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Information technology — Plenoptic image coding system (JPEG Pleno) —

Part 1: **Framework**

Technologies de l'information — Système de codage d'images plénoptiques (JPEG Pleno) —

Partie 1: Cadre

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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 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).

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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.

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 21794 series can be found on the ISO website.

Introduction

This document is part of a series of standards for a system known as JPEG Pleno. This document defines the JPEG Pleno framework. It facilitates the capture, representation, exchange and visualization of plenoptic imaging modalities. A plenoptic image modality can be a light field, point cloud or hologram, which are sampled representations of the plenoptic function in the form of, respectively, a vector function that represents the radiance of a discretized set of light rays, a collection of points with position and attribute information, or a complex wavefront. The plenoptic function describes the radiance in time and in space obtained by positioning a pinhole camera at every viewpoint in 3D spatial coordinates, every viewing angle and every wavelength, resulting in a 7D function.

JPEG Pleno specifies tools for coding these modalities while providing advanced functionality at system level, such as support for data and metadata manipulation, editing, random access and interaction, protection of privacy and ownership rights.

Information technology — Plenoptic image coding system (JPEG Pleno) —

Part 1: Framework

1 Scope

This document specifies the plenoptic image coding system framework architecture and its instantiation via a generic file format for storage of plenoptic modalities as well as associated metadata descriptors.

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 646, *Information technology — ISO 7-bit coded character set for information interchange*

ISO/IEC 15444-1:2019, *Information technology — JPEG 2000 image coding system — Part 1: Core coding system*

ISO/IEC 15444-2:2004, *Information technology — JPEG 2000 image coding system — Part 2: Extensions*

ISO/IEC 21794-2:—,[1] *Information technology — Plenoptic image coding system (JPEG Pleno) — Part 2: Light field coding*

3 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
big-endian
byte ordering for which the most significant byte and least significant byte are sequentially ordered from lower memory address to higher memory address, respectively

3.2
box
structured collection of data describing the image or the image decoding process

3.3
box content
data wrapped within the box structure

1) Under preparation. Stage at time of publication: ISO/IEC DIS 21794-2:2019.

3.4
box type
kind of information stored within the box

3.5
coder
embodiment of a coding process

3.6
codestream
coded data representation that includes all necessary data to allow a (full or approximate) reconstruction of the sample values of a digital image

3.7
coding process
encoding process, decoding process, or both

3.8
complex wavefront
wavefront represented with a complex representation, which can be, for example, real-imaginary or amplitude-phase

3.9
component
two-dimensional array of samples having the same designation in the output or display device, e. g., red, green or blue

3.10
decoder
embodiment of a decoding process

3.11
decoding process
process that takes as its input a codestream and outputs a continuous-tone image

3.12
encoder
embodiment of an encoding process

3.13
encoding process
process that takes as its input a continuous-tone image and outputs a codestream

3.14
hologram
sampled representation of the plenoptic function in the form of a complex wavefront

3.15
holographic display
three-dimensional display that renders a complex optical wavefront

3.16
light field
sampled representation of the plenoptic function in the form of a vector function that represents the radiance of a discretized set of light rays

3.17
light field data
recorded light field

3.18
plenoptic function
radiance in time and in space obtained by positioning a pinhole camera at every viewpoint in 3D spatial coordinates, every viewing angle and every wavelength, resulting in a 7D function

3.19
plenoptic data
sampled representation of the plenoptic function

Note 1 to entry: Example plenoptic functions are light field, point cloud and holographic representation.

3.20
plenoptic object
plenoptic element
plenoptic data representing a part of the scene described by the plenoptic function

3.21
point cloud
sampled representation of the plenoptic function in the form of collection of points with position and attribute information

3.22
superbox
box that carries other boxes as payload data

3.23
wavefront
locus of spatial points that share the same phase of the light wave

4 Abbreviated terms

3D	three dimensional
CGH	computer-generated holography
IPR	intellectual property rights
JPEG	Joint Photographic Experts Group
JPL	Jpeg PLeno file format
UUID	Universally Unique IDentifier
XML	eXtensible Markup Language

5 Conventions

5.1 Conformance language

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.

5.2 Naming conventions for numerical values

Integer numbers are expressed as bit patterns, hexadecimal values or decimal numbers. Bit patterns and hexadecimal values have both a numerical value and an associated particular length in bits.

Hexadecimal notation, indicated by prefixing the hexadecimal number by "0x", is used instead of binary notation to denote a bit pattern having a length that is an integer multiple of 4. For example, 0x41 represents an eight-bit pattern having only its second most significant bit and its least significant bit equal to 1. An octal notation is indicated by prefixing the octal value "\", this notation is used instead of binary notation to denote a bit pattern having a length that is an integer multiple of 3. Numerical values that are specified under a "**Code**" heading in tables that are referred to as "code tables" are bit pattern values (specified as a string of digits equal to 0 or 1 in which the left-most bit is considered the most-significant bit). Other numerical values not prefixed by "0x" are decimal values. When used in expressions, a hexadecimal value is interpreted as having a value equal to the value of the corresponding bit pattern evaluated as a binary representation of an unsigned integer (i.e., as the value of the number formed by prefixing the bit pattern with a sign bit equal to 0 and interpreting the result as a two's complement representation of an integer value). For example, the hexadecimal value 0xF is equivalent to the 4-bit pattern '1111' and is interpreted in expressions as being equal to the decimal number 15.

6 Framework definition

The plenoptic image coding system (JPEG Pleno) specifies a framework that facilitates the capture, representation and exchange of point cloud, light field and holographic imaging modalities. These imaging modalities are light representations of the plenoptic function[1], regardless of which modality was used to capture or create parts of the entire content:

— **Point clouds** are a set of data points representing the plenoptic function in a given, often 3D, coordinate system with associated attributes;

— **Light fields** are a sampled representation of the plenoptic function by capturing it by either an array of cameras (resulting in wide baseline light field data) or by a single light field camera that uses microlenses to sample individual rays of light that contribute to the final image (resulting in narrow baseline light field data);

— **Holograms** are a sampled interferometric representation of the plenoptic function that is based on a wave-based light propagation model.

This framework supports conversations between different modalities throughout an end-to-end processing chain. This document defines file format and codestream syntax for plenoptic modalities while providing advanced functionalities at system level. It also supports data and metadata manipulation, editing, random access and interaction, protection of privacy and ownership.

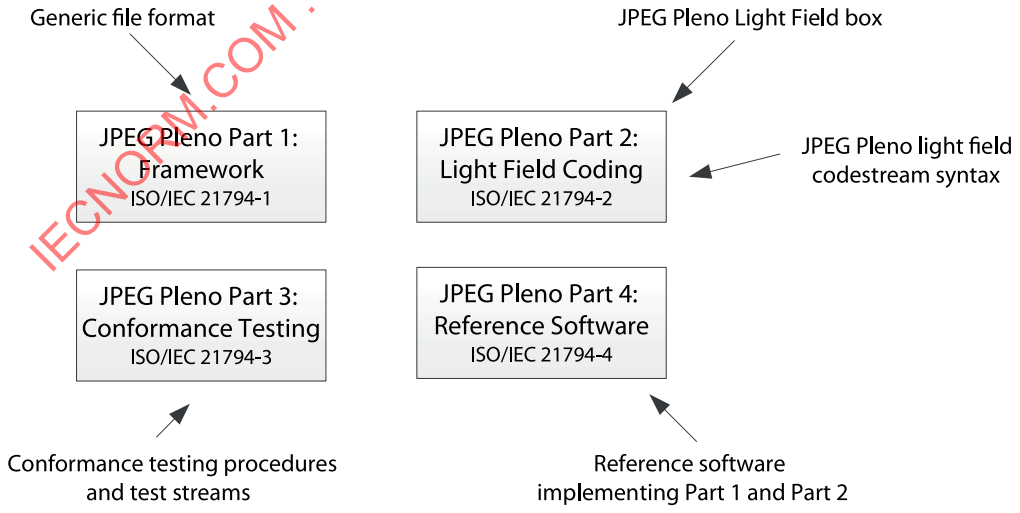

Figure 1 — JPEG Pleno framework

The ISO/IEC 21794 series consists of the following Parts (Figure 1).

— This document outlines the overall JPEG Pleno framework and specifies the generic JPEG Pleno file format.

— ISO/IEC 21794-2 specifies the file format and codestream syntax for coded light fields. Moreover, it specifies output of JPEG Pleno light field encoders and provides documentation on the encoding and decoding procedures.

— ISO/IEC 21794-3[2)] specifies conformance testing protocols.

— ISO/IEC 21794-4[2)] specifies reference software.

7 File format architecture

This document shares common definitions for the structure of files (a sequence of objects, called boxes here, and atoms in other similar file formats), and a common definition of the general structure of an object (the size and type).

The specification of the file format in Annex A is built upon the structure of ISO/IEC 15444-1 and ISO/IEC 15444-2 file formats.

All these specifications require that readers ignore objects that are unrecognizable to them.

This document shall take precedence over those on which it is based, in any case where there are differences or conflicts; however, no such conflicts are known to exist.

For better readability and understanding the syntax description for the different file formats is done in the same way as in the base formats.

8 Organization of the document

Annex A specifies the JPEG Pleno box-based file format, which includes definitions of boxes to carry light field, point cloud and holographic data. Every JPEG Pleno file shall conform to the specified file format syntax.

Annex B specifies the JPEG Pleno reference grid system, a coordinate system that allows for positioning plenoptic modalities in a global reference grid system, while using a local coordinate system per plenoptic element to facilitate efficient local addressing.

Annex C provides an example of how plenoptic objects can be signalled using the JPEG Pleno framework.

2) Under preparation.

Annex A
(normative)

JPEG Pleno file format (JPL)

A.1 General

This annex defines a still image file format that applications may choose to wrap a codestream based on a JPEG Pleno encoded image. This document is based on the same syntax as the box-based file format for JPEG 2000 in ISO/IEC 15444-1:2019, Annex I or ISO/IEC 15444-2:2004, Annex M.

This annex:

— specifies a binary container (file) for both light field and metadata;

— specifies a mechanism to indicate light field properties, such as the tone scale or colour space of the image;

— specifies a mechanism by which readers may recognize the existence of intellectual property rights information in the file;

— specifies a mechanism by which metadata (including vendor-specific information) can be included in files specified by this document.

A.2 Specification of the JPL file format

A.2.1 General

The JPL file format provides a foundation for storing application specific data (metadata) in association with a JPEG Pleno codestream, such as information which is required to display the light field. As many applications require a similar set of information to be associated with the coded light field data, it is useful to define the format of that set of data along with the definition of the coding technology and codestream syntax.

Conceptually, the JPL file format encapsulates the JPEG Pleno codestream along with other core pieces of information about that codestream. The building-block of the JPL file format is called a "box". All information contained within the JPL file is encapsulated in boxes. This document defines several types of boxes; the definition of each specific box type defines the kinds of information that may be found within a box of that type. Some boxes will be defined to contain other boxes.

A.2.2 File identification

JPL files can be identified using several mechanisms. When stored in traditional computer file systems, JPL files should be given the file extension ".jpl" (readers should allow mixed case for the alphabetic characters).

A.2.3 File organization

A JPL file represents a collection of boxes. Some of those boxes are independent, and some of those boxes contain other boxes, denoted here as "superboxes". The binary structure of a file is a contiguous sequence of boxes. The start of the first box shall be the first byte of the file, and the last byte of the last box shall be the last byte of the file.

The binary structure of a box is identical to ISO/IEC 15444-1 and defined in Annex A.3.

The conceptual structure of a JPL file is shown in Figure A.1. Boxes with dashed borders are optional in conforming JPL files. However, an optional box may define mandatory boxes within that optional box. In that case, if the optional box exists, those mandatory boxes within the optional box shall exist. If the optional box does not exist, then the mandatory boxes within those boxes shall also not exist.

Figure A.1 specifies only the containment relationship between the boxes in the file.

The order of the boxes is not completely arbitrary and shall conform to the following rules:

— The JPEG Pleno Signature box shall be the first box in a JPL file and the File Type box (defined in ISO/IEC 15444-1) shall immediately follow the JPEG Pleno Signature box.

— The JPEG Pleno Thumbnail box shall be signalled before the JPEG Pleno Light Field, JPEG Pleno Point Cloud, and JPEG Pleno Hologram superboxes.

— A JPL file can contain an optional XML box signalling catalog information (see A.5.8). An XML box containing catalogue information should be signalled after the File Type box and before the first superbox containing plenoptic data.

— The JPEG Pleno Light Field, JPEG Pleno Point Cloud, and JPEG Pleno Hologram superboxes signalling plenoptic data, shall be signalled as one monolithic block with no preferred ordering, and no other boxes shall be signalled in between.

The file in Figure A.1 is a strict sequence of boxes. Other boxes may be found between the boxes defined in this document, except the JPEG Pleno Light Field, JPEG Pleno Point Cloud, and JPEG Pleno Hologram superboxes. However, all information contained within a JPL file shall be in the box format; byte-streams not in the box format shall not be found in the file.

A JPL file may also contain an IPR box and one or more XML, UUID and UUID Info boxes. If present these boxes shall be as defined in ISO/IEC 15444-1.

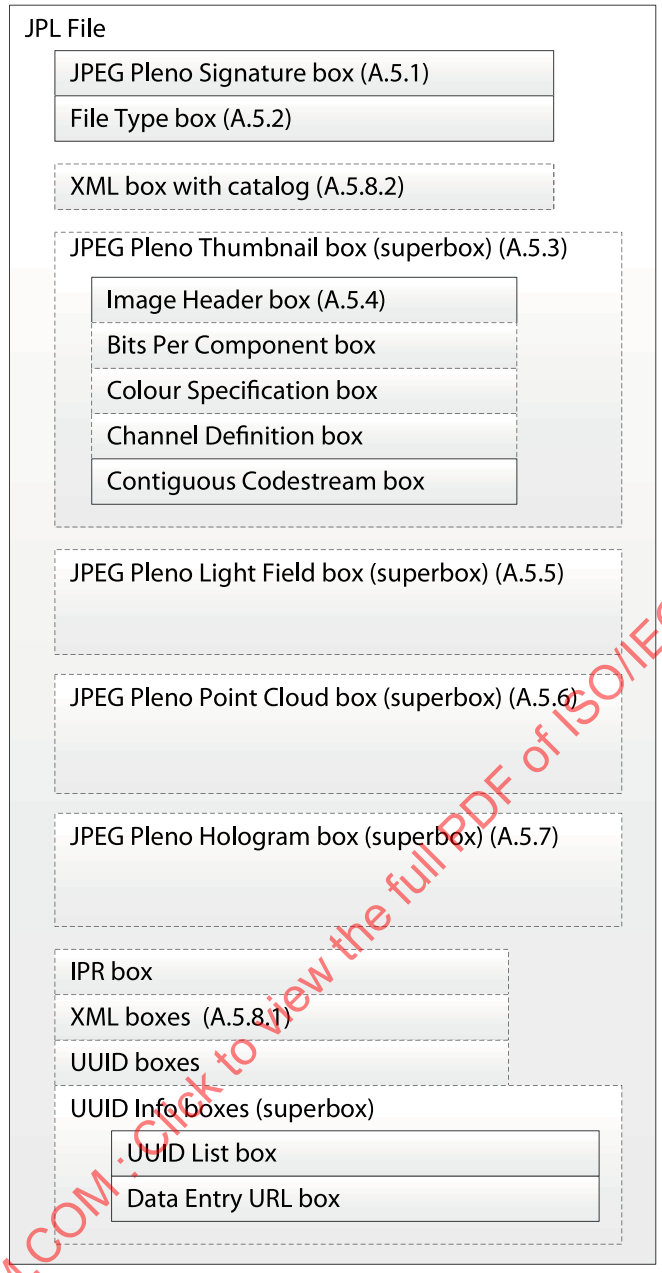

Figure A.1 — Conceptual structure of a JPL file

A.2.4 Metadata

One important aspect of the JPL file format is the ability to add metadata to a JPL file. Some of the boxes provide a set of tools by which applications can add vendor-specific information to the JPL file format, like the XML box. These boxes are optional in conforming files and may be ignored by conforming readers.

A.2.5 Conformance with the file format

All conforming files shall contain all boxes required by this document, and those boxes shall be as defined in this document. Also, all conforming readers shall correctly interpret all required boxes defined in this document and thus shall correctly interpret all conforming files.

Because all information is encapsulated in boxes, and all boxes have types, the format provides a simple mechanism for a reader to extract relevant information, while ignoring any box that contains

information that is not understood by that particular reader. In this way, new boxes can be created, either through this document or other International Standards or private implementation. Also, any new box added to a JPL file shall not change the visual appearance of the image.

A.3 Concept of boxes

A.3.1 Key to graphical descriptions

Each box is described in terms of its function, usage and length. The function describes the information contained in the box. The usage describes the logical location and frequency of this box in the file.

These descriptions are followed by a figure that shows the order and relationship of the parameters in the box. Figure A.2 provides an example. A rectangle is used to indicate the parameters in the box. The width of the rectangle is proportional to the number of bytes in the parameter. A shaded rectangle (diagonal stripes) indicates that the parameter is of varying size. Two parameters with superscripts and a grey area between them indicate a run of several of these parameters. A sequence of two groups of multiple parameters with superscripts separated by a grey area indicates a run of that group of parameters (one set of each parameter in the group, followed by the next set of each parameter in the group). Optional parameters or boxes will be shown with a dashed rectangle.

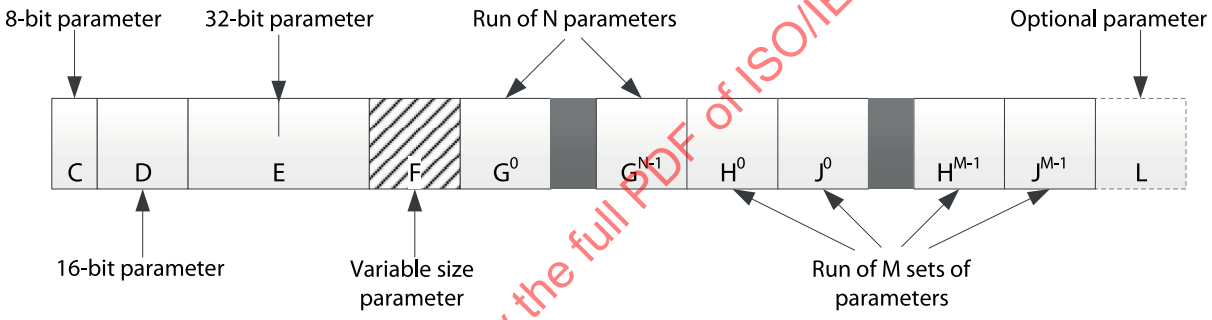

Figure A.2 — Example of a box description figure

The figure is followed by a list that describes the meaning of each parameter in the box. If parameters are repeated, the length and nature of the run of parameters is defined. As an example, in Figure A.2, parameters C, D, E and F are 8-, 16-, 32-bit and variable length respectively. The notation G^0 and G^{N-1} implies that there are N different parameters, G^i, in a row. The parameters pairs H^i and J^i, where i goes from 0 to M-1, specify that the box will contain H^0, followed by J^0, followed by H^1 and J^1, continuing to H^{M-1} and J^{M-1} (M instances of each parameter in total). Finally, the field L is optional and may not be found in this box.

After the list is a table that either describes the allowed parameter values or provides references to other tables that describe these values.

Some boxes may carry other boxes as payload data. Such boxes are denoted as superboxes. The payload size of a superbox is given by the sum of the box lengths of all the boxes it contains.

In addition, in a figure describing the contents of a superbox, an ellipsis (...) will be used to indicate that the contents of the file between two boxes are not specifically defined. Any box (or sequence of boxes), unless otherwise specified by the definition of that box, may be found in place of the ellipsis.

For example, the superbox shown in Figure A.3 must contain an AA box and a BB box, and the BB box must follow the AA box. However, there may be other boxes found between boxes AA and BB. Dealing with unknown boxes is discussed in A.6.

Figure A.3 — Example of the superbox description figures

A.3.2 Box definition

Physically, each object in the file is encapsulated within a binary structure called a box. That binary structure is shown in Figure A.4 and Table A.1.

Figure A.4 — Organization of a box

LBox Box length. This field specifies the length of the box in multiples of bytes, stored as a 4-byte big-endian unsigned integer. This value includes all of the fields of the box, including the length and type. If the value of this field is 1, then the XLBox field shall exist and the value of that field shall be the actual length of the box. If the value of this field is 0, then the length of the box was not known when the LBox field was written. In this case, this box contains all bytes up to the end of the file. If a box of length 0 is contained within another box (its superbox), then the length of that superbox shall also be 0. This means that this box is the last box in the file. The values 2-7 are reserved for future use by ISO/IEC.

TBox Box type. This field specifies the type of information found in the DBox field. The value of this field is encoded as a 4-byte big-endian unsigned integer. However, boxes are generally referred to by an ISO/IEC 646 character string translation of the integer value. For all box types defined within this document, box types will be indicated as both character string and as 4-byte hexadecimal integers. Also, a space character is shown in the character string translation of the box type as "\040". All values of TBox not defined within this document are reserved for future use by ISO/IEC.

XLBox Box extended length. This field specifies the actual length of the box if the value of the LBox field is 1. This field is stored as an 8-byte big-endian unsigned integer. The value includes all of the fields of the box, including the LBox, TBox and XLBox fields.

DBox Box contents. This field contains the actual information contained within this box. The format of the box contents depends on the box type and will be defined individually for each type. While variable length fields can be held with DBox, the length of DBox shall be an integer multiple of octets. Bit-padding shall be provided to ensure this.

Table A.1 — Binary structure of a box

Field name	Size (bits)	Value
LBox	32	0, 1, or 8 to (2^{32}– 1)
TBox	32	Variable
XLBox	64 0	16 to (2^{64}– 1); if LBox = 1 Not applicable; if LBox ≠ 1
DBox	Variable	Variable

For example, consider the illustration in Figure A.5 of a sequence of boxes, including one box that contains other boxes:

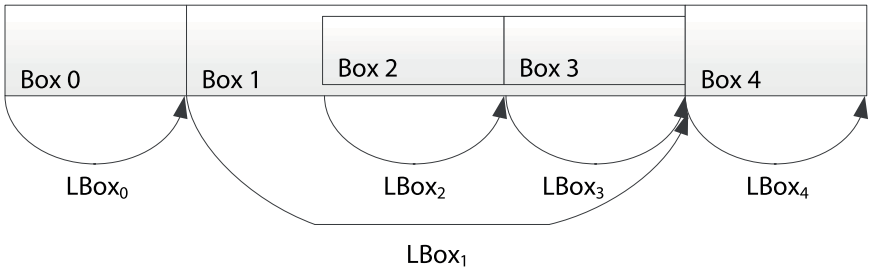

Figure A.5 — Illustration of box lengths

As shown in Figure A.5, the length of each box includes any boxes contained within that box. For example, the length of Box 1 includes the length of Boxes 2 and 3, in addition to the LBox and TBox fields for Box 1 itself. In this case, if the type of Box 1 was not understood by a reader, it would not recognize the existence of Boxes 2 and 3 because they would be completely skipped by jumping the length of Box 1 from the beginning of Box 1.

Table A.2 lists all boxes defined by this document.

A.4 Defined boxes

All conforming readers shall correctly interpret all boxes defined in this document and thus shall correctly interpret all conforming files. Each of these boxes conforms to the standard box structure as defined in A.3.2. The value of the DBox field from Table A.1 (the contents of the box) in defined in Table A.2. Note that LBox, TBox and XLBox fields shall exist for each box in the file as defined in A.3.2.

Table A.2 — Defined boxes

Box name	Type	Superbox	Required?	Comments
JPEG Pleno Signature box (A.5.1)	'jpl\040' (0x6A70 6C20)	No	Required	This box uniquely identifies the file as being part of the JPEG Pleno family of files.
File Type box (A.5.2)	'ftyp' (0x6674 7970)	No	Required	This box specifies file type, version and compatibility information, including specifying if this file is a conforming JPL file or if it can be read by a conforming JPL reader.
JPEG Pleno Thumbnail box (A.5.3)	'jpth' (0x6A70 7468)	Yes	Optional	This box contains a number of boxes that allow the signalling of a thumbnail image that represents the carried plenoptic content.
Image Header box (A.5.4)	'ihdr' (0x6968 6472)	No	Required	This box specifies the size of the image and other related fields.
JPEG Pleno Light Field box (A.5.5)	'jplf' (0x6A70 6C66)	Yes	Optional	This box contains a series of boxes that contain the encoded light field, its parameterization and associated metadata.
JPEG Pleno Point Cloud box (A.5.6)	'jppc' (0x6A70 7063)	Yes	Optional	This box contains a series of boxes that contain the encoded point cloud, its parameterization and associated metadata.
JPEG Pleno Hologram box (A.5.7)	'jpho' (0x6A70 686F)	Yes	Optional	This box contains a series of boxes that contain the encoded hologram, its parameterization and associated metadata.

A.5 Defined boxes

A.5.1 JPEG Pleno Signature box

The JPEG Pleno Signature box identifies that the format of this file was defined by this document, as well as providing a small amount of information which can help determine the validity of the rest of the file. The JPEG Pleno Signature box shall be the first box in the file, and all files shall contain one and only one JPEG Pleno Signature box.

The type of the JPEG Pleno Signature box shall be ‘jpl\040’ (0x6A70 6C20). The length of this box shall be 12 bytes. The contents of this box shall be the 4-byte character string '<CR><LF><0x87><LF>' (0x0D0A 870A). For file verification purposes, this box can be considered a fixed-length 12-byte string which shall have the value: 0x0000 000C 6A70 6C20 0D0A 870A.

The combination of the particular type and contents for this box enables an application to detect a common set of file transmission errors. The CR-LF sequence in the contents catches bad file transfers that alter newline sequences. The final linefeed checks for the inverse of the CR-LF translation problem. The third character of the box contents has its high-bit set to catch bad file transfers that clear bit 7.

A.5.2 File Type box

The File Type box completely defines all of the contents of this file, as well as a separate list of readers, defined by other International Standards, with which this file is compatible, and thus the file can be properly interpreted within the scope of that other document. This box shall immediately follow the JPEG Pleno Signature box. This differentiates between the document which describes the file, from other documents that interpret a subset of the file.

All files shall contain one and only one File Type box. The type of the File Type box shall be 'ftyp' (0x6674 7970). The contents of this box shall be as in Figure A.6 and formatted as in Table A.4.

Figure A.6 — Organization of the contents of a File Type box

BR Brand. This field specifies the International Standard which defines this file. This field is specified by a four-byte string of ISO/IEC 646 characters. The value of this field is defined in Table A.3.

Table A.3 — Allowed Brand values

Value	Meaning
'jpl\040'	ISO/IEC 21794-1
other values	Reserved for future use by ISO/IEC

In addition, the Brand field shall be considered functionally equivalent to a major version number.

NOTE A major version change (if there ever is one), representing an incompatible change in the JPL file format, will define a different value for the Brand field.

If the value of the Brand field is not 'jpl\040', then a value of 'jpl\040' in the Compatibility list indicates that a JPL reader can interpret the file in the manner intended by the creator of the file.

MinV Minor version. The parameter is defined as a 4-byte big-endian unsigned integer. The value of this field shall be zero. However, readers shall continue to parse and interpret this file even if the value of this field is not zero.

CL^i Compatibility list. This field specifies a code representing ISO/IEC 21794-1, another standard, or a profile of another standard, to which the file conforms. This field is encoded as a four-byte string of ISO/IEC 646 characters. A file that conforms to this document shall have at least one CL^i field in the File Type box, and shall contain the value 'jpl\040' in one of the CL^i fields in the File Type box, and all conforming readers shall properly interpret all files with 'jpl\040' in one of the CL^i fields. Properly interprets means that the decoder should operate within the conformance bounds specified by the corresponding standard.

Other values of the Compatibility list field are reserved for future use by ISO/IEC.

The number of CL^i fields is determined by the length of this box.

Table A.4 — Format of the contents of the File Type box

Field name	Size (bits)	Value
BR	32	0 to (2^{32}– 1)
MinV	32	0
CL^i	32	0 to (2^{32}– 1)

A.5.3 JPEG Pleno Thumbnail box (superbox)

This box contains a number of boxes that allow the signalling of a thumbnail image that represents the carried plenoptic content. This is an optional box. The type of the JPEG Pleno Thumbnail superbox shall be ‘jpth’ (0x6A70 7468).

The JPEG Pleno Thumbnail box (Figure A.7) can be embedded in the JPL file and contain an overview image of all plenoptic content that is carried by the JPL, i.e. picturing the plenoptic scene, and/or can be embedded in every separate plenoptic object. Hence, individual JPEG Pleno Light Field, Point Cloud or Hologram boxes may contain a JPEG Pleno Thumbnail box as well proving a snapshot of the content of those boxes.

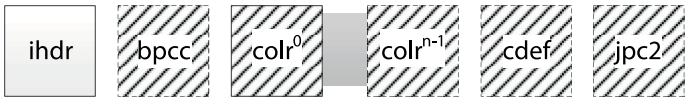

Figure A.7 — Organization of the contents of a JPEG Pleno Thumbnail box

ihdr Image Header box. This box specifies the size of the image, used coding technique and other related fields. This box shall be the first box in the JPEG Pleno Thumbnail box and is specified in A.5.4.

bpcc Bits Per Component box. This box specifies the bit depth of the components in the file in cases where the bit depth is not constant across all components. Its structure is specified in 15444-1.

colr[i] Colour Specification boxes. These boxes specify the colour space of the decoded image. Their structures are specified in ISO/IEC 15444-2. There shall be at least one Colour Specification box within the JPEG Pleno Thumbnail box. The use of multiple Colour Specification boxes provides the ability for a decoder to be given multiple optimization or compatibility options for colour processing. These boxes may be found anywhere in the JPEG Pleno Thumbnail box provided that they come after the Image Header box. All Colour Specification boxes shall be contiguous within the JPEG Pleno Thumbnail box.

cdef Channel Definition box. This box defines the channels in the image. Its structure is specified in ISO/IEC 15444-1. This box may be found anywhere in the JPL Thumbnail box provided that it comes after the Image Header box.

jpc2 This box contains an image codestream. Its structure is specified in ISO/IEC 15444-1.

A.5.4 Image Header box

The format and structure of the Image Header box is identical to that defined in the JPX file format (ISO/IEC 15444-2). The definition in ISO/IEC 15444-2 contains also the table of potential values for the coder type C.

The type of the Image Header box shall be ‘ihdr’ (0x6968 6472).

A.5.5 JPEG Pleno Light Field box (superbox)

The JPEG Pleno Light Field superbox contains boxes that message the light field parameters, encoding configuration, the encoded light field data and associated metadata. The type of the JPEG Pleno Light Field superbox shall be 'jplf' (0x6A70 6C66).

The content of this box shall be as specified in ISO/IEC 21794-2:—[3], Annex A.

A.5.6 JPEG Pleno Point Cloud box (superbox)

The JPEG Pleno Point Cloud superbox contains boxes that message the point cloud parameters, encoding configuration, the encoded point cloud data and associated metadata. The type of the JPEG Pleno Point Cloud superbox shall be 'jppc' (0x6A70 7063).

A.5.7 JPEG Pleno Hologram box (superbox)

The JPEG Pleno Hologram superbox contains boxes that message the hologram parameters, encoding configuration, the encoded hologram data and associated metadata. The type of the JPEG Pleno Hologram superbox shall be 'jpho' (0x6A70 686F).

A.5.8 XML box

A.5.8.1 General

The format and structure of the XML box is identical to that defined in the JP2 file format (ISO/IEC 15444-1). However, here a particular XML schema is defined that allows for signalling catalogue information on the JPL file.

3) Under preparation. Stage at time of publication: ISO/IEC DIS 21794-2:2019.

A.5.8.2 JPEG Pleno file catalogue

The schema elements of the JPL file contain information on the plenoptic modalities that are contained in the JPEG Pleno file. The schema provides a basic catalogue of the contained modalities, i.e., Pleno elements, their type, their descriptive level and offset position in the JPEG Pleno file. Their definition is provided in Table A.5.

This optional XML box containing catalogue information should be signalled after the File Type box and before the first superbox containing plenoptic data.

Table A.5 — Definition of JPEG Pleno schema descriptor elements

Schema elements				Meaning	Data type
jpeg-pleno-file				Root element.	complexType
	pleno-elements			Listing of all Pleno elements embedded in the file.	complexType
		pleno-element		Pleno element.	complexType
			type	Type of the pleno element (light field, hologram or point cloud).	"lightfield" | "hologram" | "pointcloud"
			label	Descriptive label.	string
			offset	Offset in bytes of the starting position of the element's box, starting from the first element in the sequence.	64 bit unsigned integer

The following XSD schema describes the JPL file content:

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name="jpeg-pleno-file">
    <xs:complexType>
      <xs:element name="pleno-elements">
        <xs:complexType>
          <xs:sequence>
            <xs:element name="pleno-element" maxOccurs="unbounded" minOccurs="1">
              <xs:complexType>
                <xs:sequence>
                  <xs:element name="type">
                    <xs:simpleType>
                      <xs:restriction base="xs:string">
                        <xs:enumeration value="lightfield"/>
                        <xs:enumeration value="hologram"/>
                        <xs:enumeration value="pointcloud"/>
                      </xs:restriction>
                    </xs:simpleType>
                  </xs:element>
                  <xs:element name="label" type="xs:string"/>
                  <xs:element name="offset" type="unsignedLong"/>
                </xs:sequence>
              </xs:complexType>
            </xs:element>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <!-- Space reserved for additional elements -->
      <xs:attribute name="version" type="xs:string" use="required"/>
    </xs:complexType>
  </xs:element>
</xs:schema>
```

The following example provides an XML schema of a JPL file that contains a light field and a point cloud. The light field is labelled a 'light field element' and the point cloud a 'point cloud element'.

Their respective offsets in the file are 0, starting to count at the first plenoptic element in the JPL file, and 2048.

```
<?xml version="1.0" encoding="utf-8"?>
<jpeg-pleno-file version="1.0">
  <pleno-elements>
    <pleno-element>
      <type>lightfield</type>
      <label>A light field element</label>
      <offset>0</offset>
    </pleno-element>
    <pleno-element>
      <type>pointcloud</type>
      <label>A point cloud element</label>
      <offset>2048</offset>
    </pleno-element>
  </pleno-elements>
</jpeg-pleno-file>
```

A.6 Dealing with unknown boxes

A conforming JPL file may contain boxes not known to applications based solely on this document. If a conforming reader finds a box that it does not understand, it shall skip and ignore that box.