

---

---

**Information technology — Coded  
representation of immersive media —  
Part 2:  
Omnidirectional media format**

*Technologies de l'information — Représentation codée de média  
immersifs — Partie 2: Format de média omnidirectionnel*





**COPYRIGHT PROTECTED DOCUMENT**

© ISO/IEC 2019

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Fax: +41 22 749 09 47  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

## Contents

Foreword .....	vii
Introduction .....	viii
1 Scope .....	1
2 Normative references .....	1
3 Terms, definitions, abbreviated terms, and conventions .....	2
3.1 Terms and definitions .....	2
3.2 Abbreviated terms .....	6
3.3 Arithmetic operators and mathematical functions .....	7
3.4 Order of operation precedence .....	8
3.5 Range notation .....	9
3.6 Variables .....	9
3.7 Processes .....	9
4 Overview .....	9
4.1 Organization of this document .....	9
4.2 Overall architecture for omnidirectional media with projected video .....	10
4.2.1 Overview .....	10
4.2.2 Stitching, rotation, projection, and region-wise packing .....	11
4.3 Overall architecture for omnidirectional media with fisheye video .....	12
4.4 Conformance and interoperability .....	13
4.4.1 General .....	13
4.4.2 Media profiles .....	14
4.4.3 Presentation profiles .....	15
4.4.4 Summary of referenceable code points .....	16
5 Omnidirectional video projection and region-wise packing .....	19
5.1 Coordinate system .....	19
5.2 Omnidirectional projection formats .....	20
5.2.1 General .....	20
5.2.2 Equirectangular projection for one sample location .....	20
5.2.3 Cubemap projection for one sample location .....	21
5.3 Conversion from the local coordinate axes to the global coordinate axes .....	23
5.4 Region-wise packing formats .....	24
5.4.1 General .....	24
5.4.2 Conversion of one sample location for rectangular region-wise packing .....	24
6 Fisheye omnidirectional video .....	25
6.1 General .....	25
6.2 FisheyeVideoEssentialInfoStruct syntax structure .....	26
6.2.1 Syntax .....	26
6.2.2 Semantics .....	26
6.3 FisheyeVideoSupplementalInfoStruct syntax structure .....	29
6.3.1 Syntax .....	29

6.3.2	Semantics .....	30
7	Omnidirectional media storage and metadata signalling in the ISOBMFF .....	33
7.1	Generic extensions to the ISOBMFF .....	33
7.1.1	Stereoscopic video track grouping .....	33
7.1.2	Indication of <code>track_group_id</code> uniqueness .....	34
7.1.3	Updated semantics of <code>track_IDs</code> of the track reference box .....	34
7.1.4	Indication of a track not intended to be presented alone .....	34
7.1.5	Timed metadata tracks .....	34
7.1.6	Compatible scheme type box .....	35
7.1.7	Multiple transformations for a single transformed media track .....	35
7.1.8	The ' <code>codecs</code> ' parameter for a transformed media track .....	35
7.1.9	Track type box .....	36
7.1.10	Clarifications on the stereo video box .....	36
7.2	Generic extensions to ISO/IEC 14496-15 .....	37
7.2.1	Alternative extraction source track grouping .....	37
7.2.2	Tile base track association with coverage information box and timed metadata data track .....	37
7.3	OMAF-specific extensions to the ISOBMFF .....	37
7.3.1	Sync samples in timed metadata tracks .....	37
7.4	OMAF-specific extensions to ISO/IEC 14496-15 .....	37
7.4.1	Coverage information box in a tile base track .....	37
7.5	Structures and semantics that are common for video tracks and image items .....	38
7.5.1	Semantics of sample locations within a decoded picture .....	38
7.5.2	Projection format structure .....	41
7.5.3	Region-wise packing structure .....	41
7.5.4	Rotation structure .....	48
7.5.5	Content coverage structure .....	48
7.5.6	Sphere region structure .....	49
7.6	Restricted video schemes for omnidirectional video .....	51
7.6.1	Scheme types .....	51
7.6.2	Projected omnidirectional video box .....	54
7.6.3	Fisheye omnidirectional video box .....	55
7.6.4	Region-wise packing box .....	55
7.6.5	Rotation box .....	56
7.6.6	Coverage information box .....	56
7.7	Timed metadata for sphere regions .....	56
7.7.1	General .....	56
7.7.2	Sample entry .....	57
7.7.3	Sample format .....	58
7.7.4	Initial viewing orientation .....	58
7.7.5	Recommended viewport .....	59
7.7.6	Timed text sphere location metadata .....	60
7.8	Signalling of region-wise quality ranking .....	61
7.8.1	General .....	61
7.8.2	Spherical region-wise quality ranking .....	61
7.8.3	2D region-wise quality ranking .....	63
7.9	Storage of omnidirectional images .....	65
7.9.1	General .....	65
7.9.2	Frame packing item property .....	65
7.9.3	Projection format item property .....	65
7.9.4	Essential fisheye image item property .....	66
7.9.5	Supplemental fisheye image item property .....	67
7.9.6	Region-wise packing item property .....	67
7.9.7	Rotation item property .....	68

7.9.8	Coverage information item property.....	68
7.9.9	Initial viewing orientation item property .....	69
7.10	Storage of timed text for omnidirectional video .....	69
7.10.1	General .....	69
7.10.2	OMAF timed text configuration box .....	70
7.10.3	IMSC1 tracks.....	72
7.10.4	WebVTT tracks .....	73
8	Omnidirectional media encapsulation and signalling in DASH .....	73
8.1	Architecture of DASH delivery in OMAF .....	73
8.2	Usage of DASH in OMAF .....	74
8.2.1	General .....	74
8.2.2	Signalling of stereoscopic frame packing .....	74
8.2.3	Carriage of timed metadata.....	74
8.3	DASH MPD descriptors for omnidirectional media.....	75
8.3.1	XML namespace and schema .....	75
8.3.2	Signalling of projection type information.....	75
8.3.3	Signalling of region-wise packing type .....	76
8.3.4	Signalling of content coverage .....	76
8.3.5	Signalling of spherical region-wise quality ranking .....	79
8.3.6	Signalling of 2D region-wise quality ranking.....	84
8.3.7	Signalling of fisheye omnidirectional video .....	88
9	Omnidirectional media encapsulation and signalling in MMT .....	89
9.1	Architecture of MMT delivery in OMAF .....	89
9.2	OMAF signalling in MPEG composition information.....	90
9.3	VR application-specific MMT signalling .....	90
9.3.1	General .....	90
9.3.2	MMT signalling.....	91
10	Media profiles .....	103
10.1	Video profiles .....	103
10.1.1	Overview .....	103
10.1.2	HEVC-based viewport-independent OMAF video profile .....	103
10.1.3	HEVC-based viewport-dependent OMAF video profile .....	106
10.1.4	AVC-based viewport-dependent OMAF video profile.....	109
10.2	Audio profiles.....	111
10.2.1	Overview .....	111
10.2.2	OMAF 3D audio baseline profile .....	111
10.2.3	OMAF 2D audio legacy profile.....	114
10.3	Image profiles.....	118
10.3.1	Overview .....	118
10.3.2	Common specifications for image profiles .....	119
10.3.3	OMAF HEVC image profile .....	120
10.3.4	OMAF legacy image profile.....	121
10.4	Timed text profiles .....	122
10.4.1	Overview .....	122
10.4.2	OMAF IMSC1 timed text profile .....	123
10.4.3	OMAF WebVTT timed text profile.....	123
11	Presentation profiles.....	124
11.1	OMAF viewport-independent baseline presentation profile.....	124
11.1.1	General (informative) .....	124

11.1.2 ISO base media file format constraints .....	124
11.2 OMAF viewport-dependent baseline presentation profile .....	124
11.2.1 General .....	124
11.2.2 ISO base media file format constraints .....	124
Annex A (normative) OMAF DASH schema .....	125
Annex B (normative) DASH integration of media profiles .....	128
Annex C (normative) CMAF integration of media profiles .....	134
Annex D (informative) Viewport-dependent omnidirectional video processing .....	136
Annex E (informative) DASH MPD examples .....	154
Annex F (informative) MMT signalling examples.....	158

## Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

A list of all parts in the ISO/IEC 23090 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

When omnidirectional media content is consumed with a head-mounted display and headphones, only the parts of the media that correspond to the user's viewing orientation are rendered, as if the user were in the spot where and when the media was captured. One of the most popular forms of omnidirectional media applications is omnidirectional video, also known as 360° video. Omnidirectional video is typically captured by multiple cameras that cover up to 360° of the scene. Compared to traditional media application formats, the end-to-end technology for omnidirectional video (from capture to playback) is more easily fragmented due to various capturing and video projection technologies. From the capture side, there exist many different types of cameras capable of capturing 360° video, and on the playback side there are many different devices that are able to playback 360° video with different processing capabilities. To avoid fragmentation of omnidirectional media content and devices, a standardized format for omnidirectional media applications is specified in this document.

This document defines a media format that enables omnidirectional media applications, focusing on 360° video, images, and audio, as well as associated timed text. What is specified in this document includes (but is not limited to):

- 1) a coordinate system that consists of a unit sphere and three coordinate axes, namely the X (back-to-front) axis, the Y (lateral, side-to-side) axis, and the Z (vertical, up) axis,
- 2) projection and rectangular region-wise packing methods that may be used for conversion of a spherical video sequence or image into a two-dimensional rectangular video sequence or image, respectively,
- 3) storage of omnidirectional media and the associated metadata using the ISO base media file format (ISOBMFF) as specified in ISO/IEC 14496-12,
- 4) encapsulation, signalling, and streaming of omnidirectional media in a media streaming system, e.g., 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, and
- 5) media profiles and presentation profiles that provide interoperable and conformance points for media codecs as well as media coding and encapsulation configurations that may be used for compression, streaming, and playback of the omnidirectional media content.



# Information technology — Coded representation of immersive media —

## Part 2: Omnidirectional media format

### 1 Scope

This document specifies the omnidirectional media format for coding, storage, delivery, and rendering of omnidirectional media, including video, images, audio, and timed text.

In an OMAF player the user's viewing perspective is from the centre of the sphere looking outward towards the inside surface of the sphere.

NOTE 1 In this document, only 3 degrees of freedom (3DOF) is supported. In other words, purely translational movement of the user does not result in different omnidirectional media being rendered to the user. For 3DOF support with stereoscopic video, when the user rolls his/her head, there could be a stereoscopic rendering issue.

NOTE 2 Omnidirectional video could contain graphics elements generated by computer graphics but encoded as video.

### 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 10918-1, *Information technology — Digital compression and coding of continuous-tone still images — Part 1: Requirements and guidelines*

ISO/IEC 14496-1, *Information technology — Coding of audio-visual objects — Part 1: Systems*

ISO/IEC 14496-3:2009, *Information technology — Coding of audio-visual objects — Part 3: Audio*

ISO/IEC 14496-10:2014, *Information technology — Coding of audio-visual objects — Part 10: Advanced video coding*

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

ISO/IEC 14496-14, *Information technology — Coding of audio-visual objects — Part 14, MP4 file format*

ISO/IEC 14496-15:2017, *Information technology — Coding of audio-visual objects — Part 15, Carriage of network abstraction layer (NAL) unit structured video in the ISO base media file format*

ISO/IEC 14496-30:2018, *Information technology — Coding of audio-visual objects — Part 30: Timed text and other visual overlays in ISO base media file format*

ISO/IEC 23000-19:2018, *Information technology — Multimedia application format (MPEG-A) — Part 19: Common media application format (CMAF) for segmented media*

ISO/IEC 23003-4:2015, *Information technology — MPEG audio technologies — Part 4: Dynamic range control*

ISO/IEC 23008-1:2017, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 1: MPEG media transport (MMT)*

ISO/IEC 23008-2:2017, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 2: High efficiency video coding*

ISO/IEC 23008-3:2015, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 3: 3D audio*

## ISO/IEC 23090-2:2019(E)

ISO/IEC 23008-12, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 12: Image file format*

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

ISO/IEC 23091-2<sup>1</sup>, *Information technology — Coding-independent code points — Part 2: Video*

ISO/IEC 23091-3, *Information technology — Coding-independent code points — Part 3: Audio*

W3C Recommendation, *TTML profiles for Internet media subtitles and captions 1.0 (IMSC1)*

WebVTT: *The web video text tracks format*, W3C (Working Draft, 08 August 2017)

W3C Recommendation, *XML schema part 1: Structures*

W3C Recommendation, *XML schema part 2: Datatypes*

IETF BCP 47, *Tags for Identifying Languages*

IETF RFC 6381, *MIME Codecs and Profiles*

---

<sup>1</sup> Under preparation. Stage at time of FDIS ballot: ISO/IEC DIS 23091-2, 40.99.