

## **Action Plan Background: JFIF 1.02**

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### **Change History:**

04/28/2004 Updated *Section 3.6 Related Legal Issues*.

08/27/20004 Added sections 1.12 (Byte Order), 1.14 (Specification Requirements) and 2.2 (Internal Technical Metadata)

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**Preface:** The file format called 'JPEG' usually refers to the JFIF file format. JPEG (Joint Photographic Experts Group) is actually a family of compression algorithms, not a file format. The JPEG working group defined requirements for a JPEG Interchange Format in ISO 10918-1, but not the file format itself. A JFIF is compatible with the defined requirements of the JPEG Interchange Format, with the addition of the mandatory presence of certain bytes in the file header (see *Section 1.12*).

## **1 General Description**

**1.1 Format Name:** JPEG File Interchange Format (JFIF)

**1.2 Version:** 1.02

**1.3 MIME media type name:** image

**1.4 MIME subtype:** jpeg

**1.5 Short Description:** A format for gray-scale or full-color JPEG-compressed images

**1.6 Common Extensions:** jpg, jpeg

**1.7 Color depth:** 24 (16 million colors)

**1.8 Color Space:** Can have 1 or 3 components. Three components (YCbCr) for true color (sometimes called YUV), or one component (Y) for grayscale (where Y is the luminance). For color images, RGB is converted to YCbCr during JPEG encoding and converted back again to RGB during JPEG decoding for display.

**1.9 Compression:** The JPEG standard (ISO 10918-1) defined four compression modes: sequential, progressive, lossless and hierarchical. For sequential and progressive modes, one of

two entropy encoding processes can be used: Huffman or Arithmetic. In addition, sequential and progressive modes can use either 8-bit or 12-bit samples. Table 1 (adapted from [Miano 1999]) shows the JPEG compression modes. Although JFIF supports the use of any JPEG process, in practice the JPEG baseline process (sequential JPEG with Huffman encoding and 8-bit sample data) is most often used [Miano 1999].

JPEG										
Sequential				Progressive				Lossless		Hierarchical
Huffman		Arithmetic		Huffman		Arithmetic		Original	JPEG-LS	
8-bit	12-bit	8-bit	12-bit	8-bit	12-bit	8-bit	12-bit	Lossless		

**Table 1:** JPEG compression modes defined in ISO 10918-1, with the addition of JPEG-LS which was defined in [JPEG/JBIG 1997]. Baseline JPEG is shaded gray.

**1.10 Progressive Display:** This is possible depending on the JPEG encoding. Sequential JPEG is stored as one single image; progressive JPEG stores the image in a series of scans that display one after the other so that the image becomes more resolute as each higher resolution scan replaces the lower resolution scan before it.

**1.11 Animation:** no

**1.12 Byte Order:** Big-endian

**1.13 Magic number(s):**

JFIF files use big-endian byte order. The JPEG standard defined the 'markers' that are used by JFIF files and other JPEG file formats. JPEG markers are 2-byte sequences of (hex) FF followed by anything other than (hex) 00 or FF.

The first 2 bytes in the file for any JPEG file is the 'SOI' (Start of Image) marker. This is (hex) FF D8. All JPEG files must start with these 2 bytes. The last two bytes of any JPEG file are (hex) FF D9 (the End of Image or 'EOI' marker).

The JFIF format can be identified by the nine additional bytes which must immediately follow the SOI marker. The APP0 marker (hex FF E0) follows the SOI marker. After skipping two bytes, the next five bytes are: hex 4A 46 49 46 ('JFIF') 00.

**1.14 Specification Requirements:**

A file in the JFIF format must meet the requirements of the JFIF specification as well as any requirements of the JPEG International standard's requirements for a JPEG interchange format.

JFIF Requirements:

- JFIF APP0 marker segment (identified by APP0 marker type: "JFIF") right after the SOI marker
- If JFIF extensions are specified in additional APP0 marker segments (identified by APP0 marker type: "JFXX"), they must immediately follow the JFIF APP0 marker

- If application-specific APP0 marker segments are included in the file, they must follow any JFIF APP0 and any JFIF extension APP0 marker segments
- All table specifications used in the encoding process be coded in the bitstream prior to use

JPEG Interchange Format Requirements:

Appendix B of [CCITT 1992] specifies the required ordering of markers, parameters, and entropy-encoded segments; the mandatory parts; the allowed parameter values; and any restrictions which are specific to the various coding processes.

## **2 Contents and Features**

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

A JFIF is a simple container for a JPEG-compressed image. The image can be grayscale or true color. JFIFs can internally store thumbnails of the image although this is hardly used in practice. JFIFs provide only a small subset of the internal technical metadata that TIFF images do, like resolution, image height and width.

### **2.2 Internal Technical Metadata**

<i>Technical metadata element (G = general file metadata, GI = general image metadata, F = format-specific metadata)</i>	<i>Obligation (R = required by spec., S= Information given by spec., O = Optional but described in spec., X = described by publication external to spec., DR = Derivable information from required metadata, DO = derivable information from optional metadata)</i>
Byte order [G]	S
Specification version [G] (APP0)	R
Compression [GI]	S
Image height [GI] (SOF)	R
Image width [GI] (SOF)	R
Bits per sample (sample precision) [GI] (SOF)	R
Number of components [GI] (SOF)	R
Colorspace [GI] (SOF)	DR
Horizontal resolution [GI] (APP0)	R
Vertical resolution [GI] (APP0)	R
Resolution unit [GI] (APP0)	R
Pixel aspect ratio [GI] (APP0)	O
Display orientation [GI]	S
Horizontal sampling factor [F] (SOF)	R
Vertical sampling factor [F] (SOF)	R
JPEG Process [F]	R

<i>Technical metadata element (G = general file metadata, GI = general image metadata, F = format-specific metadata)</i>	<i>Obligation (R = required by spec., S= Information given by spec., O = Optional but described in spec., X = described by publication external to spec., DR = Derivable information from required metadata, DO = derivable information from optional metadata)</i>
Whether a thumbnail image is included in file [F] (APP0)	DR
Thumbnail height in pixels [F] (APP0)	R
Thumbnail width in pixels [F] (APP0)	R
Thumbnail colorspace [F] (APP0)	R

### **3 Usefulness**

**3.1 Version Duration:** 11 years, 1 month

**3.2 History of Prior Versions Duration:** N/A

**3.3 Expected Newer Versions:** No expected newer versions of JFIF but there are newer versions of other JPEG interchange formats (See *4.1 Specification Variations*.)

**3.4 Existence of Publicly Available Complete Specifications:** The JFIF 1.02 specification is freely available from many websites, including the JPEG/JBIG group's site: [www.jpeg.org](http://www.jpeg.org) and the Independent JPEG Group's (IJG) site: [www.ijg.org](http://www.ijg.org). The JPEG Standard (ISO 10918-1) is available from ISO for a fee, but an identical version of the specification [CCITT 1992] is available for free from many websites.

**3.5 Specifications-controlling Body:** The JFIF 1.02 specification was written by Eric Hamilton of C-Cube Microsystems which was bought by LSI Logic in June 2001. JPEG compression is an ISO International standard.

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

Baseline (sequential compression mode with Huffman encoding) JPEGs were believed to be patent-free up until a few years ago. Since that time, it has come to the attention of the JPEG Committee that there may be some patent claims on baseline JPEGs [JPEG/JBIG, 2003]. It has been the intention of the JPEG Committee that its baseline standards be free of royalty and licensing fees. On April 22, 2004 Forgent Networks, owner of Compression Labs, filed suits against 31 world-wide companies for what it claims are infringements of its JPEG-related patent (US Patent 4,698,672 sometimes called '672) [Forgent 2004]. Forgent claims to have the exclusive right to use, license and enforce all the claims under the patent in all fields of use involving digital image compression. The 31 companies represent hardware and software companies that use JPEGs in their products. Forgent had tried unsuccessfully to get these companies to license the technology. It remains to be seen if Forgent's patent claim will stand in

court. The JPEG working group required that all participants in the JPEG standard development process disclose all related patent applications, which apparently was not done in this case. In any event, Forgent's patent expires in October 2006.

There are additional known patents owned by IBM, Mitsubishi, AT&T and others associated with optional JPEG features such as arithmetic coding and hierarchical compression mode. Arithmetic coding cannot legally be used without obtaining one or more licenses. See <http://www.w3.org/Graphics/JPEG/AnnexL.html> for a list of these patents. These JPEG features are not commonly used because the slight benefit of using them over other patent-free JPEG processes does not justify their implementation in JPEG encoders and decoders.

### **3.7 Application and Platform Support:**

JFIF images are supported by many image readers, including web browsers and word processors, on all major operating systems.

### **3.8 Limitations:**

The JFIF baseline format is a lossy compression format. Every time an image is saved as a JFIF image, more data is lost. For instance, if a JFIF image is converted to a TIFF then reconverted to a JFIF, the new JFIF will have lost data that was present in the original JFIF.

JFIF files are simple formats as compared to the TIFF format. They do not store the large amount of technical metadata that a TIFF does.

Because of the way JPEG compression works they are especially useful for true color images that resemble photographs, and not so useful for line drawings (GIFs or PNGs are better for these).

### **3.9 Perceived Popularity:**

JFIF images (commonly called 'JPEGs') are very popular. JPEG compression gives the greatest compression for photographic images of any bitmap format in common use.

## **4 Related Formats**

### **4.1 Specification Variations:**

There are many versions of JPEG file formats besides JFIF that are used by digital cameras and proprietary applications. These formats seem to be compatible with the JPEG standard. They identify themselves by using one of the APPn markers (other than JFIF's APP0) immediately after the SOI marker. The JPEG standard set these APPn markers aside for use by applications. It is very difficult to locate the official specifications for all but a few of these formats but some of this information has been documented by individuals who have experimented with the formats.

- Adobe JPEG - Adobe's version of a JPEG is compliant with the JPEG standard, but not with the JFIF format. These files begin with (hex) FF D8 FF ED or (hex) FF D8 FF EE. Adobe Photoshop can output CMYK JPEG images. These files use the same file extensions as JFIF.

- Exif - a variation of JFIF for digital cameras. These files begin with (hex) FF D8 FF E1, skip two bytes, then (hex) 45 ('E') 78 ('x') 69 ('i') 66 ('f') 00 00. These files use the same file extensions as JFIF. (<http://www.exif.org/specifications.html>)

There are a number of standardized JPEG file formats that have been invented to add features that aren't available in JFIF. Whether or not they become as popular as JFIF remains to be seen.

- JPEG-LS - a lossless/nearly lossless format based on Hewlett-Packard Laboratories' LOCO-I algorithm, currently an ISO/IEC JTC1/SC29 final committee draft. This format is somewhat compatible with the JPEG standard. It adds some markers and doesn't use other markers. (<http://www.jpeg.org/public/fcd14495p.pdf>).

- JPEG2000 - adds additional compression algorithms including lossless and wavelet, supports progressive display, additional color spaces (RGB, LAB, CMYK), full ICC color information, and metadata tags. The standard has 11 parts, only the first has been published as an International standard so far. The JPEG2000 file format is completely different from the JFIF format. The recommended file extension for this format is jp2. (<http://www.jpeg.org/JPEG2000.html>)

- SPIFF (Still Picture Interchange File Format) - an ISO/IEC standard (ISO/IEC IS 10918-3, ITU-T T.84) for exchanging JPEG- and other (MH, MR, MMR, JBIG) compressed images. This is the "official" file format for JPEG compression. It was defined in part 3 of the ISO JPEG standard. JFIF readers should be able to read SPIFF files. SPIFF supports thirteen color models and so it is unlikely that many applications will fully support it [Miano 1999]. SPIFF supports gamma specification, unlike JFIF, so the image brightness can be controlled better with SPIFF. A SPIFF is recognizable by the following header: (hex) FF D8 FF E8. This format uses various file extensions, depending on the compression used in the file (.jpg, .spf and possibly .jbg). (<http://www.jpeg.org/public/spiff.pdf>)

## **5 Summary and Conclusions**

JFIF images are popular and well-supported. They have been around for over 10 years, which is a long time relative to other file formats. JFIF is a simple file format as compared to Tiff. It does not contain as much technical metadata, is restricted in its color spaces and compression, and is not extensible.

There is uncertainty as to whether any patent claims will be filed on the baseline JPEG standard. If claims are filed, this could provide the motivation for migration away from JFIFs (and JFIF variations), similar to the way that many people migrated their GIFs to the PNG format after Unisys began charging licensing fees to generate the GIF format.

JFIF images using certain JPEG processes like arithmetic encoding and hierarchical compression mode have known associated patent issues. Their use should be discouraged.

There are variations of JFIF (Adobe's JPEG and Exif) that can be distinguished from JFIF only by parsing the file's header. Unfortunately for implementers of parsers, these variations are not as feature-restrictive as JFIF and not as well documented. The Adobe JPEG format does not appear to be documented at all, at least not for the public.

Because of the existence of formats that can act as successors to JFIFs, like SPIFF and JPEG2000, and because of potential patent claims, JFIFs are a good candidate for upcoming format migration. Although the JPEG2000 standard is not complete, there appears to be more activity on JPEG2000 software implementations than on SPIFF. This is due in part to the fact that baseline JPEG2000 reference software were created as part 5 of the JPEG2000 specification. At this point in time JPEG2000 seems to be the best successor to JFIF and its variations (Adobe JPEG, Exif).

## **6 References**

[CCITT 1992] International Telegraph and Telephone Consultative Committee (CCITT), “Information Technology - Digital Compression and Coding of Continuous-tone Still Images - Requirements and Guidelines”, Recommendation T.81, International Telecommunications Union (ITU), September 1992.

[Cuturicu and Fromme, 1999] Cuturicu, Cristi and Oliver Fromme. “CRYX's note about the JPEG decoding algorithm”, 1999. ([http://www.coco3.com/text/doc\\_JPEG.txt](http://www.coco3.com/text/doc_JPEG.txt))

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