

## **Action Plan Background: JP2**

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### **Change History:**

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**Preface:** The JPEG 2000 specification (ISO/IEC 15444) is made up of 12 parts, approved and published separately. The first part (ISO/IEC 15444-1 or “Core coding system”) describes the JP2 file format (\*.jp2) and the JPEG2000 “codestream” (image data format).

Since this report was started a second edition of 15444-1 was published. This report is based on:

- the first edition of 15444-1
- drafts of 2 amendments to 15444-1 ([ISO/IEC 2001a], [ISO/IEC 2001b])
- the second edition of 15444-1 Annex I “JP2 file format syntax”

## **1 General Description**

### **1.1 Format Name:** JP2 File

#### **1.2 Version:** 1.0

The version to use for JP2 is debatable. JPEG 2000 files have an internal metadata field labeled 'Brand' that is to be considered equivalent to a major version. For JP2 files the Brand value is 'jp2\040' ('\040' is a space character encoded in the base 8 numbering system). According to the specification, if there is ever a major version change then the value of the Brand field will be changed. There is a MinV (minor version) metadata field which is equal to 0 for JP2 files.

The specification that describes JP2 is in its second edition but the definition of a JP2 file didn't change in the newer version, nor did the value used for Brand and MinV. For simplicity the version of JP2 will be considered '1.0' instead of 'jp2\040 0' until there is a major change to the JP2 specification.

#### **1.3 MIME media type name:** image

#### **1.4 MIME subtype:** jp2

**1.5 Short Description:** a container for a single JPEG 2000 codestream (image) along with metadata about the codestream.

#### **1.6 Common Extensions:** .jp2 (mixed case should be allowed by readers)

#### **1.7 Color depth:** can have from 1 to 16,384 components, each from 1 to 38 bits

**1.8 Color Space:** A JP2 file can have any of the following enumerated color spaces: sRGB, greyscale and sRGB YCC. This last color space was added by [ISO/IEC 2001b]. As an alternative, JP2 files can specify color space by including a restricted form of an ICC profile as

defined by the ICC Profile Format Specification (ICC.1:1998-09). The profile's class can be Monochrome Input or a Three-Channel Matrix-Based Input class. These particular profiles are used to specify a greyscale or RGB color space. Lastly, the JP2 file supports palettized (indexed) images.

**1.9 Compression:** The JP2 format contains a single image that uses JPEG 2000 compression. It can be lossy (compression ratio up to 200:1) or lossless (compression ratio up to 2:1).

**1.10 Progressive Display:** yes, by resolution, quality (pixel accuracy), region and/or component. The way in which the image can be progressively displayed depends on how the image data was structured during creation.

**1.11 Animation:** no

**1.12 Byte order** big-endian

**1.13 Magic number(s):**

All JPEG 2000 formats start with the JPEG 2000 Signature box, which has the values: 0x0000 0x000C 0x6A50 0x2020 0x0D0A 0x870A

A JP2 format will follow the JPEG 2000 Signature box with the File Type box. Its contents contain a Brand field equal to 'jp2\040' (0x6a70 0x3220) if the file is completely defined by the JP2 specification. If the file is merely compatible with the JP2 specification, the brand will be something other than 'jp2\040', but 'jp2\040' will be one of the values in another field in this box, the Compatibility list.

**1.14 Specification Requirements:**

A JP2 file is structurally a sequence of 'boxes'. Some types of boxes, 'superboxes', can contain other boxes. The box structure is also used by QuickTime and MPEG-4 formats<sup>1</sup>.

- All data in the file must be in 'box' format. The box format is a variable length structure. The first 4 bytes of a box specify the length of the box, except when the value of the first four bytes is equal to 1. In that case, the length of the box is stored in the 9th through the 16th bytes. Each box has a type, identifiable by the second 4 bytes of the box.

Box requirements:

- All boxes must be at least 8 bytes long.
- If the first four bytes have the value 0x0001, then the box must have at least 16 bytes, and the second eight bytes can have a value between 16 and (2<sup>64</sup> -1 ) inclusive.
- The first four bytes can have the value 0, 1, or 8 through (2<sup>32</sup> -1) inclusive.
- The first Colour Specification box found in the file must use a color specification method that is defined in the JP2 spec. Any additional Colour Specification boxes in the file may use color specification methods defined outside of the JP2 specification.
- Other boxes besides those described in the JP2 specification may exist in a JP2 file, but they must be in correct box format.

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<sup>1</sup> Apple's QuickTime format was used as a model to create the MPEG-4 file format (MP4 version 1). MPEG-4's structure was generalized into JPEG 2000 part 12's ISO Base Media File Format. The result is that all these formats have the same box or 'atom' structure.

Table 1 shows the box requirements for the JP2 format in more detail.

**Table 1: JP2 Format Requirements.** In the Nesting requirements column, “Top-level” means that this box is not found inside of another box.

<i>Box Type</i>	<i>Obligation (R = required O = Optional)</i>	<i>Nesting requirements (hierarchical location in relation to other boxes)</i>	<i>Sequencing requirement (sequence in relation to other boxes)</i>	<i>Cardinality (how many a JP2 can have)</i>
JPEG 2000 Signature	R	top-level	must be first box in file	1
File Type	R	top-level	right after JPEG 2000 Signature box	1
JP2 Header	R	top-level	somewhere before the Contiguous Codestream box	1
Image Header	R	within JP2 Header box	none	1
Bits Per Component	O	within JP2 Header	none	1
Colour Specification	R	within JP2 Header box	none	multiple
Palette	O	within JP2 Header box	none	1
Component Mapping	R if the Palette box exists (otherwise can't have one)	within JP2 Header box	none	1
Channel Definition	O	within JP2 Header box	none	1
Resolution	O	within JP2 Header box	none	1
Capture Resolution	O, but one or the other or both must exist if the Resolution box exists	within Resolution box	none	1
Default Display Resolution		within Resolution box	none	1
Contiguous Codestream	R	top-level	somewhere after the JP2 Header box	multiple <sup>2</sup>
XML	O	top-level	none	multiple
UUID	O	top-level	none	multiple
Intellectual Property Rights (IPR)	O	top-level	none	1 assumed but not explicit
UUID Info	O	top-level	none	multiple
UUID List	R if UUID box exists	within UUID Info box	none	1 per UUIDInfo box

<sup>2</sup> Although ISO/IEC 15444-1 allows for multiple codestreams in a JP2 file, section I.5.4. states that conforming JP2 readers should ignore all but the first codestream.

<i>Box Type</i>	<i>Obligation (R = required O = Optional)</i>	<i>Nesting requirements (hierarchical location in relation to other boxes)</i>	<i>Sequencing requirement (sequence in relation to other boxes)</i>	<i>Cardinality (how many a JP2 can have)</i>
Data Entry URL <sup>3</sup>	R if UUID box exists	within UUID Info box	none	1 per UUIDInfo box

## **2 Contents and Features**

### **2.1 Essential and Distinguishing Characteristics**

The JP2 format is the simplest ISO/IEC-specified container for JPEG 2000 codestreams. The format contains a single JPEG 2000-compressed image along with technical metadata about the image. The JPEG 2000 compression can be lossy or lossless. JP2 supports a very limited and optional inclusion of intellectual property rights information. JP2 files can contain zero or more well-formed XML instances within XML boxes. A JP2 file can optionally include a UUID (Universally Unique Identifier) based on ISO/IEC 11578:1996.

### **2.2 Internal Metadata**

**Table 2:** The metadata that can be extracted from a JP2 file.

<i>metadata element (G = general file metadata, GI = general image metadata, F = format-specific metadata)</i>	<i>Obligation (R = required in file, S= supplied by spec., O = Optional in file)</i>
Byte order [G]	S
Specification version (major and minor version) [G] (File type box)	R
Compatible Standards/Profiles [G] (File type box)	O
Compression [GI] (Image header box)	R
Whether or not the file contains intellectual property rights information [G] (Image header box)	R
Image height [GI] (Image header box)	R
Image width [GI] (Image header box)	R
Number of components in codestream [GI] (Image header box)	R
Bits per component [GI] (Image header or JP2 header box)	R
Whether the bits per sample are the same for every sample [GI] (Image header box)	R
Whether the components contain signed or unsigned values [GI] (Image header box)	R
Whether or not the actual colorspace is known [GI] (Image header box)	R
Colorspace [GI] (Colour specification box)	R

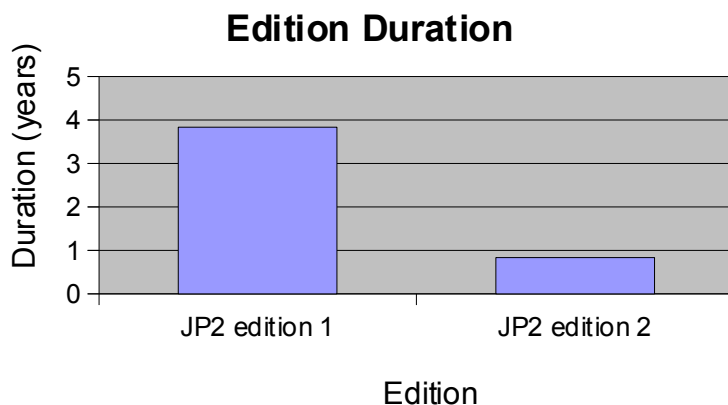
<sup>3</sup> Table I-2 of ISO/IEC 15444-1 calls this box the “URL box” but elsewhere in the specification it is called the “Data Entry URL box”.

<i>metadata element (G = general file metadata, GI = general image metadata, F = format-specific metadata)</i>	<i>Obligation (R = required in file, S= supplied by spec., O = Optional in file)</i>
How closely the color specification method approximates the correct colorspace definition [GI] (Colour specification box)	R
ICC color profile [GI] (Colour specification box)	O
Palette table [GI] (Palette box)	O
Capture resolution - vertical [GI] (Resolution box)	O
Capture resolution - horizontal [GI] (Resolution box)	O
Default display resolution - vertical [GI] (Resolution box)	O
Default display resolution - horizontal [GI] (Resolution box)	O
Resolution unit [GI] (Resolution box)	S
Opacity of components [GI] (Channel definition box)	O

### 3 Usefulness

**3.1 Version Duration:** The first edition of ISO/IEC 15444-1 was published on December 15, 2000. The second edition was published on September 23, 2004. It added an enumerated color space (sRGB YCC) and introduced 3 codestream profiles. The essential definition of JP2 did not change.

#### 3.2 History of Prior Versions Duration:



**Figure 1:** Duration in Years of JP2 Specification Editions

**3.3 Expected Newer Versions:** There are a couple of amendments to 15444-1 currently being reviewed. These define additional profiles for digital cinema applications. The first amendment defines profiles “2K-profile” and “4K-profile” and is expected to be published in October 2005. The second amendment defines extended profiles related to digital cinema and is expected to be published in 2007 [ISO/IEC 2005].

#### 3.4 Existence of Publicly Available Complete Specifications:

The second edition of the JPEG 2000 International Standard part 1 (ISO/IEC 15444-1), in which the JP2 format is specified, is available for purchase from the ISO website ([www.iso.org](http://www.iso.org)).

Early drafts of ISO/IEC 15444-1 and two related amendments are available for free from the JPEG Committee's website ([www.jpeg.org](http://www.jpeg.org)). While the early draft of 15444-1 has significant differences from the final version, the JPEG committee was able to get permission to make the final version of Annex I, which specifies the JP2 format, available for free download.

### **3.5 Specifications-controlling Body:**

Joint Technical Committee ISO/IEC JTC 1, Information technology, Subcommittee SC 29, Coding of audio, picture, multimedia and hypermedia information, in collaboration with ITU-T.

### **3.6 Related Legal Issues:**

Appendix L of 15444-1 lists 17 companies from which ISO/IEC has received statements related to patents the companies hold that are related to the information covered in the specification. These companies have assured ISO/IEC that “they are willing to negotiate licenses under reasonable and non-discriminatory terms and conditions with applicants throughout the world”. Note that this doesn't say on a fee-free basis. It further states that there could exist additional patents owned by other companies not listed in the appendix.

According to the JPEG Committee's website, the WG1 believed that as of July 17, 2003 the companies holding patents related to the essential parts of 15444-1 were not charging any fees.

ITU-T has compiled a patent database containing all the patents communicated to the Telecommunication Standardization Bureau (TSB) that are related to ITU-T recommendations like the JPEG 2000 standard. The database can be downloaded as a flat file from <http://www.itu.int/ITU-T/dbase/patent/index.html>. The database is not complete but it does contain licensing declarations from 12 companies or individuals who have 28 patents related to JPEG 2000 part 1 (ITU-T T.800). For the declaration, one of three subclauses from the Statement on ITU-T Patent Policy is chosen indicating the rights they do or do not waive. Table 3 summarizes the declarations.

**Table 3:** Licensing declarations made by holders of patents relevant to 15444-1 in the ITU-T database. Note that 1 declaration was made with subclause 2.3. An Internet search turned up an ITU document<sup>4</sup> that indicated that this patent and 5 other patents with 2.3 declarations were found to be non-essential patents for JPEG 2000 part 1.

<i>Subclause (wording taken from [ITU 2005] )</i>	<i>Number</i>	<i>Percent</i>
<b>2.1</b> The patent holder waives his rights; hence, the Recommendation is freely accessible to everybody, subject to no particular conditions, no royalties are due, etc.	23	82.0%
<b>2.2</b> The patent holder is not prepared to waive his rights but would be willing to negotiate licenses with other parties on a non-discriminatory basis on reasonable terms and conditions. Such negotiations are left to the parties concerned and are performed outside the ITU-T.	4	14.3%
<b>2.3</b> The patent holder is not willing to comply with the provisions of either paragraph 2.1 or paragraph 2.2; in such case, no Recommendation can be established.	1	3.6%
	28	100.0%

### 3.7 Application and Platform Support:

At the time that the first JPEG 2000 specification was published, it was expected to quickly replace the JPEG format. Applications that were expected to make use of JPEG 2000 include web browsers, digital cameras and graphics design software.

As of this writing, no major web browsers natively (without plug-ins) support any JPEG 2000 formats. There has been no indication from Microsoft that the next version of Internet Explorer (7) will support JPEG 2000. The beta version of Internet Explorer 7 does not. Support for JPEG 2000 in Mozilla web browsers has been on their enhancement list for five years. A discussion<sup>5</sup> between Mozilla developers about implementing JPEG 2000 support points to confusion over JPEG 2000's licensing requirements and a lack of a suitably-licensed JPEG 2000 library that can decode images as they are downloading. Because QuickTime 7.0 now supports JPEG 2000, Safari, a Mac OS X web browser which supports QuickTime, should be able to support JPEG 2000 indirectly.

Very few digital cameras support JPEG 2000. One reason for this may be that camera memory costs have decreased significantly in the last few years and so there is little demand for the higher compression of JPEG 2000. Another reason may be that without widespread web browser and other application support, camera manufacturers do not have any incentive to support it.

In the last few years, graphics software have started to support JPEG 2000. Several Adobe products like Photoshop CS and Elements support JPEG 2000, after the user manually installs a plug-in that ships with the product. ImageMagick supports JPEG 2000 using the open source JasPer library. Gimp<sup>6</sup> has had JPEG 2000 support on its enhancement list for 2 years but, like Mozilla, seems to be making little progress for some of the same reasons.

<sup>4</sup> The document is at:

<ftp://tiaonline.org/tr-30/tr305/Public/ITU-T%20SG16%20Documents/Brazil-Q14-Docs/1-004.doc>

<sup>5</sup> Read the discussion at [https://bugzilla.mozilla.org/show\\_bug.cgi?id=36351](https://bugzilla.mozilla.org/show_bug.cgi?id=36351)

<sup>6</sup> Gimp (GNU Image Manipulation Program), [www.gimp.org](http://www.gimp.org), is a popular open source alternative to Adobe Photoshop.

There are only a handful of JPEG 2000 encoding/decoding libraries. Part 5 of the JPEG 2000 standard included the creation of open-source reference software - JasPer and JJ2000. Unfortunately, neither version of software released with the standard completely implements a conforming JP2 reader. They don't support palettized color, component mapping or Restricted ICC Profiles. Work on JJ2000 ended in September 2001. JasPer is still being maintained and is being used by many open source software projects. Other 15444-1 implementations include Kakadu, LuraWave<sup>7</sup> and the Aware codec.

An unexpected use of JPEG 2000 has started to emerge. Digital Cinema Initiative (DCI)<sup>8</sup>, a joint venture of seven motion picture studios, chose the JPEG 2000 format for use in digital cinema applications. Upcoming amendments to 15444-1 will define profiles tailored for digital cinema [ISO/IEC 2005].

### **3.8 Limitations:**

The JP2 format itself is fairly simple and well-defined. Any technical complexity associated with it is due to the JPEG 2000 codestream contained by the JP2 file. The JPEG 2000 encoding/decoding process is more memory-intensive than simpler image compression schemes. The encoding process of the image is important because it affects how the image can be progressively displayed. Depending on the encoding process, a JPEG 2000 image can be displayed progressively by quality, resolution, component or region. Particle parts of an image, or "regions of interest", can be encoded in a higher resolution than the rest of the image.

A JP2 image can contain XML in one or more optional XML boxes. Because XML can refer to schema or external entities, a JP2 file may depend on external files. The optional Data Entry URL box is another location within a JP2 that may point to external files.

The optional Intellectual Property Box is not well-defined in 15444-1. It was meant to be a "means to allow applications to recognize the existence of IPR information" but not necessarily interpret its contents. IPR is addressed in more depth by part 8 of the JPEG 2000 standard.

### **3.9 Perceived Popularity:**

Although JPEG 2000 is widely accepted by various standards groups and niche groups, it is not yet supported by many applications and electronics used by the general public. The use of JPEG 2000 is somewhat hidden because it is used as the image storage format for many web applications and converted to more web browser-friendly formats on-the-fly when an image is requested. According to the JPEG Committee, this is the case with MapQuest.com.

There is a lot of interest in JPEG 2000 in the library community as measured by the content of professional conferences, journals and newsletters. Features of JPEG 2000 formats like embedded metadata, ICC color profiles, and support for lossless compression are appealing for digital preservation purposes. A website dedicated to news and discussions related to the adoption of JPEG 2000 by archives and libraries can be found at <http://j2karclib.info/>.

## **4 Related Formats**

### **4.1 Specification Variations:**

Part 4 of the JPEG 2000 standard defines JPEG 2000 profiles.

There are two profiles, profile-0 and profile-1, of JPEG 2000 codestreams defined by an amendment to the first edition of 15444-1. The profiles restrict how the codestream can be constructed and what codestream markers can be used. Profile-0 is more restrictive than profile-

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<sup>7</sup> <http://www.luratech.com/products/lurawave/>

<sup>8</sup> <http://dcimovies.com/>



1. The amendment states that codestreams not conforming to profile-0 or profile-1 can be called profile-2, so essentially three profiles are defined by the amendment.

The US National Imagery and Mapping Agency (NIMA) and NATO have developed some JPEG 2000 profiles such as BPJ2K and NISF. Some of these profiles are supported by GIS applications like ERMapper and GeoExpress as well as the Aware codec.

An amendment to 15444-1 in review will introduce profiles tailored for digital cinema applications, 2K-profile and 4K-profile.

#### **4.2 Auxiliary Specifications:**

Section 2 of 15444-1 lists 13 ISO/IEC, W3C and IETF specifications referenced by 15444-1.

### **5 Summary and Conclusions**

The JP2 format is the simplest ISO/IEC format designed to encapsulate a JPEG 2000 codestream together with its metadata. A conforming JP2 is required to contain general image technical metadata but can optionally include any XML and IPR metadata.

JPEG 2000 is appealing for both image delivery and digital preservation. Because it supports display in varying resolutions, quality and different regions from the same image, less files can be stored. Because it is an international standard and can support lossless compression and embedded metadata, it seems amenable to long-term preservation. Note that depending on the use of the images - whether primarily for delivery or as archival masters or both, different JPEG 2000 / JP2 requirements may be desired. If the use includes being an archival master, lossless compression should be used.

Although application support for JPEG 2000 / JP2 is still minimal, JP2 is the least complex of the JPEG 2000 family of file formats and is likely to be the first to be widely supported. In particular the more restrictive profiles defined by the amendment to 15444-1 are likely to be supported.

Something to watch out for is the somewhat dangerous combination of the popularity of the format amongst libraries and the relative dearth of widely available encoding/decoding software that fully implements the JPEG 2000 standard. Particular care needs to be taken for this format to ensure any JP2 files that the archive ingests are valid according to the specification.

### **6 References**

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