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**Information technology — JPEG 2000  
image coding system: Reference  
software**

*Technologies de l'information — Système de codage d'image  
JPEG 2000: Logiciel de référence*

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## Electronic attachment:

JASPER	reference software
JJ2000	reference software

## Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO/IEC 15444 may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 15444-5 was prepared by 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. The identical text is published as ITU-T Rec. T.804.

ISO/IEC 15444 consists of the following parts, under the general title *Information technology — JPEG 2000 image coding system*:

- *Part 1: Core coding system*
- *Part 2: Extensions*
- *Part 3: Motion JPEG 2000*
- *Part 4: Conformance testing*
- *Part 5: Reference software*
- *Part 6: Compound image file format*
- *Part 9: Interactivity tools, APIs and protocols*
- *Part 12: ISO base media file format*

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**INTERNATIONAL STANDARD  
ITU-T RECOMMENDATION**

**Information technology –  
JPEG 2000 image coding system: Reference software**

## 1 Scope

ITU-T Rec. T.800 | ISO/IEC 15444-1 defines a set of lossless and lossy compression methods for coding continuous-tone, bi-level, greyscale or colour digital still images. This Recommendation | International Standard provides two independently created software reference implementations of ITU-T Rec. T.800 | ISO/IEC 15444-1, in order to assist implementers of ITU-T Rec. T.800 | ISO/IEC 15444-1 in testing and understanding its content.

The reference software is informative only. This Recommendation | International Standard does not define any additional part of the JPEG 2000 image coding system.

Each version of the reference software contains source code, which may be compiled to provide the following functionality:

- transcoding from selected, widely available image formats into a JPEG 2000 codestream;
- transcoding from selected, widely available image formats into the JP2 file format;
- selection of a wide range of JPEG 2000 encoding options (as documented in each reference software);
- decoding from a JPEG 2000 codestream to a range of selected widely available image formats;
- partial processing of a JP2 file to extract a JPEG 2000 codestream for decoding to a range of selected widely available image formats;
  - NOTE – The reference software does not implement a conforming JP2 file reader. See clause 9.
- some additional tools to help with evaluation and testing.

The reference software is intended for use as a testing and validation tool for other implementations of JPEG 2000, and to help in the understanding of ITU-T Rec. T.800 | ISO/IEC 15444-1. Although components of the reference software may find application in software intended for product development, this was not an objective of the development of this software, and prospective implementors are cautioned against making any estimations of performance or resource usage based on the reference software.

## 2 Normative references

The following Recommendations and International Standards contain provisions which, through reference in this text, constitute provisions of the Recommendation | International Standard. At the time of publication, the editions indicated were valid. All Recommendations and Standards are subject to revision, and parties to agreements based on this Recommendation | International Standard are encouraged to investigate the possibility of applying the most recent edition of the Recommendations and Standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards. The Telecommunication Standardization Bureau of the ITU maintains a list of currently valid ITU-T Recommendations.

### 2.1 Identical Recommendations | International Standards

- ITU-T Recommendation T.800 (2002) | ISO/IEC 15444-1:2002, *Information technology – JPEG 2000 Image Coding System: Core coding system*.

### 2.2 Additional references

- ISO/IEC 9899:1999, *Programming languages – C*.
- ISO/IEC 9945-1:1996, *Information technology – Portable Operating System Interface (POSIX) – Part 1: System Application Program Interface (API) (C language)*.
- ISO/IEC 9945-2:1993, *Information technology – Portable Operating System Interface (POSIX) – Part 2: Shell and utilities*.

### 3 Definitions

For the purposes of this Recommendation | International Standard, the following definitions apply:

- 3.1 bit endian:** The bits of a value representation occur in order from most significant to least significant.
- 3.2 bit:** A contraction of the term "binary digit"; a unit of information represented by a zero or a one.
- 3.3 bit-plane:** A two-dimensional array of bits. In this Recommendation | International Standard, a bit-plane refers to all the bits of the same magnitude in all coefficients or samples. This could refer to a bit-plane in a component, tile-component, code-block, region of interest, or other.
- 3.4 bit stream:** The actual sequence of bits resulting from the coding of a sequence of symbols. It does not include the markers or marker segments in the main and tile-part headers or the EOC marker. It does include any packet headers and in stream markers and marker segments not found within the main or tile-part headers.
- 3.5 box:** A portion of the file format defined by a length and unique box type. Boxes of some types may contain other boxes.
- 3.6 box contents:** Refers to the data wrapped within the box structure. The contents of a particular box are stored within the DBox field within the Box data structure.
- 3.7 byte:** Eight bits.
- 3.8 channel:** One logical component of the image. A channel may be a direct representation of one component from the codestream, or may be generated by the application of a palette to a component from the codestream.
- 3.9 code-block:** A rectangular grouping of coefficients from the same subband of a tile-component.
- 3.10 coder:** An embodiment of either an encoding or decoding process.
- 3.11 codestream:** A collection of one or more bit streams and the main header, tile-part headers, and the EOC required for their decoding and expansion into image data. This is the image data in a compressed form with all of the signalling needed to decode.
- 3.12 coefficient:** The values that are the result of a transformation.
- 3.13 component:** A two-dimensional array of samples. An image typically consists of several components, for instance representing red, green and blue.
- 3.14 compressed image data:** Part or all of a bit stream. Can also refer to a collection of bit streams in part or all of a codestream.
- 3.15 decoder:** An embodiment of a decoding process, and optionally a colour transformation process.
- 3.16 decoding process:** A process which takes as its input all or part of a codestream and outputs all or part of a reconstructed image.
- 3.17 discrete wavelet transformation (DWT):** A transformation that iteratively transforms one signal into two or more filtered and decimated signals corresponding to different frequency bands. This transformation operates on spatially discrete samples.
- 3.18 encoder:** An embodiment of an encoding process.
- 3.19 encoding process:** A process, that takes as its input all or part of a source image data and outputs a codestream.
- 3.20 file format:** A codestream and additional support data and information not explicitly required for the decoding of codestream. Examples of such support data include text fields providing titling, security and historical information, data to support placement of multiple codestreams within a given data file, and data to support exchange between platforms or conversion to other file formats.
- 3.21 header:** Either a part of the codestream that contains only markers and marker segments (main header and tile-part header) or the signalling part of a packet (packet header).
- 3.22 image:** The set of all components.
- 3.23 image area:** A rectangular part of the reference grid, registered by offsets from the origin and the extent of the reference grid.
- 3.24 image area offset:** The number of reference grid points down and to the right of the reference grid origin where the origin of the image area can be found.

- 3.25 image data:** The components and component samples making up an image. Image data can refer to either the source image data or the reconstructed image data.
- 3.26 irreversible:** A transformation, progression, system, quantization, or other process that, due to systemic or quantization error, disallows lossless recovery. An irreversible process can only lead to lossy compression.
- 3.27 JP2:** The name of the file format defined by ITU-T Rec. T.800 | ISO/IEC 15444-1.
- 3.28 JPEG:** Used to refer globally to the encoding and decoding process of the following Recommendations | International Standards:
- ITU-T Recommendation T.81 (1992) | ISO/IEC 10918-1:1994, Information technology – Digital compression and coding of continuous-tone still images: Requirements and guidelines.
  - ITU-T Recommendation T.83 (1994) | ISO/IEC 10918-2:1995, Information technology – Digital compression and coding of continuous-tone still images: Compliance testing.
  - ITU-T Recommendation T.84 (1996) | ISO/IEC 10918-3:1997, Information technology – Digital compression and coding of continuous-tone still images: Extensions.
  - ITU-T Recommendation T.84 (1996)/Amd. 1 (1999), Information technology – Digital compression and coding of continuous-tone still images: Extensions – Amendment 1: Provisions to allow registration of new compression types and versions in the SPIFF header.
  - ITU-T Recommendation T.86 (1998) | ISO/IEC 10918-4, Information technology – Digital compression and coding of continuous-tone still images: Registration of JPEG Profiles, SPIFF Profiles, SPIFF Tags, SPIFF colour Spaces, APPn Markers, SPIFF Compression types and Registration authorities (REGAUT).
- 3.29 JPEG 2000:** Used to refer globally to the encoding and decoding processes in this Recommendation | International Standard and their embodiment in applications.
- 3.30 layer:** A collection of compressed image data from coding passes of one, or more, code-blocks of a tile-component. Layers have an order for encoding and decoding that must be preserved.
- 3.31 lossless:** A descriptive term for the effect of the overall encoding and decoding processes in which the output of the decoding process is identical to the input to the encoding process. Distortion free restoration can be assured. All of the coding processes or steps used for encoding and decoding are reversible.
- 3.32 lossy:** A descriptive term for the effect of the overall encoding and decoding processes in which the output of the decoding process is not identical to the input to the encoding process. There is distortion (measured mathematically). At least one of the coding processes or steps used for encoding and decoding is irreversible.
- 3.33 marker:** A two-byte code in which the first byte is hexadecimal FF (0xFF) and the second byte is a value between 1 (0x01) and hexadecimal FE (0xFE).
- 3.34 marker segment:** A marker and associated (not empty) set of parameters.
- 3.35 packet:** A part of the bit stream comprising a packet header and the compressed image data from one layer of one precinct of one resolution level of one tile-component.
- 3.36 packet header:** Portion of the packet that contains signalling necessary for decoding that packet.
- 3.37 precinct:** A one rectangular region of a transformed tile-component, within each resolution level, used for limiting the size of packets.
- 3.38 precision:** Number of bits allocated to a particular sample, coefficient, or other binary numerical representation.
- 3.39 progression:** The order of a codestream where the decoding of each successive bit contributes to a "better" reconstruction of the image. What metrics make the reconstruction "better" is a function of the application. Some examples of progression are increasing resolution or improved sample fidelity.
- 3.40 quantization:** A method of reducing the precision of the individual coefficients to reduce the number of bits used to entropy code them. This is equivalent to division while compressing and multiplying while decompressing. Quantization can be achieved by an explicit operation with a given quantization value or by dropping (truncating) coding passes from the codestream.
- 3.41 raster order:** A particular sequential order of data of any type within an array. The raster order starts with the top left data point and moves to the immediate right data point, and so on, to the end of the row. After the end of the row is reached, the next data point in the sequence is the left-most data point immediately below the current row. This order is continued to the end of the array.

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- 3.42 reconstructed image:** An image, that is the output of a decoder.
- 3.43 reconstructed sample:** A sample reconstructed by the decoder. This always equals the original sample value in lossless coding but may differ from the original sample value in lossy coding.
- 3.44 reference grid:** A regular rectangular array of points used as a reference for other rectangular arrays of data. Examples include components and tiles.
- 3.45 reference tile:** A rectangular sub-grid of any size associated with the reference grid.
- 3.46 region of interest (ROI):** A collection of coefficients that are considered of particular relevance by some user defined measure.
- 3.47 resolution level:** Equivalent to decomposition level with one exception: the LL subband is also a separate resolution level.
- 3.48 reversible:** A transformation, progression, system, or other process that does not suffer systemic or quantization error and, therefore, allows lossless signal recovery.
- 3.49 sample:** One element in the two-dimensional array that comprises a component.
- 3.50 source image:** An image used as input to an encoder.
- 3.51 subband:** A group of transform coefficients resulting from the same sequence of low-pass and high-pass filtering operations, both vertically and horizontally.
- 3.52 subband coefficient:** A transform coefficient within a given subband.
- 3.53 tile:** A rectangular array of points on the reference grid, registered with and offset from the reference grid origin and defined by a width and height. The tiles which overlap are used to define tile-components.
- 3.54 tile-component:** All the samples of a given component in a tile.
- 3.55 tile index:** The index of the current tile ranging from zero to the number of tiles minus one.
- 3.56 transformation:** A mathematical mapping from one signal space to another.

## 4 Abbreviations and symbols ISO/IEC 15444-5:2003

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### 4.1 Abbreviations

For the purposes of this Recommendation | International Standard, the following abbreviations apply.

<b>CCITT</b>	International Telegraph and Telephone Consultative Committee, now ITU-T
<b>ICC</b>	International Colour Consortium
<b>ICT</b>	Irreversible Colour transformation
<b>IEC</b>	International Electrotechnical Commission
<b>ISO</b>	International Organization for Standardization
<b>ITTF</b>	Information Technology Task Force
<b>ITU</b>	International Telecommunication Union
<b>ITU-T</b>	International Telecommunication Union – Telecommunication Standardization Sector (formerly the CCITT)
<b>JPEG</b>	Joint Photographic Experts Group – The joint ISO/ITU committee responsible for developing standards for continuous-tone still picture coding. It also refers to the standards produced by this committee: ITU-T Rec. T.81   ISO/IEC 10918-1, ITU-T Rec. T.83   ISO/IEC 10918-2, ITU-T Rec. T.84   ISO/IEC 10918-3 and ITU-T Rec. T.87   ISO/IEC 14495-1.
<b>JURA</b>	JPEG Utilities Registration Authority
<b>1D-DWT</b>	One-dimensional Discrete Wavelet Transformation
<b>FDWT</b>	Forward Discrete Wavelet Transformation
<b>IDWT</b>	Inverse Discrete Wavelet Transformation
<b>LSB</b>	Least Significant Bit
<b>MSB</b>	Most Significant Bit



<b>PCS</b>	Profile Connection Space
<b>RCT</b>	Reversible Colour Transformation
<b>ROI</b>	Region of Interest
<b>SNR</b>	Signal to Noise Ratio
<b>UCS</b>	Universal Character Set
<b>URI</b>	Uniform Resource Identifier
<b>URL</b>	Uniform Resource Locator
<b>UTF-8</b>	UCS Transformation Format 8
<b>UUID</b>	Universal Unique Identifier
<b>XML</b>	Extensible Markup Language
<b>W3C</b>	World-Wide Web Consortium

## 4.2 Symbols

For the purposes of this Recommendation | International Standard, the following symbols apply.

<b>0x----</b>	Denotes a hexadecimal number
<b>\nnn</b>	A three-digit number preceded by a backslash indicates the value of a single byte within a character string, where the three digits specify the octal value of that byte
<b>COC</b>	Coding style component marker
<b>COD</b>	Coding style default marker
<b>COM</b>	Comment marker
<b>CRG</b>	Component registration marker
<b>EPH</b>	End of packet header marker
<b>EOC</b>	End of codestream marker
<b>PLM</b>	Packet length, main header marker
<b>PLT</b>	Packet length, tile-part header marker
<b>POC</b>	Progression order change marker
<b>PPM</b>	Packed packet headers, main header marker
<b>PPT</b>	Packed packet headers, tile-part header marker
<b>QCC</b>	Quantization component marker
<b>QCD</b>	Quantization default marker
<b>RGN</b>	Region of interest marker
<b>SIZ</b>	Image and tile size marker
<b>SOC</b>	Start of codestream marker
<b>SOP</b>	Start of packet marker
<b>SOD</b>	Start of data marker
<b>SOT</b>	Start of tile-part marker
<b>TLM</b>	Tile-part lengths marker

## 5 Conventions

The source files provided are supplied in the form of an individual zip file for each source tree. File locations given in this Recommendation | International Standard are expressed relative to the top level of the corresponding source tree. A Unix style file structure and delimiters are assumed.

Basic instructions are provided within the reference software for the installation and compilation of the sources under a variety of operating systems and platforms. No support can be provided by ISO | ITU-T beyond that offered in this Recommendation | International Standard and through links on the official JPEG web site, <http://www.jpeg.org>.