Action Plan Background: JPX

Author: Andrea Goethals
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Change History:

Preface: The JPEG 2000 specification (ISO 15444) is made up of 12 parts, approved and published separately. The second part (ISO/IEC 15444-2 or "Extensions") describes the JPX file format. The specification states that a JPX reader does not have to support all the features described in the specification. A subset of the features is defined as 'JPX baseline'.

1 General Description

1.1 Format Name: JPX File

1.2 Version: 1.0
See the discussion of version in JPEG 2000 formats in the JP2 Action Plan Background Report. The Brand value for JPX files is 'jpx\040'.

1.3 MIME media type name: image

1.4 MIME subtype: jpx

1.5 Short Description: a container for one or more JPEG 2000 codestreams (images) along with metadata about the codestreams

1.6 Common Extensions: .jpf (preferred by the specification because .jpx was already in use), .jpx (more common)

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

1.8 Color Space: bi-level, YCbCr(1), YCbCr(2), YCbCr(3), PhotoYCC, CMY, CMYK, YCCK, CIELab, Bi-Level(2), sRGB, greyscale, sYCC, CIEJab, e-sRGB, ROMM-RGB, YPbPr(1125/60), YPbPr(1150/50), e-sYCC, restricted ICC methods (the Monochrome or Three-Channel Matrix-Based class of input profiles as defined by the ICC Profile Format Specification, v. 2.2.0), any ICC methods, vendor color methods, palettized color

1.9 Compression: The JPX format can have any of the following compression types: uncompressed, Modified Huffman (for bi-level images), Modified READ (for bi-level images), Modified Modified READ (for bi-level images), JBIG, JPEG, JPEG-LS, JPEG 2000, and JBIG2. Although any of these compression types are allowed, the specification says that "support for compression types other than JPEG 2000 ... shall not be required to properly display the file".

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

1.11 Animation: yes by combining multiple codestreams using embedded rendering instructions

1.12 Magic number(s):

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

A JPX format will follow the JPEG 2000 Signature box with the File Type box. Its contents contain a Brand field equal to 'jpx\040' (`0x6a70 0x7820`) if the file is completely defined by the JPX spec. If the file is merely compatible with the JPX spec, the brand will be something other than 'jpx\040', but 'jpx\040' will be one of the values in another field in this box, the Compatibility list.

Unfortunately the specification is a little fuzzy in places regarding the file header. Section M.11.5 states that the JPX format allows the JP2 header box to be located anywhere at the top level of the file (just not within another box). It also says the the JPX baseline definition "may restrict the placement of the box".

1.13 Specification Requirements:

Structurally a JPX file is exactly like a JP2 file in the sense that it is made up of a sequence of 'boxes'. These boxes must meet the same requirements as described in the JP2 Action Plan Background Report. There can not be any data outside of boxes in the file. Like the JP2 format, a JPX file can include boxes that are not described in the specification which can be ignored by JPX parsers. *Table 1* shows the box requirements for the JPX format.

Table 1: JPX Format Requirements

Box Type	***Obligation (R = required O = Optional)***	***Nesting requirements (hierarchical location)***	***Sequencing requirements (sequence in relation to other boxes)***	***Cardinality***
JPEG 2000 Signature	R	top-level	must be first in file (although section M.11.5 says otherwise)	1
File Type	R	top-level	right after JPEG 2000 Signature box	1
Reader Requirements	R	top-level	right after File Type box	1
JP2 Header	O	top-level	none	1
Label	O	within JP2 Header, Codestream Header, Compositing Layer Header, or Association box	none	1 per box

Box Type	***Obligation (R = required O = Optional)***	***Nesting requirements (hierarchical location)***	***Sequencing requirements (sequence in relation to other boxes)***	***Cardinality***
Image Header	R within a JP2 Header, O within a Codestream Header (R to have at least one somewhere)	within JP2 Header or Codestream Header box	none	1 per box
Bits Per Component	O	within JP2 Header or Codestream Header box	none	1 per box
Colour Specification	O within JP2 header, R within Colour Group box (R to have at least one somewhere)	within JP2 Header or Colour Group box	none	multiple per box
Palette	O	within JP2 Header or Codestream Header box	none	1 per box
Component Mapping	O	within JP2 Header or Codestream Header box	none	1 per box
Channel Definition	O	within JP2 Header or Compositing Layer Header box	none	1 per box
Resolution	O	within JP2 Header or Compositing Layer Header box	none	1 per box
Capture Resolution	O	within Resolution box	none	1 per box
Default Display Resolution	O	within Resolution box	none	1 per box
Codestream header	O	top-level	none	1 per codestream, or 0
Compositing Layer Header	O	top-level	none	1 per layer
Colour Group	O	within Compositing Layer Header box	none	1 per box
Opacity	O	within Compositing Layer Header box	none	1 per box
Codestream Registration	O (if any Compositing Layer Header box contains one, they all must)	within Compositing Layer Header box	none	1 per box

Box Type	*Obligation (R = required O = Optional)*	*Nesting requirements (hierarchical location)*	*Sequencing requirements (sequence in relation to other boxes)*	*Cardinality*
Data Reference	O	top-level	none	1
Fragment Table	O	top-level	none	multiple
Fragment List	O within Fragment Table, R within Cross-Reference	within Fragment Table or Cross-Reference box	none	multiple within Fragment Table, 1 within Cross-Reference
Contiguous Codestream	O	top-level	none	multiple
Media Data	O	top-level	none	multiple
Composition	O	top-level	none	1
Composition Options	O	within Composition box	first box in Composition box	1
Instruction Set	O	within Composition box	none	multiple
Desired Reproductions	O	anywhere after the Reader Requirements box	none	1
Graphics Tech. Standard Output	O	within Desired Reproductions box	none	1
ROI Description	O	top-level or within JP2 Header, Codestream Header or Association box	none	multiple
Cross-Reference	O	within Codestream Header, Compositing Layer Header, or Association box	none	multiple
Association box	O	anywhere after the Reader Requirements box; can recursively nest within a Association box	none	multiple
Number List	O	within an Association box	none	1 per box
Binary Filter	O	anywhere after the Reader Requirements box	none	multiple
Digital Signature	O	anywhere after the Reader Requirements box	none	multiple
MPEG-7 Binary	O	anywhere after the Reader Requirements box	none	multiple
Free	O	anywhere after the Reader Requirements box	none	multiple
XML	O	top-level or within an Association box	none	multiple
UUID	O	top-level	none	multiple
Intellectual Property Rights	O	top-level	none	1?

Box Type	*Obligation (R = required O = Optional)*	*Nesting requirements (hierarchical location)*	*Sequencing requirements (sequence in relation to other boxes)*	*Cardinality*
UUID Info	O	top-level	none	multiple
UUID List	R within a UUID Info box	within UUID Info box	none	1 per box
Data Entry URL	R within a Data Reference or UUID Info box	within UUID Info or Data Reference box	none	multiple within a Data Reference, 1 per UUID Info box

2 Contents and Features

2.1 Essential and Distinguishing Characteristics

JPX files support all the features of the JP2 format with many additions including:
- support for multiple codestreams (images)
- support for more color spaces (CMYK, CIELab, etc.), including any ICC profiles and vendor colors
- allow image readers to select a color space out of a prioritized list of color spaces
- allows opacity channels to be stored in codestreams separate from the color data
- support full transparency of chroma-keys (specified color combinations)
- support MPEG-7 binary format (BiM) metadata as defined by ISO/IEC 15938
- includes metadata about what requirements a reader of the JPX file must support in order to fully use the file
- supports splitting the image codestream into fragments stored non-contiguously in the file or even outside of the file (including Internet locations)
- supports the combination of multiple codestreams for the purpose of compositing (layering) or animation
- supports the specification of rendering instructions for combining composite layers, namely:
    - rendered result height and width of composition/animation as a whole
    - number of times to loop through rendering instructions
    - number of times to repeat rendering instructions
    - duration and timing of instructions
    - horizontal and vertical offsets of compositing layers
    - rendered result height and width of individual compositing layers
    - horizontal and vertical crop offsets of individual compositing layers
    - horizontal and vertical crop size of individual compositing layers
- parts of the file (presumably metadata such found in an XML box) can be 'filtered' using compression (GZIP using DEFLATE) or encryption (DES)
- supports the specification of ROIs (region of interests) which can be rectangular or ellipse.
- supports inclusion of checksum or digital signature for specific byte streams within the file
- supports the inclusion of metadata for the image identifier, image creation, content description, history and intellectual property rights information. The metadata schema (both DTDs and W3C XML Schema) is included in the specification in sections N.8 and N.9.

2.2 Internal Metadata

Table 2: The metadata that can be extracted from a JPX file. Note that some of the boxes listed in this table, i.e. the Image Creation box and History box, are special types of the XML box and are not included as separate entries in *Table 1*.

Metadata element (G = general file metadata, GI = general image metadata, F = format-specific metadata)	***Obligation (R = required , S= Information given by spec., O = Optional,)***
Byte order [G]	S
Specification version (major and minor version) [G] (File type box)	R
Compatible Standards/Profiles [G] (File type box)	O
Whether or not the file contains intellectual property rights information [G] (Image header box)	R
Checksum (MD5 or SHA-1) for a contiguous range of bytes in the file [G] (Digital signature box)	O
Digital signature (DSA, RSA/MD5, RSA/SHA-1) for a contiguous range of bytes in the file [G] (Digital signature box)	O
Content description metadata (date/time of creation, description of the event or location the image illustrates) [G] (Content description box)	O
Intellectual property rights metadata [G] (Intellectual property rights box)	O
Whether it contains opacity [GI] (Reader requirements box)	O
Compression [GI] (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 or not the actual colorspace is known [GI] (Image header box)	R
Colorspace [GI] (Colour specification box)	R
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 or Opacity box)	O
Output ICC profile for a specific output device [GI] (Graphics technology standard output box)	O

Metadata element (G = general file metadata, GI = general image metadata, F = format-specific metadata)	*Obligation (R = required , S= Information given by spec., O = Optional,)*
Image creation metadata (camera, lens, scanner, creation software, capture condition, etc.) [GI] (Image creation box)	O
History metadata (image processing steps) [GI] (History box)	O
Whether the codestream contains extensions[1] [F] (Reader requirements box)	O
Whether it contains multiple composition layers [F] (Reader requirements box)	O
Whether it is compressed using JPEG 2000 and needs at least a Profile 0 decoder as defined by ITU-T Rec. T.800 | ISO/IEC 15444-1, A.10 Table A.45 [F] (Reader requirements box)	O
Whether it is compressed using JPEG 2000 and needs at least a Profile 1 decoder as defined by ITU-T Rec. T.800 | ISO/IEC 15444-1, A.10 Table A.45 [F] (Reader requirements box)	O
Whether it is compressed using JPEG 2000 as defined by ITU-T Rec. T.800 | ISO/IEC 15444-1 [F] (Reader requirements box)	O
Whether it is compressed using JPEG 2000 as defined by ISO/IEC 15444-2 International Standard version 1 [F] (Reader requirements box)	O
Whether it is compressed using DCT [F] (Reader requirements box)	O
Whether a compositing layer includes a non-premultiplied opacity channel [F] (Reader requirements box)	O
Whether a compositing layer includes a premultiplied opacity channel [F] (Reader requirements box)	O
Whether a compositing layer specifies opacity using a chroma-key value [F] (Reader requirements box)	O
Whether the codestream is contiguous [F] (Reader requirements box)	O
Whether the codestream is fragmented such that all fragments are in this file and in order [F] (Reader requirements box)	O
Whether the codestream is fragmented such that all fragments are in this file but not in order [F] (Reader requirements box)	O
Whether the codestream is fragmented such that all fragments are in multiple local files [F] (Reader requirements box)	O
Whether the codestream is fragmented such that fragments are across the Internet [F] (Reader requirements box)	O
Whether the rendered result is created using compositing [F] (Reader requirements box)	O
Whether support for compositing layers is not required [F] (Reader requirements box)	O
Whether it contains multiple, discrete layers that should not be combined through animation or compositing [F] (Reader requirements box)	O
Whether compositing layers each contain a single codestream [F] (Reader requirements box)	O
Whether compositing layers contain multiple codestreams [F] (Reader requirements box)	O

[1] Extensions are defined as additions to the capabilities of the specification after the specification has been published (ISO/IEC 15444-2 M.2)

Metadata element (G = general file metadata, GI = general image metadata, F = format-specific metadata)	*Obligation (R = required , S= Information given by spec., O = Optional,)*
Whether all compositing layers are in the same color space [F] (Reader requirements box)	O
Whether compositing layers are in multiple color spaces [F] (Reader requirements box)	O
Whether the rendered result is created using animation [F] (Reader requirements box)	O
Whether the rendered result is created using animation, but the first layer covers the entire area and is opaque [F] (Reader requirements box)	O
Whether the rendered result is created using animation, but the first layer does not cover the entire area [F] (Reader requirements box)	O
Whether the rendered result is created using animation, and no layer is reused [F] (Reader requirements box)	O
Whether the rendered result is created using animation, and layers are reused [F] (Reader requirements box)	O
Whether the rendered result is created using animation with persistent frames only [F] (Reader requirements box)	O
Whether the rendered result is created using animation with non-persistent frames [F] (Reader requirements box)	O
Whether the rendered result is created without using scaling [F] (Reader requirements box)	O
Whether the rendered result involves scaling within a layer [F] (Reader requirements box)	O
Whether the rendered result involves scaling between layers [F] (Reader requirements box)	O
Whether it contains ROI metadata [F] (Reader requirements box)	O
Whether it contains IPR metadata [F] (Reader requirements box)	O
Whether it contains Content metadata [F] (Reader requirements box)	O
Whether it contains History metadata [F] (Reader requirements box)	O
Whether it contains Creation metadata [F] (Reader requirements box)	O
Whether or not the codestream is contiguous [F] (Reader requirements box)	O
Whether a portion of the file is digitally signed in a secure method [F] (Reader requirements box)	O
Whether a portion of the file is checksummed [F] (Reader requirements box)	O
Whether the Desired Graphic Arts reproduction is specified [F] (Reader requirements box)	O
Whether a compositing layer uses palettized color space [F] (Reader requirements box)	O
Whether a compositing layer uses restricted ICC profile [F] (Reader requirements box)	O
Whether a compositing layer uses any ICC profile[F] (Reader requirements box)	O
Whether a compositing layer uses sRGB enumerated color space [F] (Reader requirements box)	O
Whether a compositing layer uses sRGB-grey enumerated color space [F] (Reader requirements box)	O
Whether a compositing layer uses BiLevel 1 enumerated color space [F] (Reader requirements box)	O

Metadata element (G = general file metadata, GI = general image metadata, F = format-specific metadata)	*Obligation (R = required , S= Information given by spec., O = Optional,)*
Whether a compositing layer uses BiLevel 2 enumerated color space [F] (Reader requirements box)	O
Whether a compositing layer uses YCbCr 1 enumerated color space [F] (Reader requirements box)	O
Whether a compositing layer uses YCbCr 2 enumerated color space [F] (Reader requirements box)	O
Whether a compositing layer uses YCbCr 3 enumerated color space [F] (Reader requirements box)	O
Whether a compositing layer uses PhotoYCC enumerated color space [F] (Reader requirements box)	O
Whether a compositing layer uses YCCK enumerated color space [F] (Reader requirements box)	O
Whether a compositing layer uses CMY enumerated color space [F] (Reader requirements box)	O
Whether a compositing layer uses CMYK enumerated color space [F] (Reader requirements box)	O
Whether a compositing layer uses CIELab enumerated color space with default parameters [F] (Reader requirements box)	O
Whether a compositing layer uses CIELab enumerated color space with parameters [F] (Reader requirements box)	O
Whether a compositing layer uses CIEJab enumerated color space with default parameters [F] (Reader requirements box)	O
Whether a compositing layer uses CIEJab enumerated color space with parameters [F] (Reader requirements box)	O
Whether a compositing layer uses e-sRGB enumerated color space [F] (Reader requirements box)	O
Whether a compositing layer uses ROMM-sRGB enumerated color space [F] (Reader requirements box)	O
Whether compositing layers have non-square samples [F] (Reader requirements box)	O
Whether compositing layers have labels [F] (Reader requirements box)	O
Whether codestreams have layers [F] (Reader requirements box)	O
Whether compositing layers have different color spaces [F] (Reader requirements box)	O
Whether compositing layers have different metadata[F] (Reader requirements box)	O
URLs referenced by this file [F] (Data Reference box)	O
Horizontal grid size of compositing layer [F] (Codestream Registration box)	O
Vertical grid size of compositing layer [F] (Codestream Registration box)	O
Horizontal resolution of compositing layer [F] (Codestream Registration box)	O
Vertical resolution of compositing layer [F] (Codestream Registration box)	O
Horizontal offset of compositing layer [F] (Codestream Registration box)	O

Metadata element (G = general file metadata, GI = general image metadata, F = format-specific metadata)	*Obligation (R = required , S= Information given by spec., O = Optional,)*
Vertical offset of compositing layer [F] (Codestream Registration box)	O
Rendering instructions for composition/animation [F] (Composition box)	O
Image / composite layer / image set / ROI label [F] (Association box)	O
Type of filter (compression/encryption) used on data in the file [F] (Binary filter box)	O

3 Usefulness

3.1 Version Duration: The first edition of ISO/IEC 15444-2 was published on May 15, 2004, so it is 1 year, 3 months old.

3.2 History of Prior Versions Duration: N/A

3.3 Expected Newer Versions: There is an amendment to 15444-2 labeled 'Extended capabilities marker segment' being reviewed [ISO/IEC 2005].

3.4 Existence of Publicly Available Complete Specifications:
The first edition of the JPEG 2000 International Standard part 2 (ISO/IEC 15444-2), in which the JPX format is specified, is available for purchase from the ISO website (www.iso.org). An early draft of ISO/IEC 15444-2 is available for free from the JPEG Committee's website (www.jpeg.org). The JPEG Committee was able to get permission to provide for free download the final version of two of the specification's annexes, one that described JPX, and one that describes JPX' metadata.

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:

It would be reasonable to expect that because of all the additional features of 15444-2, there is more patented technology involved than in part 1 of the JPEG 2000 standard (15444-1). However the patent statement included in 15444-2 only lists 2 companies that have formally declared patents related to 15444-2, as compared to the 17 companies listed in the patent statement in 15444-1.

As described in the JP2 Action Plan Background Report, the ITU-T maintains a database of patent declarations related to their Recommendations. The database only lists two patents related to 15444-2.

A key difference between the patent statements of 15444-1 and 15444-2 is that the statement in 15444-1 says that the patent holders have assured ISO/IEC that they are willing to "negotiate licenses under reasonable and non-discriminatory terms and conditions with applicants throughout the world". The statement in 15444-2 doesn't say anything like this. Instead it says that "conformance or compliance [with this specification] may require use of an invention covered by patent rights".

3.7 Application and Platform Support:

There is very limited software support for the JPX format. Because the JPX format is so feature-rich as compared to the JP2 format, more than likely there isn't an encoder/decoder that supports all its features. Software claiming to support at least some features of JPX include:

- Kakadu framework (http://www.kakadusoftware.com/)
- Aware JPX SDK, included in ArchivePack (http://www.aware.com/products/compression/archvpck.html)
- Adobe Photoshop JPEG2000 plug-in

3.8 Limitations:

3.8.1 Complexity. The JPX format has support for many different types of file structures including animation, image collections, and different versions of the content within the same file (e.g. print and display versions). Because there is potentially a wide range of requirements for being able to read a JPX file, a JPX file is required to contain a Reader Requirements box[2]. This box tells a JPX reader what special features are used by the file, how it should ideally be displayed, and the minimum acceptable display ("fallback mode").

There are a lot of vague areas in the specification. For example, there is an optional box called the Media Data box (section M.11.9 of 15444-2). The specification says that it can contain fragments of the JPEG 2000 codestream or other media data, such as MPEG-4 audio data but that the box contents in general is not defined by the specification.

3.8.2 External Content. A JPX file can contain part of or entire images outside of the file. Metadata in the Reader Requirements box specifies whether or not any codestream fragments are contained in external local files or in any Internet-addressable files. In a baseline JPX file, all fragments of the first compositing layer in the file must be contained in the file.

3.8.3 External References. Like the JP2 format, the JPX format can contain XML data in XML boxes. The XML box is better defined in 15444-2 as it specifies how to determine the physical location of the schema.

3.9 Perceived Popularity:

The JPX format is not likely to become popular as a general use still image format because of its complexity. It may become popular for applications that require features not supported by other image formats. It seems a good fit for high-end graphics software because of its extensive color space support. GIS applications could take advantage of its support for layer composition and animation. It has extensive support for multiple types of metadata which is appealing for digital preservation purposes.

4 Related Formats

4.1 Specification Variations:

None at this time.

4.2 Auxialiary Specifications:

[2] Some JPX writers were not writing out the Reader Requirement box according to Kakadu documentation. The Kakadu reader now makes exceptions for JPX files that don't have the box in order to display them.

Section 2 of 15444-2 lists 36 ISO/IEC, ITU-T, W3C, ICC, DIG, PIMA, NIST, ANSI and IETF specifications referenced by 15444-1. Section N.2 lists 17 specifications related to JPX extended metadata.

5 Summary and Conclusions

The JPX format is an extremely flexible format allowing for multiple variations on the number of images it contains and where they are physically located. For this reason it is less conducive to interoperability than the JP2 format. The JP2 format contains a single image which is located within the JP2 file. A JPX file could split its image across multiple files or could contain metadata, no image data and a URL pointing to the image data. It is much more difficult to write a reader for JPX files than for JP2 files because of the number of allowed features. The JP2 format was kept relatively simple by putting all the extended features into 15444-2. One result of this, however, is that the JPX format is almost too complex.

One solution to getting the benefits of some of the JPX features without the disadvantages of its complexity would be to develop JPX profiles. For example, one profile could be equivalent to a simple JP2 file but with the addition of being in the CMYK color space (which isn't allowed by JP2).

Fortunately, it is not as hard to parse and validate a JPX file as it is to parse and display it. Because a JPX file has the same simple box structure as a JP2 file, it is relatively easy to check that it is well-formed. The more difficult portion of the validation would be identifying and retrieving any external files containing image content or metadata.

Another area of decision related to the JPX format, for digital preservation, is what if anything to do with the potentially enormous amount of metadata that the file can contain. No other file format to this author's knowledge has ever been designed with such an emphasis on metadata. Seventy-seven pages in 15444-2 are devoted to describing the JPX extended metadata. The metadata is XML-based and concerns image creation, content description, history, and IPR metadata. It could be argued that because the metadata is optional, archives can choose to use it or not depending on their preference.

6 References

[ISO/IEC 2004] ISO/IED JTC1/SC29 WG1. “Information technology - JPEG 2000 image coding system : Extensions”, First edition, ISO/IEC 15444-2 International Standard, May 15, 2004.

[ISO/IEC 2005] ISO/IEC JTC 1/SC 29 Programme of Work, website, August 2005. http://www.itscj.ipsj.or.jp/sc29/29w42901.htm

[Singer et al. 2004] Singer, D.; R. Clark, and D. Lee. “MIME Type Registrations for JPEG 2000 (ISO/IEC 15444)”, Request for Comments: 3745, Network Working Group, April 2004.