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Foreword

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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 ISO documents 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).

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This document was prepared by Joint 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 19566 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.

Introduction

The ISO/IEC 19566 series is designed primarily for format and metadata storage and protection method of compressed continuous-tone photographic content.

There is increasing use of multi-sensor images from multiple image sensor devices, such as 360 degree capturing cameras or dual-camera smartphones available to consumers. Images from these cameras are shown on computers, smartphones, and head-mounted displays (HMD).

Because existing JPEG standards do not fully cover these new uses, incompatibilities have reduced the interoperability of these images, and thus reducing the widespread ubiquity which consumers have come to expect when using JPEG-based images.

Additionally, new modalities for interacting with images, such as computer-based augmentation, face-tagging, and object classification require support for metadata that was not part of the original JPEG scope.

This document defines "JPEG 360", building upon the features of JPEG Universal Metadata Box Format (JUMBF) (see ISO/IEC 19566-5) which itself builds upon ISO/IEC 15477-3 (Box file format) which provides compatibility with ISO/IEC 10918-5 (JPEG File Interchange Format (JFIF)).

This document defines the use of the JPEG 360 Content Type JUMBF superbox with respect to the sub-box components which include the definition of an XML box, the use of other boxes such as unstitched image elements for omnidirectional captures together with the main image and descriptive metadata, and encrypted parts of the image.

Information technologies — JPEG systems —

Part 6:
JPEG 360

1 Scope

This document specifies omnidirectional/360-degree image and motion contents using Rec. ITU-T T.81 | ISO/IEC 10918-1, Rec. ITU-T T.800 (11/2015) | ISO/IEC 15444-1, and ISO/IEC 18477-3.

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 19566-5, *Information technology — JPEG Systems — Part 5: JPEG Universal Metadata Box Format (JUMBF)*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

— IEC Electropedia: available at http://www.electropedia.org/

3.1.1
box
binary structure that encapsulates an object embedded in a file

3.1.2
box-based file format
file format whose composing elements are boxes containing structured data in compliance with ISO-based media file format

3.1.3
deserialization
extraction of data structure from a series of bytes

3.1.4
equirectangular projection
projection for mapping a portion of the surface of a sphere to a flat image

3.1.6
metadata
data that describes other data, including text, image, hypertext and combinations thereof

3.1.7
omnidirectional
(sub)spherical surface of an image of a scene as if observed from a single point of projection.

3.1.8
serialization
translation of data structures into a series of bytes that can be stored and/or transmitted

3.2 Abbreviated terms

ASCII	American Standard Code for Information Interchange
DCT	discrete cosine transform
ERP	equirectangular projection
FOV	field of view
JSON	JavaScript object notation
JPEG	joint photographic experts group
JUMBF	JPEG universal metadata box format
MIME	multipurpose internet mail extensions
URL	uniform resource locator
XML	eXtensible Markup Language
XMP	eXtensible Metadata Platform
RDF	resource description framework
W3C	World Wide Web Consortium
umf	universal metadata framework

4 Conventions

4.1 Conformance language

In this document, the following verbal forms are used:

— “shall” indicates a requirement;

— “should” indicates a recommendation;

— “may” indicates a permission;

— “can” indicates a possibility or a capability.

Information marked as “NOTE” is intended to assist the understanding or use of the document. “Notes to entry” used in Clause 3 provide additional information that supplements the terminological data and can contain provisions relating to the use of a term.

The keyword "reserved" indicates a provision that is not specified at this time, shall not be used, and may be specified in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be specified in the future.

4.2 Typesetting

Regular face fonts as this text describe informative text that provides instructions, comments or details for the reader.

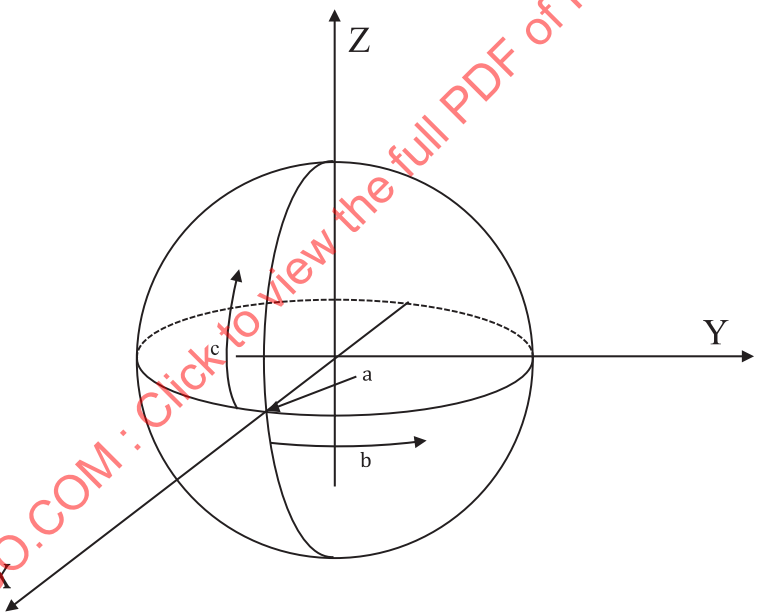
`Monospaced text as this paragraph indicates program input or output as necessary to either run the software, or as generated by the software on the console.`

NOTE The character values of the monospaced text in this document could differ the actual value due to differences in the character encodings used; e.g., IS0 8859 vs UTF-8.

5 Description and definition of JPEG 360 images

The equirectangular projection is a commonly used projection of omnidirectional cameras to a two-dimensional rectangular image and is the default image projection for JPEG 360.

The equirectangular projection maps the image onto a spherical surface from a single projection point at the centre of the sphere. The surface of the sphere is described by two angular measures as shown in Figure 1; for convenience, a unit sphere is assumed. The centre of the sphere is coincident with the origin of the three-dimensional Cartesian coordinates. A point on the surface of the sphere is defined by the two angles ϕ and θ, which are also referred to as "longitude" and "latitude" respectively.



Key

a origin of 360 image (θ = ϕ = 0)
b direction of increasing ϕ
c direction of increasing θ

Figure 1 — Spherical and Cartesian coordinates

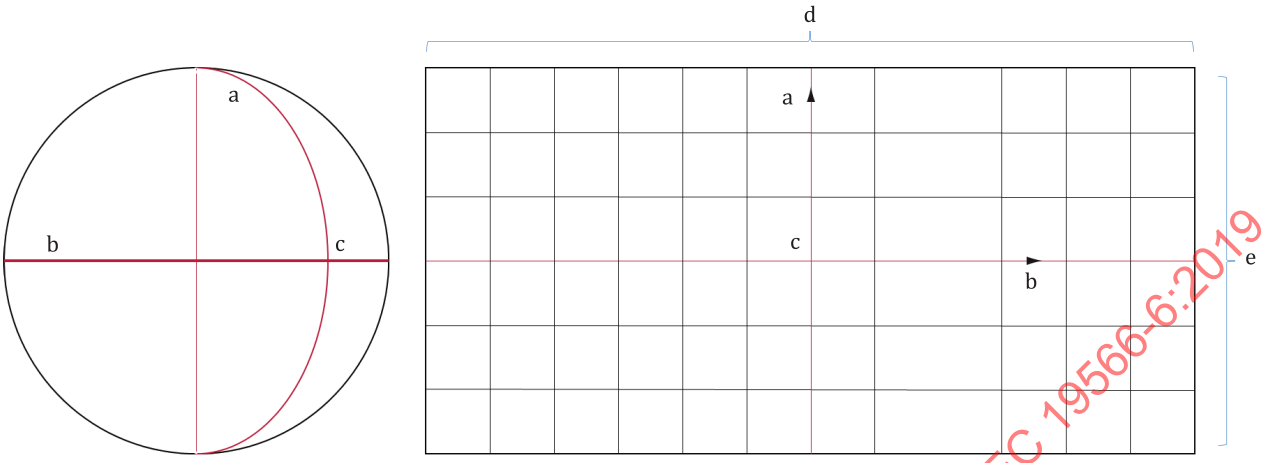
In Cartesian coordinates, the points on the sphere are defined as follows:

— $x = \cos\phi \cdot \cos\theta$

— $y = \sin\phi \cdot \sin\theta$

— $z = \sin\theta$

For an equirectangular projection the sphere's surface, expressed in terms of the angles ϕ and θ, can be mapped to a two-dimensional Cartesian surface. For example, in Figure 2 which includes the mapping for several lines of constant longitude or constant latitude.



Key

a prime meridian (commonly at ϕ = 0)
b equator (typically at θ = 0)
c origin of 360 image (θ = ϕ = 0)
d span of ϕ (commonly −180° to 180°)
e span of θ (commonly −90° to 90°)

Figure 2 — Description of mapping from spherical surface to equirectangular

For this document, a simplified representation will be used, for example, for equirectangular projection for a full spherical surface as shown in Figure 3.

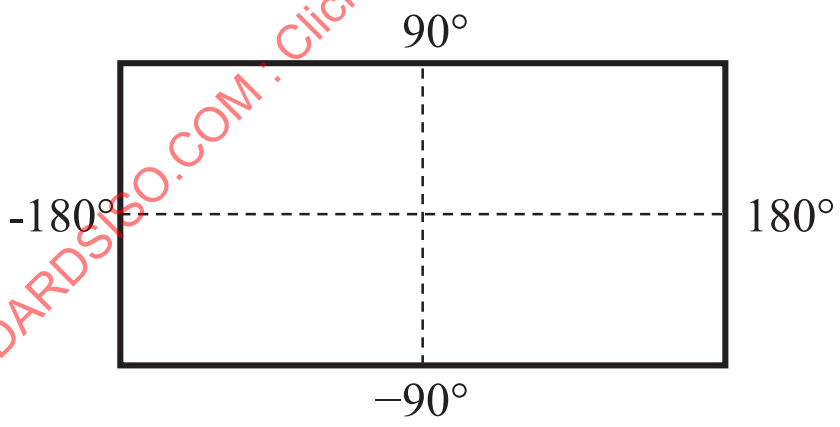


Figure 3 — Simplified representation for equirectangular projection for full spherical surface

The generalized equirectangular projection is expressed in terms of ranges for ϕ and θ by defining four values ϕ_{min}, ϕ_{max}, θ_{min}, and θ_{max} as shown in Figure 4.

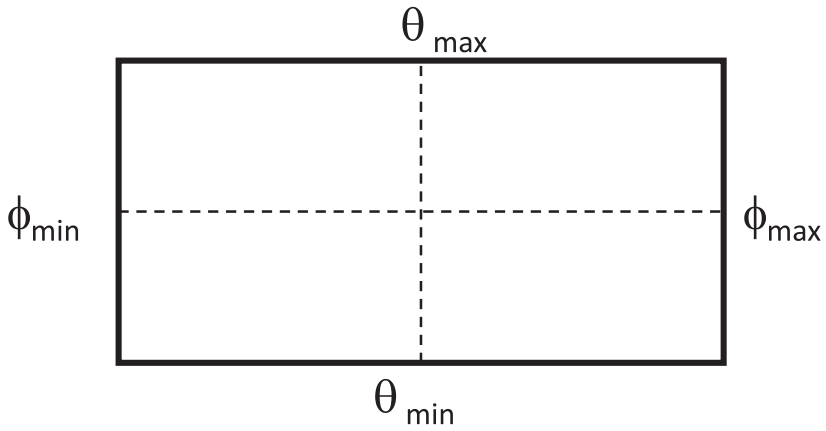


Figure 4 — Generalized description of equirectangular projection

ϕ_{min}, and ϕ_{max} are constrained by the two conditions:

— $-360 \leq \phi_{min} \leq \phi_{max} \leq 360$, and

— $\phi_{max} - \phi_{min} \leq 360$

θ_{min}, and θ_{max} are constrained by the two conditions:

— $-180 \leq \theta_{min} \leq \theta_{max} \leq 180$, and

— $\theta_{max} - \theta_{min} \leq 180$

The advantages of this generalized description are:

i) it defines equirectangular projections that are smaller than a full sphere, and

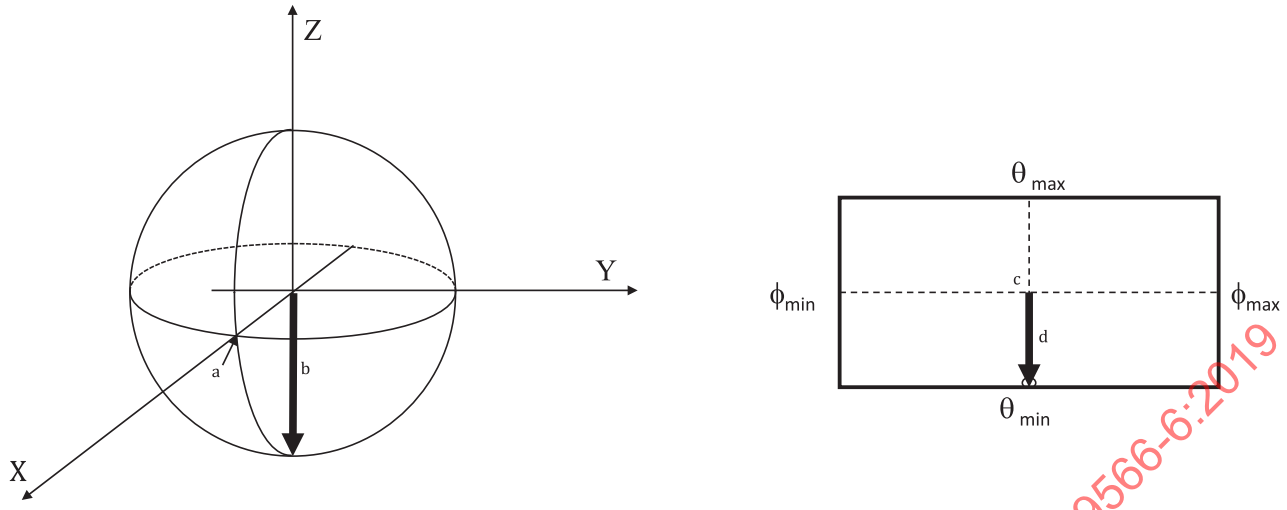
ii) it can mathematically shift the origin (0, 0) of the equirectangular project in terms of the angle range values.

For example, an "equatorial image" to be a band around the equator of the equirectangular projection, or set the origin at the left edge of the equirectangular projection.

5.1 Relative orientation

The full 360 camera captures equivalent scenes regardless of the exact position the user holds the camera during image exposure. However, it is highly desirable to improve viewer's experience of the image by displaying the image in a way that is nominally oriented so that the scene horizon is parallel to the equirectangular projection's centre line. Sensors in the camera can provide the camera orientation relative to the local direction of the Earth's gravity; using this information allows the image to be remapped to the expected view.

In Figure 5 shows the direction of Earth's gravity with respect to the camera's local coordinate systems in both 3D space and equirectangular projection for a full spherical surface as might be expected when the camera is held in its upright position.

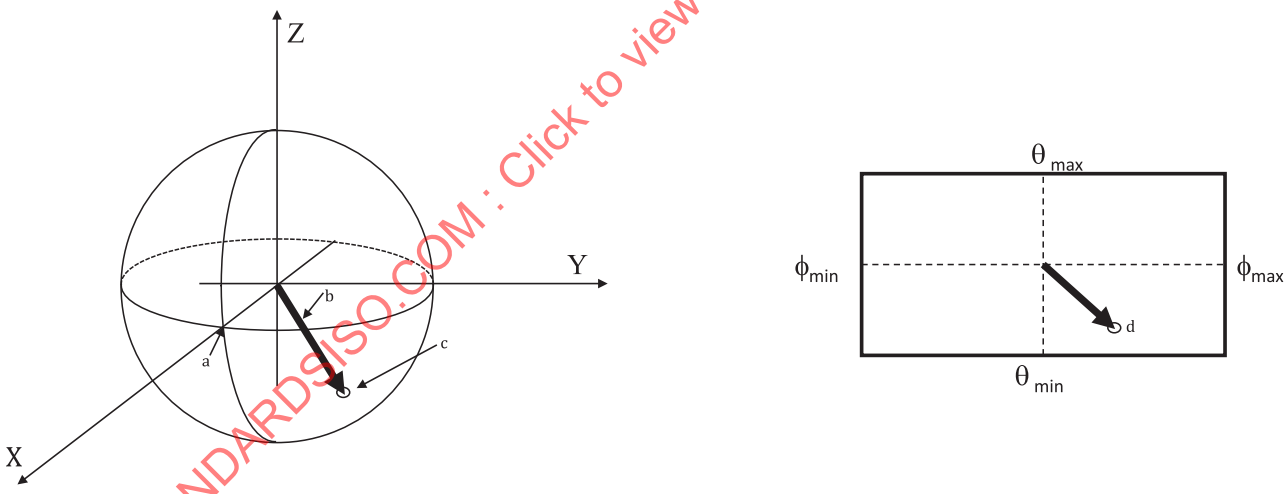


Key

a centre of 360 image as projected on sphere (θ = ϕ = 0)
b direction of gravity as projected on sphere
c centre of 360 image in equirectangular projection (θ = ϕ = 0)
d direction of gravity in equirectangular projection

Figure 5 — Representation of the direction of Earth's gravity for upright camera

When the camera is not held upright, the direction of Earth's gravity is shifted relative to the camera's coordinate systems. In Figure 6, this is illustrated.



Key

a centre of 360 image as projected on sphere (θ = ϕ = 0)
b direction of gravity as projected on sphere
c point on surface of sphere along direction of gravity
d direction of gravity in equirectangular projection

Figure 6 — Representation for direction of gravity for non-upright camera

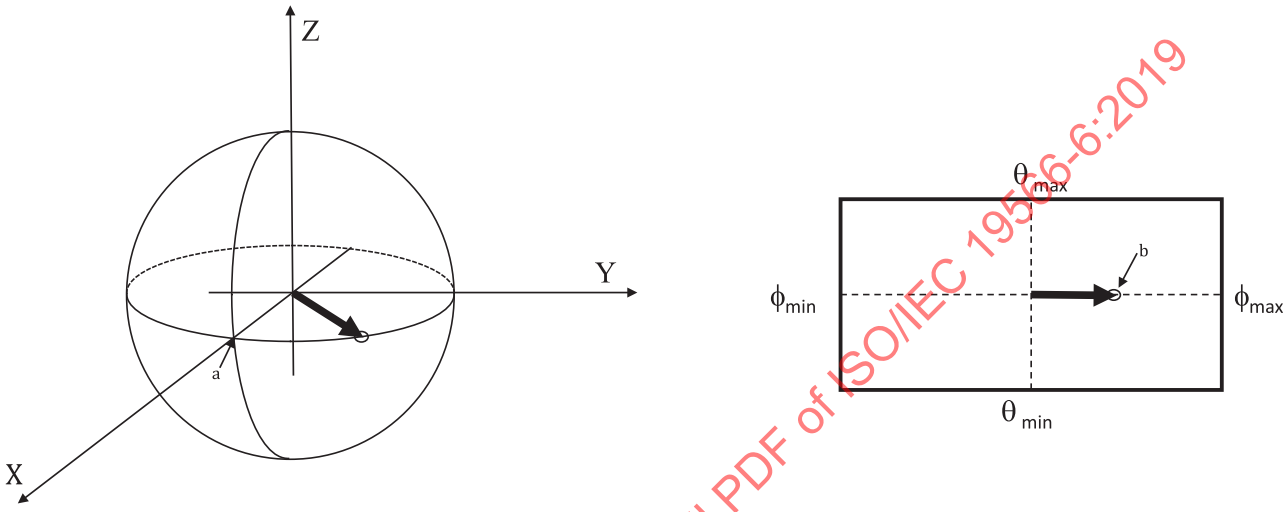
The direction of Earth's gravity is defined to be the vector from the centre of the sphere to the point defined by the pair $\phi_{gravity}$ and $\theta_{gravity}$. It is possible for the equirectangular position of the Earth's

gravity to be outside the ranges defined by ϕ_{min}, ϕ_{max}, θ_{min}, and θ_{max}. The $\phi_{gravity}$ and $\theta_{gravity}$ are constrained shown below:

— $-180 + (\phi_{max} - \phi_{min}) < \phi_{gravity} < (\phi_{max} - \phi_{min}) + 180$, and

— $-90 + (\phi_{max} - \phi_{min}) < \theta_{gravity} < + (\phi_{max} - \phi_{min}) + 90$.

The compass heading relative to the camera's coordinates is very useful information. This is a one-dimensional value given by the angle, ω, where $0 \leq \omega < 360$, as shown in Figure 7.



Key

a centre of 360 image as projected on sphere ($\theta = \phi = 0$)

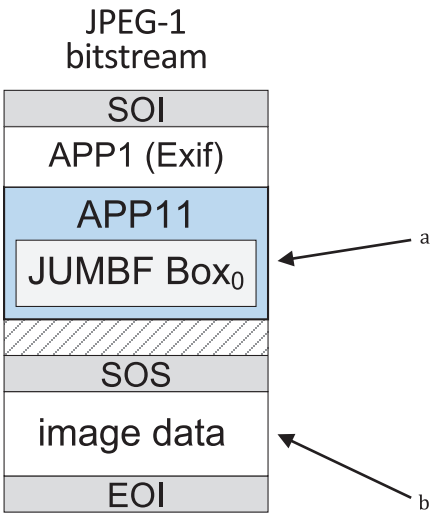
b compass heading (ω)

Figure 7 — Compass heading definition

NOTE For the general case, the value of the compass heading can be less than ϕ_{min} or greater than ϕ_{max}.

5.2 File position for the 360 image codestream

The JPEG standards have defined specific locations in the file structure for an image codestream. With the new usages supported by JPEG 360, images are included in a broader definition of metadata. It is possible to signal that the encoded equirectangular image is located within JPEG 360 Content Type box or is located in the file position of another standard. A simplified diagram of the file structure is shown in Figure 8.



Key

a file position for JPEG 360 metadata and codestreams within JUMBF box

b file position for a single codestream which can be used for the equirectangular projection; compatible with conventional viewers

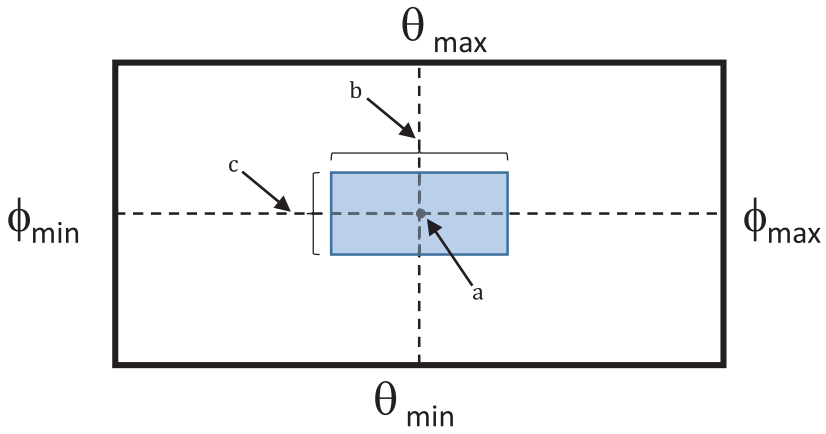
Figure 8 — Possible file positions for the equirectangular image codestream

This "legacy" file position may be desirable so that an image is decoded when the file is opened by conventional JPEG viewing applications.

5.3 Viewport representation

A common interaction modality is to present the viewer with only a limited view of the equirectangular projection that corresponds to the perspective that is familiar to the human visual experience. Further to guide the viewer's experience of the image by starting at an initial location in the equirectangular projection. This is referred to a "viewport". A viewport is defined as a rectangular sub-region within the equirectangular projection.

In Figure 9, the blue box represents a viewport; while not required, it is recommended to render a view into the equirectangular projection through a viewport.



Key

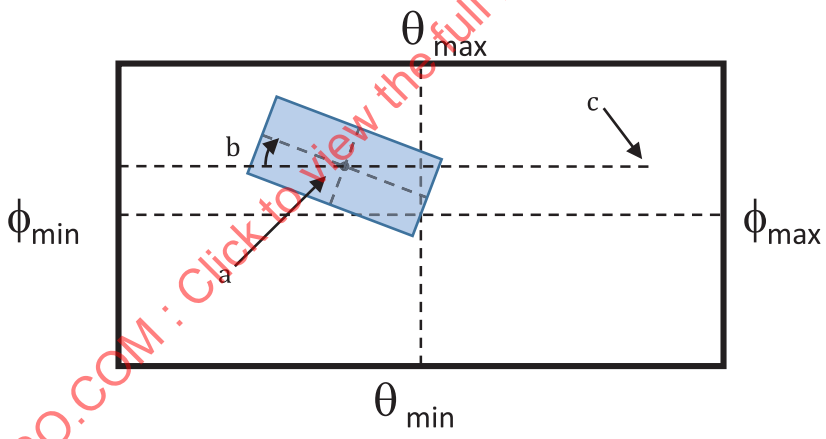
a viewport centre

b viewport horizontal field of view span

c viewport vertical field of view span

Figure 9 — Viewport as a subset of the equirectangular projection

In general, as shown in Figure 10, the edges of the viewport may not be parallel to the equirectangular projection coordinates.



Key

a viewport centre

b direction of increasing viewport roll

c line of constant ϕ

Figure 10 — Non-parallel viewport

The viewport can be described by:

— The centre of the viewport as defined by longitude (ϕ) and latitude values (θ),

— The span in ϕ and θ dimensions, and

— The viewport roll which is the rotation angle between a line-of-constant-φ through the viewport centre point and the centre line of the viewport.

5.4 Basic set of general 360 image parameters

Based on the discussion above, there are the following set of basic 360 image characteristics:

360 image parameters

— JPEG360VersionNumber: provides a way to identify parameter sets and associated definitions.

— MediaType: commonly referred to as MIME type, this identifies the codestream format.

— ProjectionType: identifies the spherical projection for the associated image.

— PhiMin: ϕ_{min} as described above.

— PhiMax: ϕ_{max} as described above.

— ThetaMax: θ_{max} as described above.

— ThetaMin: θ_{min} as described above.

— PhiGravity: $\phi_{gravity}$ as described above.

— ThetaGravity: corresponding to $\theta_{gravity}$ as described above.

— CompassHeading: the angle between the camera's coordinate system and the Earth's compass coordinates.

— BoxReference: indication if the equirectangular image position in the file is in the codestream position expected by earlier versions of JPEG standards.

Viewport parameters

— JPEG360ViewportNumber: a numbered set of viewport descriptors

— ViewportPhi: phi angle value for viewport centre: the longitude value for the centre of the rectangular sub-region in the equirectangular projection.

— ViewportTheta: theta angle value for viewport centre: the latitude value for the centre of the rectangular sub-region in the equirectangular projection.

— ViewportPhiFOV: the longitude span of the viewport with span centred at the viewport latitude centre.

— ViewportThetaFOV: the latitude span of the viewport with span centred at the viewport longitude centre.

— ViewportRoll: the angular rotation of the viewport.

6 Structuring of JPEG 360 Metadata

6.1 General

This Clause defines the JPEG 360 Content Type box, which is based on the JUMBF superbox defined by ISO/IEC 19566-5. The sub-box components are defined, which include the definition of an XML box, the use of other boxes such as unstitched image elements for omnidirectional captures together with the main image and descriptive metadata, and encrypted parts of the image in order to construct a conformant JPEG 360 image file. An overview of the JPEG 360 Content Type box is shown in Figure 11.

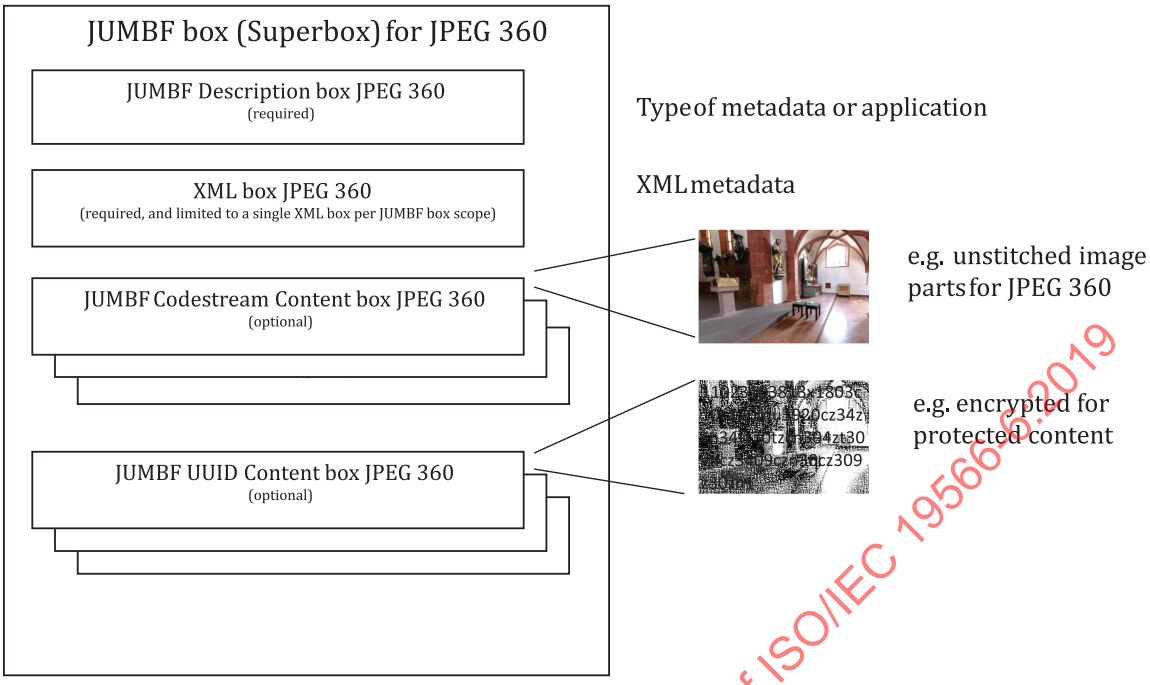


Figure 11 — Overview of JPEG 360 Content Type box

6.2 Definition of JPEG 360 Content Type boxes

With reference to ISO/IEC 19566-5, the JPEG 360 Content Type box shall be defined in:

— Annex A, which contains the definition of the JUMBF box that shall be used for JPEG 360 (e.g., the structure and definitions of required content of this box);

— Annex B, which defines the JPEG 360 metadata schema that shall be used.

The boxes described in Annex A follow the box-based file construction as described in ISO/IEC 18477-3 and ISO/IEC 14496-12, and which has a compatible form with ISO/IEC TR 19566-1.

Annex A
(normative)

JPEG 360 Content Type JUMBF box

A.1 General

This annex defines the use of JUMBF elements for JPEG 360; the elements are defined in ISO/IEC 19566-5.

A.2 JUMBF box for JPEG 360

Box name	Type
JUMBF box	'jumb' (0x6a75 6d62)

A.3 JUMBF Description box for JPEG 360

Box name	Type
JUMBF Description box	'jumd' (0x6a75 6d64)

A.4 JUMBF Description box: Type for JPEG 360

Parameter	Value
TYPE	0x785f34b7-5d4b-474c-b89f-1d99e0e3a8dd NOTE The UUID above is per Recommendation ITU-T X.667 | ISO/IEC 9834-8.

A.5 JUMBF Description box: TOGGLES for JPEG 360

The JPEG 360 TOGGLES values shall follow ISO/IEC 19566-5 definitions.

Binary value	TOGGLE Meaning	JPEG 360 Allowed TOGGLE values
0000 xx11	**Requestable**	0 or 1
0000 xxx0	**Not requestable**	
0000 xx1x	**Label present**	0 or 1
0000 xx0x	**No label present**	
0000 x1xx	**ID present**	0 or 1
0000 x0xx	**No ID present**	
0000 1xxx	**Signature present**	0 or 1
0000 0xxx	**No signature present**	
All other values are reserved for future use.		

If Requestable Toggle is set to 1, a request shall return the JPEG 360 XML instance with MIME type ‘text/xml’ first.

A.6 JUMBF Description box: recommended/default label string for JPEG 360

Parameter	Value
LABEL	"JPEG360Metadata"

Each instance can have a distinct label or the same label if they are embedded in different files. If there are multiple JUMBF boxes in the same file, the user is responsible to assign a unique label within the scope of the file. It is recommended to use the label "JPEG360Metadata", if this label does not already exist in the current scope of the file; e.g., a newly created JPEG 360 image.

A.7 Description of the JPEG 360 Content Type JUMBF box

As shown in Figure 11, JPEG 360 metadata is contained within a JUMBF superbox. This JPEG 360 Content Type JUMBF box is internally composed of the following:

— The JUMBF Descriptor box for JPEG 360

— Exactly one XML box which contains the JPEG 360 metadata as described in Annex B.

— Optional JUMBF Codestream Content Type boxes.

— Optional JUMBF UUID Content Type boxes.

The use of the JUMBF boxes to contain codestreams and custom data allows the JPEG 360 metadata to make references to associated codestreams and custom data, and simplifies the encapsulation of codestreams.

Annex B
(normative)

XML box for JPEG 360

B.1 Approach to setting the standard

JPEG 360 is designed to balance the need to provide a timely standard while keeping flexibility to grow the feature sets to more fully accommodate the identified use cases. To meet this need, a basic schema descriptor and an empty metadata set are provided; which assign default values for the metadata elements.

However, without loss of generality, metadata elements can be set to support a variety of basic equirectangular images, and a number of viewports. See the discussion of these details in subclause 5.4.

B.2 Definition of JPEG 360 metadata

The schema elements of the JPEG 360 metadata contains basic properties, described in Table B.1.

Table B.1 — Definition of JPEG 360 schema descriptor elements

JPEG 360 schema descriptor elements			Meaning	Data type
JPEG-360Meta-data			Schema name	string
	JPEG360ImageMetadata		Name of subschema for JPEG 360 image parameters	string
		JPEG360Version	Version # of JPEG image metadata schema; provides a way to identify parameter sets and associated definitions	integer
		MediaType	Media type (formerly MIME type) for encoded 360 projection image codestream	string
		ProjectionType	360 image projection type	string
		PhiMin	As shown in Clause 6, in units of degrees (°)	real
		PhiMax		real
		ThetaMax		real
		ThetaMin		real
		PhiGravity		real
		ThetaGravity		real
		CompassPhi		real
		CompassTheta		real
		BoxReference	Refers to a label for either a JUMBF codestream box or a JUMBF UUID box, as per ISO/IEC 19566-5.	string

Table B.1 *(continued)*

	JPEG360ViewportMetadata		Name of subschema for JPEG 360 viewport	string
		JPEG360Viewport Number	As several viewports can be assigned, a unique ID to further differentiate them The value '0' is reserved for the default viewport as described in Table B.4.	integer
		ViewportPhi	As shown in Clause 6, in units of degrees (°)	real
		ViewportTheta		real
		ViewportPhiFOV		real
		ViewportThetaFOV		real
		ViewportRoll		real

The JPEG 360 metadata elements are required to follow the definitions of the JPEG 360 schema descriptor.

B.3 Overview of metadata representation

This Annex defines JPEG 360 schema based on XMP specification which is also covered as part of ISO 16684-1. The data source layer implements serialization, deserialization and embedding of metadata with using XMP with the addition of new tags to express a schema descriptor, and to associate metadata elements with that schema descriptor, as shown diagrammatically in Figure B.1.

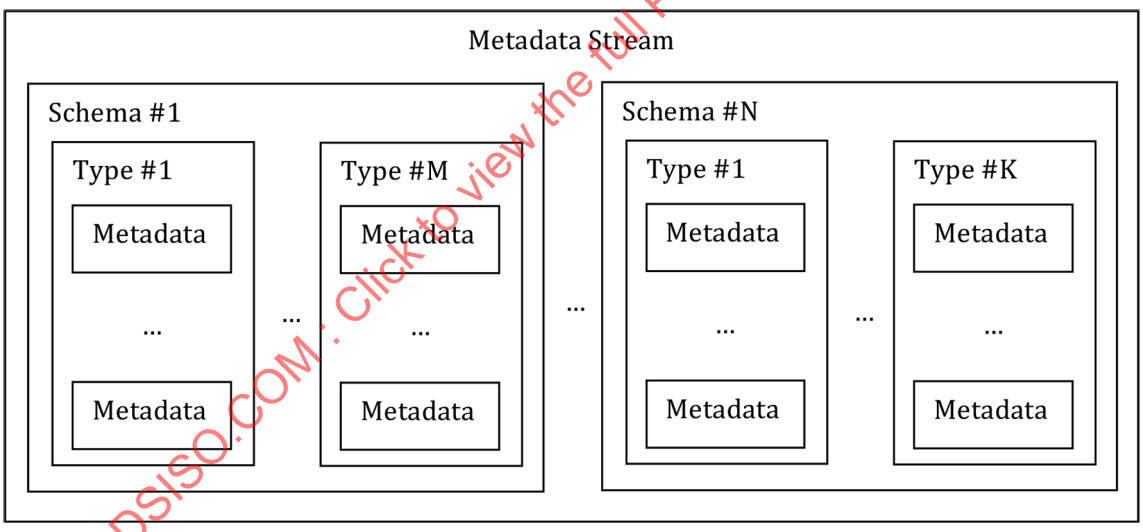


Figure B.1 — Logical view of the metadata

The high-level structuring of the JPEG 360 XML box is shown below.

XMP framing	Purpose	Top level structure and tags	Second level structure and tags
	Internal counter	**umf:next-id**	
	Schemas description storage	XMP arrays of schemas **umf:schemas**	XMP array of schema names **umf:descriptors**
			XMP array of fields/types **umf:fields**
	Metadata storage	XMP array of metadata **umf:metadata**	XMP array of metadata items **umf:set**
			XMP array of metadata field/values, references **umf:fields, umf:refs**

It should be understood that the top-level structure ordering is not critical as the structure below is equivalent to the structure above.

XMP framing	Purpose	Top level structure and tags	Second level structure and tags
	Internal counter	**umf:next-id**	
	Metadata storage	XMP array of metadata **umf:metadata**	XMP array of metadata items **umf:set**
			XMP array of metadata field/values, references **umf:fields, umf:refs**
	Schemas description storage	XMP arrays of schemas **umf:schemas**	XMP array of schema names **umf:descriptors**
			XMP array of fields/types **umf:fields**

B.4 Encoding JPEG 360 metadata syntax

The JPEG 360 schema is serialized and stored using a subset of the W3C Resource Description Framework (RDF), expressed in XML. (Please note that XMP character encoding uses UTF-8, so the text characters shown in the following monospaced examples may be different from their UTF-8 values.)

The XMP statement to frame a metadata stream is:

```
<x:xmpmeta xmlns:x="adobe:ns:meta/" x:xmptk="XMP Core 5.4.0">
   <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
      <rdf:Description rdf:about="" xmlns:umf="http://ns.intel.com/umf/2.0">
      <!- internal structure -->
      </rdf:Description>
   </rdf:RDF>
</x:xmpmeta>
```

B.5 Reserved tags

Table B.2 defines tags reserved in the JPEG 360 XML Box.

Table B.2 — JPEG 360 reserved XML tags

Reserved tag	Description
umf:schemas	Tag to define start of schema descriptor. Multiple schema descriptors can be defined, each with multiple sets of metadata elements.
umf:schema	Tag to define a unique name for a schema.
umf:name	Tag to define name of schema descriptor elements, or to label sets of metadata elements.
umf:type	Tag to associate a data type to a name in the schema descriptor.
umf:id	Unique id of a metadata set.
umf:next-id	Used by implementation(s) to assign a unique id to metadata items.
umf:index	Reserved tag. Index into an image sequence that contains the first image associated with this metadata item (-1 in case of global metadata).
umf:nframes	Reserved tag. Number of sequential frames the metadata item is associated with (0 in case of global metadata).
umf:fields	Tag for description of schema fields. Fields of metadata items provide a list of value/name pairs (in case it is a structure) or an array of values (in case it is an array) or just a single value.
umf:refs	Array of references to other metadata items. Each reference is stored as metadata id.
umf:set	Tag to associate fields of metadata elements.

B.6 Values for JPEG 360 metadata

The schema descriptor elements of the JPEG 360 metadata are shown in Table B.3.

Table B.3 — JPEG 360 schema descriptor elements

JPEG 360 schema descriptor			Schema descriptor
JPEG360Metadata			<umf:schema>JPEG360Metadata</umf:schema>
	JPEG360ImageMetadata		<umf:name>JPEG360ImageMetadata</umf:name>
		JPEG360Version	<umf:name>JPEG360Version</umf:name> <umf:type>integer</umf:type>
		MediaType	<umf:name>MediaType</umf:name> <umf:type>string</umf:type>
		ProjectionType	<umf:name>ProjectionType</umf:name> <umf:type>string</umf:type>
		PhiMin	<umf:name>PhiMin</umf:name> <umf:type>real</umf:type>
		PhiMax	<umf:name>PhiMax</umf:name> <umf:type> real</umf:type>
		ThetaMax	<umf:name>ThetaMax</umf:name> <umf:type> real</umf:type>

Table B.3 *(continued)*

		ThetaMin	<umf:name>ThetaMin</umf:name> <umf:type> real</umf:type>
		PhiGravity	<umf:name>PhiGravity</umf:name> <umf:type> real</umf:type>
		ThetaGravity	<umf:name>ThetaGravity</umf:name> <umf:type> real</umf:type>
		CompassPhi	<umf:name>CompassPhi</umf:name> <umf:type> real</umf:type>
		BoxReference	<umf:name>BoxReference</umf:name> <umf:type> string</umf:type>
	JPEG360ViewportMetadata		<umf:name>JPEG360ViewportMetadata</umf:name>
		JPEG 360Viewport-Number	<umf:name>JPEG360ViewportNumber</umf:name> <umf:type>integer</umf:type>
		ViewportPhi	<umf:name>ViewportPhi</umf:name> <umf:type>real</umf:type>
		ViewportTheta	<umf:name>ViewportTheta</umf:name> <umf:type>real</umf:type>
		ViewportPhiFOV	<umf:name>ViewportPhiFOV</umf:name> <umf:type>real</umf:type>
		ViewportThetaFOV	<umf:name>ViewportThetaiFOV</umf:name> <umf:type>real</umf:type>
		ViewportRoll	<umf:name>ViewportRoll</umf:name> <umf:type>real</umf:type>

B.7 XMP expression of minimum self-describing schema (without metadata elements)

The JPEG 360 XML box contains data which is structured using XMP; the XMP expression of the schema defines its properties.

The minimal XMP expression consists of the JPEG 360 schema descriptor and an unpopulated JPEG 360 metadata storage, as shown below. When this minimal expression is provided, a number of default values for the JPEG 360 image description are assigned; these default values are detailed in B.8.

```
http://ns.adobe.com/xap/1.0/ <?xpacket begin="ï»¿" id="W5M0MpCehiHzreSzNTczkc9d"?>
<x:xmpmeta xmlns:x="adobe:ns:meta/" x:xmptk="XMP Core 5.5.0">
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
<rdf:Description rdf:about=""
xmlns:xmp="http://ns.adobe.com/xap/1.0/"
xmlns:umf="http://ns.intel.com/umf/2.0">
<umf:next-id>0</umf:next-id>
<umf:schemas>
<rdf:Bag>
<rdf:li rdf:parseType="Resource">
<!-- JPEG 360 Metadata -->
<umf:schema>JPEG360Metadata</umf:schema>
<umf:descriptors>
<rdf:Bag>
<rdf:li rdf:parseType="Resource">
<umf:name>JPEG360ImageMetadata</umf:name>
<umf:fields>
<rdf:Bag>
<rdf:li rdf:parseType="Resource">
```

```
<umf:name>JPEG360Version</umf:name>
<umf:type>integer</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>MediaType</umf:name>
<umf:type>string</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>ProjectionType</umf:name>
<umf:type>string</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>PhiMin</umf:name>
<umf:type>real</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>PhiMax</umf:name>
<umf:type>real</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>ThetaMax</umf:name>
<umf:type>real</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>ThetaMin</umf:name>
<umf:type>real</umf:type>
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<umf:name>ThetaGravity</umf:name>
<umf:type>real</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>CompassPhi</umf:name>
<umf:type>real</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>BoxReference</umf:name>
<umf:type>string</umf:type>
</rdf:li>
</rdf:Bag>
</umf:fields>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>JPEG360ViewportMetadata</umf:name>
<umf:fields>
<rdf:Bag>
<rdf:li rdf:parseType="Resource">
<umf:name>JPEG360ViewportNumber</umf:name>
<umf:type>integer</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>ViewportPhi</umf:name>
<umf:type>real</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>ViewportTheta</umf:name>
<umf:type>real</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>ViewportPhiFOV</umf:name>
<umf:type>real</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
<umf:name>ViewportThetaFOV</umf:name>
<umf:type>real</umf:type>
</rdf:li>
<rdf:li rdf:parseType="Resource">
```