated profiles are not supported or recognized.

The `setupUnit` array shall include data units that are constant for the bitstream referred to by the sample entry in which the decoder configuration record is present. The type of data units is restricted to indicate SPS, GPS, and APS.

7.2.1.2 Syntax

```
aligned(8) class GPCCDecoderConfigurationRecord {
    unsigned int(8)      configurationVersion = 1;
    unsigned int(2)      reseverd = 1;
    unsigned int(1)      simple_profile_compliant;
    unsigned int(1)      dense_profile_compliant;
    unsigned int(1)      predictive_profile_compliant;
    unsigned int(1)      main_profile_compliant;
    unsigned int(18)     reserved_profile_18bits
    unsigned int(8)      level_idc;
    unsigned int(8)      numOfSetupUnits;
    for (i=0; i<numOfSetupUnits; i++) {
        tlv_encapsulation setupUnit;    //as defined in ISO/IEC 23090-9, Annex B
    }
    // additional fields
}
```

7.2.1.3 Semantics

`configurationVersion` is a version field. Incompatible changes to the record are indicated by a change of the value of this field. In this edition of the document, it shall be equal to 1.

`simple_profile_compliant` equal to 1 specifies that the G-PCC bitstream conforms to the Simple profile defined in ISO/IEC 23090-9:2023, Annex A. `simple_profile_compliant` equal to 0 specifies that the G-PCC bitstream does not conform to the Simple profile.

`dense_profile_compliant` equal to 1 specifies that the G-PCC bitstream conforms to the Dense profile defined in ISO/IEC 23090-9:2023, Annex A. `dense_profile_compliant` equal to 0 specifies that the G-PCC bitstream does not conform to the Dense profile.

`predictive_profile_compliant` equal to 1 specifies that the G-PCC bitstream conforms to the Predictive profile defined in ISO/IEC 23090-9:2023, Annex A. `predictive_profile_compliant` equal to 0 specifies that the G-PCC bitstream does not conform to the Predictive profile.

`main_profile_compliant` equal to 1 specifies that the G-PCC bitstream conforms to the Main profile defined in ISO/IEC 23090-9:2023, Annex A. `main_profile_compliant` equal to 0 specifies that the G-PCC bitstream does not conform to the Main profile.

NOTE When none of `simple_profile_compliant`, `dense_profile_compliant`, `predictive_profile_compliant`, and `main_profile_compliant` set to 1, it means the G-PCC bitstream does not conform to profiles defined in ISO/IEC 23090-9:2023, Annex A.

`reserved_profile_18bits` shall be equal to 0 in this configuration version 1 of this record. Other values for `reserved_profile_18bits` are reserved for future use by ISO/IEC. The G-PCC player conforming to this edition of the document shall ignore the value of `reserved_profile_18bits`.

`level_idc` indicates a level to which the G-PCC bitstream conforms as specified in ISO/IEC 23090-9:2023, Annex A. The bitstream shall not contain values of `level_idc` other than those specified in ISO/IEC 23090-9:2023, Annex A. Other values of `level_idc` are reserved for future use by ISO/IEC.

`numOfSetupUnits` specifies the number of following `setupUnit` present in the decoder configuration record.

`setupUnit` contains one data unit carrying one of SPS, GPS, and APS as defined in ISO/IEC 23090-9.

7.2.2 G-PCC decoder configuration box

7.2.2.1 General

A G-PCC decoder configuration box includes the `GPCCDecoderConfigurationRecord` which contains the information for configuration and initialization of G-PCC decoder as defined in [subclause 7.2.1](#).

This edition of this document, the `version` shall be equal to 0.

7.2.2.2 Syntax

```
aligned(8) class GPCCConfigurationBox extends FullBox('gpcC', 0, 0) {
    GPCCDecoderConfigurationRecord();
}
```

7.2.2.3 Semantics

`GPCCDecoderConfigurationRecord` is defined in [subclause 7.2.1](#).

7.2.3 G-PCC component information box

7.2.3.1 Definition

This box specifies G-PCC component information including the type of G-PCC components (e.g. geometry, attribute). When this box is present in a sample entry of a track, it indicates the type of G-PCC components carried by the respective track. When this box is present in a sample entry of the G-PCC attribute track, it also provides the attribute name, index and an optional attribute type information by the attribute label or the international object identifier of G-PCC attribute component carried by the respective G-PCC attribute track.

The value of `flags` in this box indicates the presence of attribute type information and how the attribute type is indicated if the attribute type information presents as follows:

flags value	Description
0x000000	No attribute type information presents
0x000001	The attribute type information presents, and the attribute type is indicated by the value of <code>attr_label</code> .
0x000002	Reserved
0x000003	The attribute type information presents, and the attribute type is indicated by the value of <code>attr_label_oid</code> .
0x000004.. 0xFFFFFFFF	Reserved.

7.2.3.2 Syntax

```
aligned(8) class GPCCComponentInfoBox extends FullBox('ginf', 0, flags){
    GPCCComponentInfoStruct(flags);
}

aligned(8) class GPCCComponentInfoStruct(bit(24) flags){
    unsigned int(8) comp_type;
    if(comp_type == 4){
        unsigned int(8) attr_index;
        if(flags == 0x000001){
            unsigned int(3) attr_label;
        }elseif(flags == 0x000003){
            oid attr_label_oid;
        }
        utf8string attr_name;
    }
}
```

7.2.3.3 Semantics

`comp_type` identifies the type of G-PCC component as specified in [Table 8](#). In this edition of the document, the value of this field shall be either 2 or 4.

Table 8 — G-PCC Component Type

comp_type value	Description
1	Reserved
2	Geometry component
3	Reserved
4	Attribute component
5..31	Reserved.

`attr_index` identifies an attribute component by indicating the order of the attribute signalled in the SPS. The first four bits of this value shall be equal to `sps_seq_parameter_set_id` of the SPS in G-PCC bitstream and the last four bits of this value shall be equal to `attrIdx` signalled in the SPS indicated by the `sps_seq_parameter_set_id`.

`attr_label` identifies the type of attribute component as specified in ISO/IEC 23090-9:2023, Table 9.

`attr_label_oid` specifies an ASN.1 object identifier value in the international object identifier tree. The international object identifier shall either be assigned by a registration authority in accordance with Rec. ITU-T X.660 | ISO/IEC 9834-1 or generated without registration using a universally unique identifier (UUID) as specified by Rec. ITU-T X.667 | ISO/IEC 9834-8. The syntax of object identifier is described in ISO/IEC 23090-9:2023, subclause 11.4.7.1.

`attr_name` specifies a human-readable name for the type of G-PCC attribute components.

7.2.4 Tile inventory information sample group

7.2.4.1 Definition

Group Types: 'gtii'
 Container: Sample Group Description Box ('sgpd')
 Mandatory: No
 Quantity: Zero or more

The use of 'gtii' for the `grouping_type` in sample grouping represents the assignment of samples in G-PCC track to the tile inventory information carried in this sample group. When a `SampleToGroupBox` with `grouping_type` equal to 'vaps' is present, an accompanying `SampleGroupDescriptionBox` with the same `grouping_type` shall be present and contains the ID of the group that the samples belong to.

When the tile inventory data units are present in the G-PCC bitstream, it is carried as the below.

- When the G-PCC bitstream is carried by using G-PCC tracks with track type 'gpc1', the tile inventory information sample group with grouping type 'gtii' shall be present in the G-PCC geometry track. The G-PCC attribute tracks shall not contain the sample group with grouping type 'gtii'.
- Under the 'gpcg' sample entry, the tile inventory information may be present in a tile inventory information sample group description entry with grouping type 'gtii' or in the samples of the G-PCC geometry track.
- Under the 'gpel' sample entry, the tile inventory information sample group with grouping type 'gtii' shall be present.
- Under the 'gpeg' sample entry, the tile inventory information may be present in a tile inventory information sample group description entry with grouping type 'gtii' or in the samples of the G-PCC bitstream track.
- When the G-PCC bitstream is carried by using G-PCC tile tracks, sample grouping type 'gtii' shall not be present with a track with a sample entry 'gpcb', 'gpeb', and 'gpt1'. The tile inventory information shall be available in G-PCC tile base track samples.

7.2.4.2 Syntax

```
aligned(8) class TileInventoryInfoEntry()
    extends VolumetricVisualSampleGroupEntry ('gtii'){
        //tlv_encapsulation as defined in ISO/IEC 23090-9
        tlv_encapsulation    tile_inventory_DU;
    }
```

7.2.4.3 Semantics

`tile_inventory_DU` contains a tile inventory data unit, as instance of TLV encapsulation structure of `tlv_type` equal to 5 as defined in ISO/IEC 23090-9, which applies to associated samples in the track.

7.3 Single track encapsulation

7.3.1 General

A single track encapsulation of G-PCC bitstream requires that the entire G-PCC bitstream is carried by a G-PCC bitstream track. Each sample in the track corresponds to a single point cloud frame and contains at least one GDUs, zero or more ADUs, and zero or more parameter set data units.

More than one track for same G-PCC bitstream shall not be present. Any G-PCC component tracks shall not be present.

7.3.2 Sample entry

7.3.2.1 Definition

Sample Entry Type: 'gpel' or 'gpeg'
Container: SampleDescriptionBox
Mandatory: A 'gpel' or 'gpeg' sample entry is mandatory.
Quantity: One or more sample entries may be present.

A G-PCC bitstream track shall use the GPCCBistreamSampleEntry with a sample entry type of 'gpel' or 'gpeg'.
A G-PCC bitstream track sample entry shall contain a GPCCConfigurationBox as defined in [subclause 7.2.2](#).

Under the 'gpel' sample entry, all parameter set data units carrying SPS, GPS, and APS shall be in the setupUnit array. Under the 'gpeg' sample entry, the parameter set data units can be present in the setupUnit array, or in the stream.

A G-PCC bitstream track sample entry shall not contain a GPCCComponentInfoBox as defined in [subclause 7.2.3](#).

7.3.2.2 Syntax

```
aligned(8) class GPCCBistreamSampleEntry()  
    extends VolumetricVisualSampleEntry (unsigned int type) {  
    // type is 'gpel' or 'gpeg'  
    GPCCConfigurationBox    config;    //mandatory  
}
```

7.3.2.3 Semantics

compressorname in the base class VolumetricVisualSampleEntry indicates the name of the compressor used with the value "\013GPCC Coding" being recommended; the first byte is a count of the remaining bytes, here represented by \013, which (being octal 13) is 11 (decimal), the number of bytes in the rest of the string.

config includes G-PCC decoder configuration record information, as defined in [subclause 7.2.2](#).

7.3.3 Sample format

7.3.3.1 Definition

Each G-PCC sample corresponds to a single point cloud frame and shall contain one or more data units which belong to the same presentation time. A sample may be self-contained (e.g. a sync sample).

[Figure 2](#) depicts an example of the sample structure of a G-PCC bitstream track when the original G-PCC bitstream contains geometry component and one attribute component. In this case, each sample contains at least one GDU, one ADU, or zero or more parameter set data units.

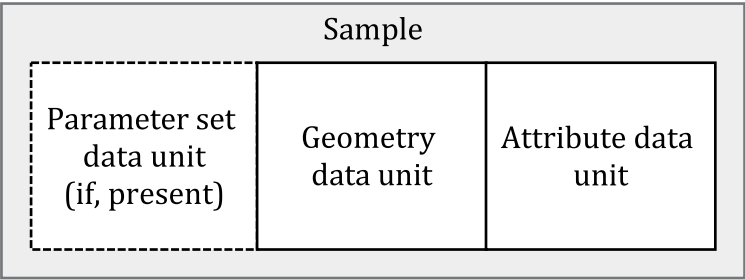


Figure 2 — Example of sample structure of a G-PCC bitstream track

When FSAP DUs are available in G-PCC bitstream, FSAP DUs shall be carried in the sample containing ADUs of the corresponding point cloud frame. If it is present, it shall precede any ADUs in the sample.

7.3.3.2 Syntax

```
aligned(8) class GPCCSample
{
    unsigned int GPCCLength = sample_size; //Size of Sample
    for (i=0; i< GPCCLength; )           // to end of the sample
    {
        unsigned int(8)    tlv_type;
        unsigned int(32)    tlv_num_payload_bytes;
        bit(tlv_num_payload_bytes*8)    data_unit;
        i += (1+4)+tlv_num_payload_bytes;
    }
}
```

7.3.3.3 Semantics

`tlv_type` identifies the syntax structure represented by the following `data_unit` as defined in ISO/IEC 23090-9:2023, Annex B.

`tlv_num_payload_bytes` specifies the length in bytes of the syntax element of the following `data_unit`.

`data_unit` contains a single DU which corresponds to the same point cloud frame.

7.3.3.4 Sub-sample

For the use of `SubSampleInformationBox`, a sub-sample is defined on the basis of the value of the `flags` field of the `SubSampleInformationBox`. The `flags` field specifies the type of sub-sample information given in this box as follows:

- 0: G-PCC data unit based sub-samples. A sub-sample contains only one DU.
- 1: Tile-based sub-samples. A sub-sample either contains one or more contiguous DUs corresponding to one G-PCC tile or contains one or more contiguous DUs which contain either each parameter set, tile inventory or frame boundary marker.
- Other values of `flags` are reserved.

The `subsample_priority` field shall be set to a value in accordance with the specification of this field in ISO/IEC 14496-12.

The `discardable` field shall be set to 1 only if this sample is still decodable if this sub-sample is discarded (e.g. the sub-sample consists of only tile inventory, frame boundary marker, and user data unit).

The `codec_specific_parameters` field of the `SubsampleInformationBox` is defined as follows:

```
if (flags == 0) {
    unsigned int(8)    payloadType;
    if (payloadType == 4) {
        unsigned int(6)    attrIdx;
        bit(18)    reserved = 0;
    }
    else
        bit(24)    reserved = 0;
} else if (flags == 1) {
    unsigned int(1)    tile_data_present;
    bit(7)    reserved = 0;
    if (tile_data_present)
        unsigned int(24)    tile_id;
    else
        bit(24)    reserved = 0;
}
```

`payloadType` provides the value of the `tlv_type` of the DU present in the sub-sample.

`attrIdx` indicates the `ash_attr_sps_attr_idx` of the ADU present in the sub-sample.

`tile_data_present` equal to 1 indicates that the sub-sample contains GDUs, defaulted ADUs, or ADUs corresponding to one G-PCC tile. `tile_data_present` equal to 0 indicates that the sub-sample contains DUs which contain either each parameter set, tile inventory, frame-specific attribute properties, or frame boundary marker.

`tile_id` indicates the index of the G-PCC tile, which the sub-sample is associated with, in the tile inventory.

For single track encapsulation, when sub-samples are present, the `SubSampleInformationBox` with flags equal to 0 in `SampleTableBox`, or in the `TrackFragmentBox` of each of its `MovieFragmentBoxes` shall be present.

7.4 Multiple track encapsulation

7.4.1 General

When the G-PCC bitstream is carried in multiple tracks, the coded bitstream of each G-PCC component is mapped to an individual track. There are two types of G-PCC component tracks: G-PCC geometry track and G-PCC attribute track. Each sample in each component track contains DUs of an instance of a single component, not both of GDUs and ADUs. When multiple attributes are present in the G-PCC bitstream, any attribute track shall not multiplex DUs of different attributes.

For multiple track encapsulation, the below conditions shall be satisfied:

- One geometry track shall present and shall be an entry point.
- One or more G-PCC attribute tracks can be present. The `track_in_movie` flags of each attribute track shall be set to 0.
- In each component track sample entry, one `GPCCComponentInfoBox` shall be present to indicate the role of the bitstream contained in the track.
- All component tracks shall have same values of `simple_profile_compliant`, `dense_profile_compliant`, `predictive_profile_compliant`, `main_profile_compliant`, and `level_idc` in a track sample entry.
- A 'gpca' track reference from a geometry track to attribute tracks shall be present.
- All component tracks shall have the same implied or explicit edit lists.
- Any of G-PCC tile base track and tile tracks shall not be present.

Component tracks belonging to the same G-PCC bitstream are time-aligned. Samples that contribute to the same point cloud frame across different component tracks shall have the same presentation time. When any parameter sets are present in samples, the decoding time of parameter sets used for such samples shall be equal or prior to the decoding time of samples of corresponding DUs. When all parameter sets are present in samples across multiple tracks, the decoding time of samples containing the SPS shall be equal or prior to the decoding time of samples containing the GPS, or APS.

NOTE Synchronization between the elementary streams in the tracks are handled by the ISOBMFF track timing structures (`stts`, `ctts`, and `cslg`), or equivalent mechanisms in movie fragments.

When the G-PCC bitstream only contains the G-PCC geometry component and no G-PCC attribute component, this multiple track encapsulation shall not be applied.

7.4.2 Sample entry

7.4.2.1 Definition

Sample Entry Type: 'gpc1' or 'gpcg'
 Container: `SampleDescriptionBox`
 Mandatory: A 'gpc1' or 'gpcg' sample entry is mandatory
 Quantity: One or more sample entries may be present

Component track shall use `GPCCSampleEntry` which extends `VolumetricVisualSampleEntry` with a sample entry type of 'gpcl' or 'gpcg'.

A component track sample entry shall contain `GPCCConfigurationBox` as defined in [subclause 7.2.2](#) and `GPCCComponentInfoBox`, as defined in [7.2.3](#), respectively.

Under the 'gpcl' sample entry, the `setupUnit` array of geometry track shall contain all DUs carrying SPS and GPS. The `setupUnit` array of attribute track shall contain all DUs carrying APS associated with samples in the track and shall not contain DUs carrying any of SPS and GPS. When multiple G-PCC attribute tracks present, the `setupUnit` array of G-PCC attribute tracks shall contain the same information.

Under the 'gpcg' sample entry, DUs carrying SPS or GPS can be present in the `setupUnit` array of the sample entry or in the stream of geometry track. The DUs carrying APS can be present in the `setupUnit` array of the sample entry or in the stream of attribute track. Any DUs carrying SPS and GPS shall not be present in G-PCC attribute tracks.

7.4.2.2 Syntax

```
aligned(8) class GPCCSampleEntry()
    extends VolumetricVisualSampleEntry (unsigned int type) {
    //type is 'gpcl' or 'gpcg'
    GPCCConfigurationBox      config;
    GPCCComponentInfoBox      info;
    // optional boxes
}
```

7.4.2.3 Semantics

`compressorname` in the base class `VolumetricVisualSampleEntry` indicates the name of the compressor used with the value "\013GPCC Coding" being recommended; the first byte is a count of the remaining bytes, here represented by \013, which (being octal 13) is 11 (decimal), the number of bytes in the rest of the string.

`config` contains the information for configuration and initialization of G-PCC decoder as defined in [subclause 7.2.2](#).

`info` indicates G-PCC component information carried in the respective track, as defined in [subclause 7.2.3](#). It indicates the component type carried in the track. It also provides the attribute name, index, and optionally attribute type carried in the G-PCC attribute track.

7.4.3 Sample format

7.4.3.1 General

Each sample corresponds to a single point cloud frame and samples that contribute to the same point cloud frame across different component tracks shall have the same presentation time.

Each sample shall be comprised of one or more DUs of G-PCC component indicated in the `GPCCComponentInfoBox` in the sample entry and zero or more DUs carrying one of associated parameter sets. The DUs of G-PCC component which is not indicated in the sample entry shall not be present in samples. When DUs carrying any parameter sets are present in the sample, it shall be appeared before DUs of G-PCC component. When any FASP data units are available in the G-PCC bitstream, these FASP data units shall be carried in the sample containing ADUs of the corresponding point cloud frame. If presents, it shall precede any ADUs in the sample.

[Figure 3](#) describes an example of the sample structure of the geometry track. In this case, each sample contains at least one GDU, zero or more DUs carrying SPS or GPS. When DUs carrying SPS or GPS are present, it shall precede GDUs in the sample.

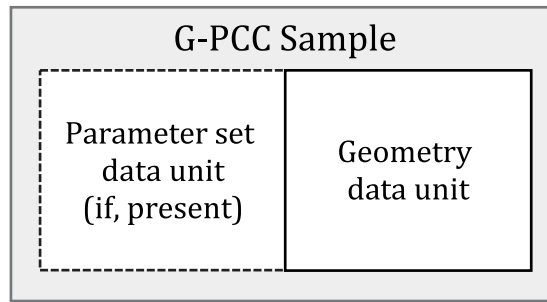


Figure 3 — Example of sample structure of geometry track

The syntax and semantics of the sample in component track as defined in [subclause 7.3.3.2](#) and [7.3.3.3](#), respectively, are applied.

7.4.3.2 Sub-sample

For multiple track encapsulation without G-PCC tile tracks, when sub-samples are present, only `SubSampleInformationBox` with `flags` equal to 1 in `SampleTableBox`, or in the `TrackFragmentBox` of each of its `MovieFragmentBoxes` shall be present. The syntax and semantics of the sub-sample with `flags` equal to 1 as defined in [subclause 7.3.3.4](#), shall be applied.

7.4.4 Track references

To link between different types of component tracks, the track reference tool of ISO/IEC 14496-12 shall be used.

One `TrackReferenceTypeBox` shall be added to a `TrackReferenceBox` within the `TrackBox` of the geometry track. The `TrackReferenceTypeBox` shall contain an array of `track_ids` designating the tracks which the G-PCC track references. To link the geometry track to the attribute track, `reference_type` of a `TrackReferenceTypeBox` in the geometry track identifies the associated attribute tracks. The 4CCs of these track reference types shall be:

- 'gpca': the referenced attribute track(s).

7.5 Encapsulation of tiled G-PCC bitstream

7.5.1 General

ISO/IEC 23090-9 provides the support for spatial random access with G-PCC tiles. The G-PCC tiles do not have coding dependencies with other G-PCC tiles in the same coded point cloud frame. Each G-PCC tile is described through a single 3D bounding box and an identifier, and it is associated with the group of slices.

There are cases where storing data units of G-PCC tiles in different tracks are useful for easy access to one or a few particular tile regions. For such cases, one or more G-PCC tiles are carried in separate tracks, the followings shall be satisfied:

- One G-PCC tile base track carrying all of parameter sets and tile inventory shall be present and shall be an entry point.
- One or more G-PCC tile tracks carrying data units of G-PCC tiles shall be present.
- A 'gpbt' track reference from the G-PCC tile base track to G-PCC tile tracks shall be present.
- When DUs of each component corresponding to G-PCC tiles are mapped to separate tracks, one or more geometry tile tracks shall be present, and the same number of attribute tile tracks shall be present.
- When attribute tile tracks are present, the `track_in_movie` flag of each attribute tile track shall be set to 0.

- When attribute tile tracks are present, a 'gpca' track reference shall be present in associated geometry tile tracks.

7.5.2 G-PCC tile base track

7.5.2.1 Sample entry

7.5.2.1.1 Definition

Sample Entry Type: 'gpeb' or 'gpcb'
 Container: SampleDescriptionBox
 Mandatory: No
 Quantity: Zero or more sample entries may be present

The G-PCC tile base track shall use a `GPCCBitstreamSampleEntry`, which is defined in [subclause 7.3.2](#), with sample entry type of 'gpeb' or 'gpcb'. Parameter sets, which apply to decode all samples of tile tracks, can be present in the `setupUnit` array of the sample entry or in the stream.

NOTE When all parameter sets are present in the sample entry of G-PCC tile base track and do not present in any of samples of G-PCC tile base track, these parameter sets in the sample entry of G-PCC tile base track are applied for decoding all samples of tile tracks.

When each G-PCC tile track carries DUs of all components present in the G-PCC bitstream, a G-PCC tile base track shall use a `GPCCBitstreamSampleEntry` with a sample entry type of 'gpeb'.

When each G-PCC tile track carries DUs of one instance of a particular component corresponding to G-PCC tiles, a G-PCC tile base track shall use a `GPCCBitstreamSampleEntry` with a sample entry type of 'gpcb'.

The sample entry names of a G-PCC tile base track and the corresponding G-PCC tile tracks shall be one of the rows in [Table 9](#). Any types of combination of G-PCC tile base track and G-PCC tile tracks other than one defined in [Table 9](#) are not considered in this edition of the document.

Table 9 — Sample entry type for a G-PCC tile base track according to associated G-PCC tile tracks

G-PCC tile base track sample entry type	Samples of associated G-PCC tile tracks
gpeb	Contain DUs of all components present in the G-PCC bitstream
gpcb	Contain DUs of one instance of a particular component indicated in the sample entry

The G-PCC tile base track sample entry can contain a `GPCCSpatialRegionInfoBox`, as defined in [subclause 9.1.2](#). When the `GPCCSpatialRegionInfoBox` is not present in the sample entry, this G-PCC tile base track shall be associated with the dynamic spatial region timed metadata track.

7.5.2.2 Sample format

Each sample in G-PCC tile base track shall be comprised of DUs containing one of SPS, GPS, APS, and tile inventory. Any GDUs, defaulted ADUs or ADUs shall not be present in samples.

FSAP DUs shall be present in samples when the FSAP DUs are present in the G-PCC bitstream. Frame boundary marker DUs shall be present in samples when the frame boundary marker DUs are present in the G-PCC bitstream.

The syntax and semantics of the sample in G-PCC tile base track as defined in [subclause 7.3.3.2](#) and [7.3.3.3](#), respectively, are applied.

7.5.2.2.1 Sub-sample

G-PCC tile base track shall not contain any sub-samples. Sub-samples shall not be present in G-PCC tile base track.

7.5.3 G-PCC tile tracks

7.5.3.1 Sample entry

7.5.3.1.1 Definition

Sample Entry Type: 'gpt1'

Container: Sample Description Box

Mandatory: No

Quantity: Zero or more sample entries may be present

This sample entry describes samples of a G-PCC tile track. It shall use `GPCCTileSampleEntry` which extends `VolumetricVisualSampleEntry` with a sample entry type of 'gpt1'.

The G-PCC tile identifiers present in samples of the respective G-PCC tile track are signalled in `GPCCTileSampleEntry`. The tile identifiers present in G-PCC tile track sample entry shall have the below constraints.

- When each G-PCC tile track carries DUs of all components present in the G-PCC bitstream, the G-PCC tile identifiers present in G-PCC tile track sample entry shall not overlap with the G-PCC tile identifiers present in other G-PCC tile track sample entry.
- When each G-PCC tile track carries DUs of one instance of a particular component, the G-PCC tile identifiers present in the geometry tile track sample entry shall not overlap with the G-PCC tile identifiers present in other geometry tile track sample entry. The G-PCC tile identifiers present in the attribute tile track sample entry shall be equals to the G-PCC tile identifiers in the associated geometry tile track sample entry.

When a G-PCC tile track carries DUs of all components, the `GPCCComponentInfoBox` shall not be present.

When a G-PCC tile track carries DUs of one instance of a particular component, the `GPCCComponentInfoBox` shall be present in the sample entry to indicate the type of the component carried in the track.

7.5.3.1.2 Syntax

```
aligned(8) class GPCCTileConfigurationBox extends Box('gptC',0,0) {
    unsigned int(1)    dynamic_num_tiles_flag;
    bit(7)            reserved = 0;
    unsigned int(16)   max_num_tile_ids_in_track;
    for(i=0; i < max_num_tile_ids_in_track; i++){
        unsigned int(16) tile_id;
    }
}

aligned(8) class GPCCTileSampleEntry extends VolumetricVisualSampleEntry ('gpt1') {
    GPCCTileConfigurationBox config;
    GPCCComponentInfoBox    info;        // optional
}
```

7.5.3.1.3 Semantic

`dynamic_num_tile_flag` indicates whether the number of G-PCC tiles or G-PCC tile identifiers present in samples of the respective G-PCC tile track are changed or not in the stream. Value 0 indicates the number of G-PCC tiles and G-PCC tile identifiers keep constant across all samples in the respective track and the number of G-PCC tiles and G-PCC tile identifiers corresponding to all samples are signalled in the sample entry. Value 1 indicates the number of G-PCC tiles or G-PCC tile identifiers presents in samples are changed in the stream.

`max_num_tiles_ids_in_track` indicates the maximum number of unique G-PCC tile identifiers present in the samples of the respective track. When `dynamic_num_tiles_flag` is 0, each sample in the respective G-PCC tile track shall contain `max_num_tile_ids_in_track` number of G-PCC tiles and the identifiers of those G-PCC tiles are not changing in the stream. When `dynamic_num_tiles_flag` is 1, each sample in the