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Information technology — JPEG 2000 image coding system: Extensions for three-dimensional data

Technologies de l'information — Système de codage d'images JPEG 2000: Extensions pour données tridimensionnelles

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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 document 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 15444-10 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.809.

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 8: Secure JPEG 2000*

— *Part 9: Interactivity tools, APIs and protocols*

— *Part 10: Extensions for three-dimensional data*

— *Part 11: Wireless*

— *Part 12: ISO base media file format*

— *Part 13: An entry level JPEG 2000 encoder*

INTERNATIONAL STANDARD
ITU-T RECOMMENDATION

Information technology – JPEG 2000 image coding system: Extensions for three-dimensional data

1 Scope

ITU-T Rec. T.809 | ISO/IEC 15444-10 is a work item subdivision of ISO/IEC 15444 that provides extensions of ITU-T Rec. T.800 | ISO/IEC 15444-1 and ITU-T Rec. T.801 | ISO/IEC 15444-2 for logically cuboidal data sets. In particular, it respects all existing capabilities and syntax of ITU-T Rec. T.800 | ISO/IEC 15444-1 and part of the existing capabilities of ITU-T Rec. T.801 | ISO/IEC 15444-2 for multi-component images, while providing alternatives and extensions to some of those capabilities. Within these constraints, it provides an isotropic specification for three-dimensional data sets; i.e., the project provides identical processing capabilities in all three dimensions even though ITU-T Rec. T.800 | ISO/IEC 15444-1 and ITU-T Rec. T.801 | ISO/IEC 15444-2 codestream syntax differentiates between the two spatial axes and the cross-component axis. The context models currently used in this Recommendation | International Standard are as in ITU-T Rec. T.800 | ISO/IEC 15444-1 and ITU-T Rec. T.801 | ISO/IEC 15444-2. Improved context models will be introduced through an amendment.

2 Normative references

The following Recommendations and International Standards contain provisions which, through reference in this text, constitute provisions of this 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.

– ITU-T Recommendation T.800 (2002) | ISO/IEC 15444-1:2004, *Information technology – JPEG 2000 image coding system: Core coding system*.

– ITU-T Recommendation T.801 (2002) | ISO/IEC 15444-2:2004, *Information technology – JPEG 2000 image coding system: Extensions*.

3 Terms and definitions

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

3.1 3D bit-block: A three-dimensional array of bits. In this Recommendation | International Standard, a 3D bit-block refers to all the bits of the same magnitude in all coefficients or samples. This could refer to a 3D bit-block in a component, tile-component, 3D code-block, region of interest, or other.

3.2 3D code-block: A rectangular three-dimensional grouping of coefficients from the same sub-band of a tile-component.

3.3 3D code-block scan: The order in which the coefficients within a 3D code-block are visited during a coding pass. The 3D code-block is processed in stripes, each consisting of four rows (or all remaining rows if less than four) and spanning the width of the 3D code-block. Each stripe is processed column by column from top to bottom and from left to right. The complete 3D code-block is consequently scanned slice by slice. Within a slice, ITU-T Rec. T.800 | ISO/IEC 15444-1 is followed.

3.4 component (update of ITU-T Rec. T.801 | ISO/IEC 15444-2): Compressed data from the codestream representing a single set of two- or three-dimensional data.

3.5 conforming reader (update of ITU-T Rec. T.800 | ISO/IEC 15444-1): An application that reads and interprets a JP3D file correctly.

3.6 decomposition level (update of ITU-T Rec. T.801 | ISO/IEC 15444-2): A collection of sub-bands where each coefficient has the same spatial impact or span with respect to the original samples. These include the [H|L|X][H|L|X][H|L|X] sub-band (e.g., LLL, LXL, XXH, …, exclusive XXX) split out of the three-dimensional decomposition sublevels.

3.7 [H|L|X][H|L|X][H|L|X] sub-band: H refers to high-pass filtering and L to low-pass filtering, while X refers to no filtering. The filter specified first refers to the horizontal filtering, the second to the vertical filtering and the third to the axial filtering (i.e., respectively along X-, Y- and Z-axes). The filter ordering for this sub-band should always be respected. The reconstruction will follow the inverse filtering order.

NOTE – The XXX sub-band does not exist (as defined in 3.6).

3.8 image (update of ITU-T Rec. T.800 | ISO/IEC 15444-1): The set of all components, which can have either two- or three-spatial dimensions.

3.9 image area offset (update of ITU-T Rec. T.800 | ISO/IEC 15444-1): The number of reference grid points down, to the right (and to an increased axial position) of the reference grid origin.

3.10 intermediate component (update of ITU-T Rec. T.801 | ISO/IEC 15444-2): A single two- or three-dimensional array of data involved in a stage of a multiple component transformation.

3.11 raster order (update of ITU-T Rec. T.800 | ISO/IEC 15444-1): A particular sequential order of data of any type within an array. The raster order starts with the top left data point of the first slice and moves to the data point immediately to the right, 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 slice. Thereafter the next slice is processed in case of a three-dimensional array. This order is continued to the end of the array.

3.12 resolution (update of ITU-T Rec. T.801 | ISO/IEC 15444-2): The spatial relation of samples to a physical space. In this Recommendation | International Standard, the decomposition levels of the wavelet transform create resolutions that differ by powers of two in the horizontal, the vertical, or – in the three-dimensional case – the axial direction, or any possible combination of directions. The last (highest) decomposition level includes an [L|X][L|X][L|X] sub-band (note that XXX is non-existing), which is considered to be a lower resolution. Therefore, there is one more resolution level than decomposition levels.

3.13 resolution level (update of ITU-T Rec. T.800 | ISO/IEC 15444-1): Equivalent to decomposition level with the exception that the [L|X][L|X][L|X] sub-band is also a separate resolution level.

3.14 sample (update of ITU-T Rec. T.800 | ISO/IEC 15444-1): One element in the two-dimensional or three-dimensional array that comprises a component.

3.15 slice: A slice is a two-dimensional pixel subset of a volumetric entity, a volumetric code-block or a volumetric image. A slice is positioned perpendicular to the axial or z-axis.

3.16 spatial coordinates: Spatial coordinates are indicated by *x*, *y* and *z*. Generally, the term axial will be used to address the Z dimension.

3.17 sub-band (update of ITU-T Rec. T.800 | ISO/IEC 15444-1): A group of transform coefficients resulting from the same sequence of low-pass and high-pass filtering operations.

3.18 sub-band order: Within one resolution level, sub-bands are processed and signalled as defined in ITU-T Rec. T.800 | ISO/IEC 15444-1 and ITU-T Rec. T.801 | ISO/IEC 15444-2 for two-dimensional filtering, following a Morton scanning order [1]. The specification is extended to the three-dimensional case by deploying consequently a three-dimensional Morton scanning order.

3.19 tile (update of ITU-T Rec. T.800 | ISO/IEC 15444-1): A cuboidal array of points on the reference grid, registered with an offset from the reference grid origin and defined by a width (*x* dimension), a height (*y* dimension) and a depth (*z* dimension). The tiles that overlap are used to define tile-components.

4 Abbreviations

For the purposes of this Recommendation | International Standard, the abbreviations defined in ITU-T Rec. T.800 | ISO/IEC 15444-1, clause 4, and ITU-T Rec. T.801 | ISO/IEC 15444-2, clause 4, also apply to this Recommendation | International Standard.

5 Symbols (and abbreviated terms)

For the purposes of this Recommendation | International Standard, the symbols defined in ITU-T Rec. T.800 | ISO/IEC 15444-1, clause 4, and ITU-T Rec. T.801 | ISO/IEC 15444-2, clause 5, also apply to this Recommendation | International Standard.

6 General description

This Recommendation | International Standard defines a set of lossless (bit-preserving) and lossy compression methods for coding continuous-tone, bi-level, grey-scale, colour digital volumetric images, or multi-component volumetric images. This set of methods (see Annex A) extends the elements in the core coding system described in ITU-T Rec. T.800 | ISO/IEC 15444-1 and ITU-T Rec. T.801 | ISO/IEC 15444-2. Extensions which pertain to encoding and decoding are defined as procedures which may be used in combination with the encoding and decoding processes described in ITU-T Rec. T.800 | ISO/IEC 15444-1 and ITU-T Rec. T.801 | ISO/IEC 15444-2. Each encoding or decoding extension shall be used only in combination with particular coding processes and only in accordance with the requirements set forth herein. This Recommendation | International Standard also defines extensions to the compressed data format, i.e., interchange format and the abbreviated formats.

In particular, for ITU-T Rec. T.801 | ISO/IEC 15444-2, the following extensions are supported by this Recommendation | International Standard:

1) variable DC offset;
2) arbitrary wavelet transform kernels;
3) multi-component transformations;
4) non-linear transformations;
5) region-of-interest.

Annex A

Codestream syntax, extension

(This annex forms an integral part of this Recommendation | International Standard)

A.1 Extended capabilities

The syntax in this annex supports the extensions in this Recommendation | International Standard. These marker segments conform to the same rules as the syntax in ITU-T Rec. T.800 | ISO/IEC 15444-1 Annex A. The addition of parameter values to some marker segments in ITU-T Rec. T.800 | ISO/IEC 15444-1 and ITU-T Rec. T.801 | ISO/IEC 15444-2, and the addition of new marker segments signals the information specific to the extensions in this Recommendation | International Standard.

In every marker segment, the first two bytes after the marker shall be an unsigned value that denotes the length in bytes of the marker segment parameters (including the two bytes of this length parameter but not the two bytes of the marker itself).

When a marker segment that is not specified in this Recommendation | International Standard or in ITU-T Rec. T.800 | ISO/IEC 15444-1 and ITU-T Rec. T.801 | ISO/IEC 15444-2 is encountered in a codestream, the decoder shall use the length parameter to discard the marker segment. Table A.1 shows the marker segments adopted/extended for this Recommendation | International Standard.

Table A.1 – List of JP3D markers and marker segments

	Symbol	Code	Main header	Tile-part header	ITU-T Rec. T.80x | ISO/IEC 15444-x Heritage/ Extended
Delimiting markers and marker segments					
Start of codestream	SOC	0xFF4F	required	not allowed	ITU-T Rec. T.800 | ISO/IEC 15444-1
Start of tile-part	SOT	0xFF90	not allowed	required	ITU-T Rec. T.801 | ISO/IEC 15444-2
Start of data	SOD	0xFF93	not allowed	last marker	ITU-T Rec. T.800 | ISO/IEC 15444-1
End of codestream	EOC	0xFFD9	not allowed	not allowed	ITU-T Rec. T.800 | ISO/IEC 15444-1
Fixed information marker segments					
Image and tile size	SIZ	0xFF51	required	not allowed	ITU-T Rec. T.800 | ISO/IEC 15444-1
Additional dimension image and tile size	NSI	0xFF54	required	not allowed	
Functional marker segments					
Coding style default	COD	0xFF52	required	optional	ITU-T Rec. T.800 | ISO/IEC 15444-1, Extended
Coding style component	COC	0xFF53	optional	optional	ITU-T Rec. T.800 | ISO/IEC 15444-1, Extended
Region-of-interest	RGN	0xFF5E	optional	optional	ITU-T Rec. T.801 | ISO/IEC 15444-2, Extended
Quantization default	QCD	0xFF5C	required	optional	ITU-T Rec. T.800 | ISO/IEC 15444-1, Extended
Quantization component	QCC	0xFF5D	optional	optional	ITU-T Rec. T.800 | ISO/IEC 15444-1, Extended
Arbitrary transformation kernels	ATK	0xFF79	optional	optional	ITU-T Rec. T.801 | ISO/IEC 15444-2
Component bit depth definition	CBD	0xFF78	optional	optional	ITU-T Rec. T.801 | ISO/IEC 15444-2
Multiple component transformation definition	MCT	0xFF74	optional	optional	ITU-T Rec. T.801 | ISO/IEC 15444-2

Table A.1 – List of JP3D markers and marker segments

	Symbol	Code	Main header	Tile-part header	ITU-T Rec. T.80x | ISO/IEC 15444-x Heritage/ Extended
Multiple component transform collection	MCC	0xFF75	optional	optional	ITU-T Rec. T.801 | ISO/IEC 15444-2
Multiple component transform ordering	MCO	0XFF77	optional	optional	ITU-T Rec. T.801 | ISO/IEC 15444-2
Non-linearity point transformation	NLT	0xFF76	optional	optional	ITU-T Rec. T.801 | ISO/IEC 15444-2
Variable DC offset	DCO	0XFF70	optional	optional	ITU-T Rec. T.801 | ISO/IEC 15444-2
Pointer marker segments					
Tile-part lengths	TLM	0xFF55	optional	not allowed	ITU-T Rec. T.800 | ISO/IEC 15444-1
Packet length, main header	PLM	0xFF57	optional	not allowed	ITU-T Rec. T.800 | ISO/IEC 15444-1
Packet length, tile-part header	PLT	0xFF58	not allowed	optional	ITU-T Rec. T.800 | ISO/IEC 15444-1
Packed packet headers, main header	PPM	0xFF60	optional	not allowed	ITU-T Rec. T.800 | ISO/IEC 15444-1
Packed packet headers, tile-part header	PPT	0xFF61	not allowed	optional	ITU-T Rec. T.800 | ISO/IEC 15444-1
In bit stream markers and marker segments					
Start of packet	SOP	0xFF91	not allowed	not allowed in tile-part header, optional in bit stream	ITU-T Rec. T.800 | ISO/IEC 15444-1
End of packet header	EPH	0xFF92	optional inside PPM marker segment	optional inside PPT marker segment or in bit stream	ITU-T Rec. T.800 | ISO/IEC 15444-1
Informational marker segments					
Component registration	CRG	0xFF63	optional	not allowed	ITU-T Rec. T.800 | ISO/IEC 15444-1, Extended
Comment	COM	0xFF64	optional	optional	ITU-T Rec. T.800 | ISO/IEC 15444-1
[a] Required means the marker or marker segment shall be in this header, optional means it may be used.					

A.2 Extensions to ITU-T Rec. T.800 | ISO/IEC 15444-1 and ITU-T Rec. T.801 | ISO/IEC 15444-2 marker segment parameters

A.2.1 Additional dimension image and tile size (NSI)

Function: Provides information about the uncompressed image such as the depth of the reference grid, the depth of the tiles, and the separation of component samples with respect to the reference grid.

Usage: Main header. There shall be one and only one in the main header after the CAP marker segment and before the first JP3D-extended marker segment. There shall be only one NSI per codestream.

Length: Variable depending on the number of components.

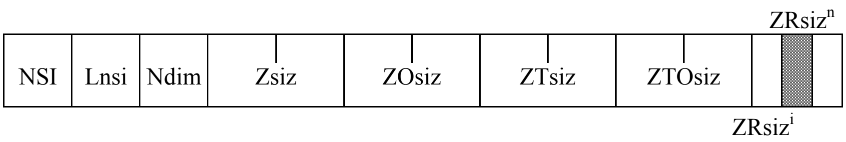


Figure A.1 – Additional dimension image and tile size syntax (extended)

NSI: Marker code. Table A.2 shows the size and parameter values of the symbol and parameters for additional dimension image and tile size marker segment.

Lnsi: Length of marker segment in bytes (not including the marker). The value of this parameter is determined by the following equation:

$$Lnsi = 19 + Csiz \tag{A-1}$$

Ndim: Defines the dimensionality of the dataset (disregarding the component dimension). This value is set to 3 by default.

Zsiz: Depth of the reference grid.

ZOsiz: Depth offset from the origin of the reference grid to the front left upper corner of the image volume.

ZTsiz: Depth of one reference tile with respect to the reference grid.

ZTOsiz: Vertical offset from the origin of the reference grid to the front left upper corner of the first tile.

ZRsiz^i: Depth separation of a sample of the *i*th component with respect to the reference grid. There is one occurrence of this parameter for each component, in order.

Table A.2 – Additional dimension image and tile size parameter values (extended)

Parameter	Size (bits)	Values
NSI	16	0xFF54
Lnsi	16	20-16403
Ndim	8	3
Zsiz	32	1-(2^{32} – 1)
ZOsiz	32	0-(2^{32} – 1)
ZTsiz	32	1-(2^{32} – 1)
ZTOsiz	32	1-(2^{32} – 2)
ZRsiz^i	8	1-255

A.2.2 Coding style default (COD), ITU-T Rec. T.800 | ISO/IEC 15444-1 extended

Function: Describes the coding style, number of decomposition levels and layering that is the default used for compressing all components of an image (if in the main header) or a tile (if in the tile-part header). The parameter values can be overridden for an individual component by a COC marker segment in either the main or tile-part header.

Usage: Main and first tile-part header of a given tile. There shall be one and only one in the main header. Additionally, there may be at most one for each tile. If there are multiple tile-parts in a tile, and this marker segment is present, it shall be found only in the first tile-part (*TPsot* = 0).

When used in the main header, the COD marker segment parameter values are used for all tile-components that do not have a corresponding COC marker segment in either the main or tile-part header. When used in the tile-part header, it overrides the main header COD and COCs and is used for all components in that tile without a corresponding COC marker segment in the tile-part. Thus, the order of precedence is the following:

Tile-part COC > Tile-part COD > Main COC > Main COD

where the "greater than" sign, >, means that the greater overrides the lesser marker segment.

Length: Variable depending on the value of Scod (see Lcod parameter).

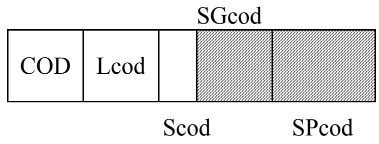


Figure A.2 – Coding style default syntax

COD: Marker code. Table A.3 shows the size and values of the symbol and parameters for coding style default marker segment.

Lcod: Length of marker segment in bytes (not including the marker). The value of this parameter is determined by the following equation:

$$Lcoc = \begin{cases} 17 & \text{maximum\_precincts} \\ 17 + 2 \cdot \text{number\_of\_resolution\_levels} & \text{user\_defined\_precincts} \end{cases} \quad \text{(A-2)}$$

where *maximum_precincts* and *user_defined_precincts* are indicated in the *Scod* parameter and *number_of_resolution_levels* is calculated by use of the number of decomposition level parameters for each of the three dimensions, X, Y and Z, as indicated in the *SPcod* parameter. The actual equation for calculating the number of resolution levels is given in subclause B.5.

Scod: Coding style for all components. Table A.4 shows the value for the *Scod* parameter.

SGcod: Parameters for coding style designated in *Scod*. The parameters are independent of components and are designated, in order from top to bottom, in Table A.5. The coding style parameters within the *SGcod* field appear in the sequence shown in Figure A.3.

SPcod: Parameters for coding style designated in *Scod*. The parameters relate to all components and are designated, in order from top to bottom, in Table A.6. The coding style parameters within the *SPcod* field appear in the sequence shown in Figure A.3.

Table A.3 – Coding style default parameters values, extended

Parameter	Size (bits)	Values
COD	16	0xFF52
Lcod	16	17-83
Scod	8	Table A.4
SGcod	32	Table A.5
SPcod	variable	Table A.6

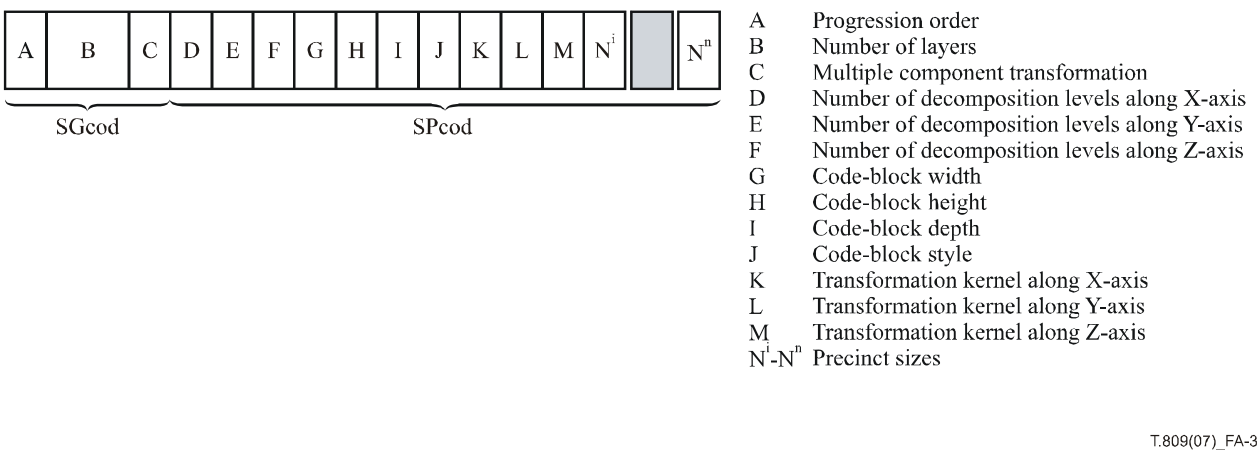


Figure A.3 – Coding style parameter diagram of the *SGcod* and *SPcod* parameters

Table A.4 – Coding style parameter values for the Scod parameter

Values (bits) MSB LSB	Coding style
xxxx xxx0	Entropy coder, precincts with *PPx* = 15, *PPy* = 15 and *PPz* = 15
xxxx xxx1	Entropy coder with custom precincts defined below
xxxx xx0x	No SOP marker segments used
xxxx xx1x	SOP marker segments may be used
xxxx x0xx	No EPH marker used
xxxx x1xx	EPH marker shall be used
	All other values reserved

Table A.5 – Coding style parameter values for the SGcod parameter

Parameters (in order)	Size (bits)	Values	Meaning of SGcod values
Progression order	8	ITU-T Rec. T.800 | ISO/IEC 15444-1 Table A.16	Progression order
Number of layers	16	1-65535	Number of layers
Multiple component transform	8	ITU-T Rec. T.801 | ISO/IEC 15444-2 Table A.8	Multiple component transform usage

Table A.6 – Coding style parameter values of the SPcod and SPcoc paramaters, extended

Parameters (in order)	Size (bits)	Values	Meaning of SPcod values
Number of decomposition levels along X-axis	8	0-32	Number of decomposition levels along X-axis, N_{LX}, zero implies no transformation
Number of decomposition levels along Y-axis	8	0-32	Number of decomposition levels along Y-axis, N_{LY}, zero implies no transformation
Number of decomposition levels along Z-axis	8	0-32	Number of decomposition levels along Z-axis, N_{LZ}, zero implies no transformation
3D code-block width	8	Table A.7	Code-block width exponent offset value, *xcb*
3D code-block height	8	Table A.7	Code-block height exponent offset value, *ycb*
3D code-block depth	8	Table A.7	Code-block depth exponent offset value, *zcb*
3D code-block style	8	Table A.8	Style of the 3D code-block coding passes
Transformation kernel along X-axis	8	ITU-T Rec. T.801 | ISO/IEC 15444-2 Table A.10	Wavelet transformation used along X-axis
Transformation kernel along Y-axis	8	ITU-T Rec. T.801 | ISO/IEC 15444-2 Table A.10	Wavelet transformation used along Y-axis
Transformation kernel along Z-axis	8	ITU-T Rec. T.801 | ISO/IEC 15444-2 Table A.10	Wavelet transformation used along Z-axis
Precinct size	variable	Table A.9	If *Scod* or *Scoc* = xxxx xxx0, this parameter is not present; otherwise this indicates precinct width, height and depth. The first parameter (16 bits) corresponds to the N_LLLL sub-band. Each successive parameter corresponds to each successive resolution level in order.

Table A.7 – Width, height or depth exponent of the 3D code-blocks for the SPcod and SPcoc parameters

Values (bits) MSB LSB	3D code-block width, height and depth
xxxx 0000 – xxxx 1011	3D code-block width, height and depth exponent values *xcb* = *value*, *ycb* = *value* or *zcb* = *value*. NOTE – This redefines ITU-T Rec. T.800 | ISO/IEC 15444-1 significantly! The 3D code-block width, height and depth are limited to powers of two with the minimum size being 2^0 and the maximum being 2^{10}. Further, the 3D code-block size is restricted so that $4 \le xcb+ycb+zcb \le 18$.
	All other values reserved

Table A.8 – 3D code-block style for the SPcod and SPcoc paramaters, extended

Values (bits) MSB LSB	3D code-block style
xxxx xxx0	No selective arithmetic coding bypass
xxxx xxx1	Selective arithmetic coding bypass
xxxx xx0x	No reset of context probabilities on coding pass boundaries
xxxx xx1x	Reset context probabilities on coding pass boundaries
xxxx x0xx	No termination on each coding pass
xxxx x1xx	Termination on each coding pass
xxxx 0xxx	No causal contexts
xxxx 1xxx	Causal contexts
xxx0 xxxx	No predictable termination
xxx1 xxxx	Predictable termination
xx0x xxxx	No segmentation symbols are used
xx1x xxxx	Segmentation symbols are used
	All other values reserved

Table A.9 – Precinct width, height and depth for the SPcod and SPcoc parameters, extended

Values (bits) MSB LSB	Precinct size
xxxx xxxx xxxx 0000 – xxxx xxxx xxxx 1111	4 LSBs are the precinct width exponent *PPx* = *value*. This value may only equal zero at the resolution level corresponding to the N_LLLL band.
xxxx xxxx 0000 xxxx – xxxx xxxx 1111 xxxx	Next 4 bits are the precinct height exponent *PPy* = *value*. This value may only equal zero at the resolution level corresponding to the N_LLLL band.
xxxx 0000 xxxx xxxx – xxxx 1111 xxxx xxxx	Next 4 bits are the precinct depth exponent *PPz* = *value*. This value may only equal zero at the resolution level corresponding to the N_LLLL band.
	All other values reserved

A.2.3 Coding style component (COC), ITU-T Rec. T.800 | ISO/IEC 15444-1 extended

Function: Describes the coding style and number of decomposition levels used for compressing a particular component.

Usage: Main and first tile-part header of a given tile. The usage is optional in both the main and tile-part headers. No more than one per any given component may be present in either the main or tile-part headers. If there are multiple tile-parts in a tile, and this marker segment is present, it shall be found only in the first tile-part (*TPsot* = 0).

When used in the main header, it overrides the main COD marker segment for the specific component. When used in the tile-part header, it overrides the main header COD, main COC and tile COD for the specific component. Thus, the order of precedence is the following:

Tile-part COC > Tile-part COD > Main COC > Main COD where the "greater than" sign, >, means that the greater overrides the lesser marker segment.

Length: Variable depending on the value of Scoc (see Lcoc parameter).

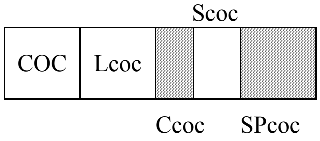


Figure A.4 – Coding style component syntax

COC: Marker code. Table A.10 shows the size and values of the symbol and parameters for the coding style component marker segment.

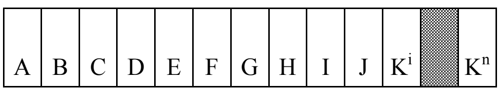
Lcoc: Length of marker segment in bytes (not including the marker). The value of this parameter is determined by the following equation:

$$Lcoc = \begin{cases} 14 & \text{maximum\_precincts AND } Csiz < 257 \\ 15 & \text{maximum\_precincts AND } Csiz \geq 257 \\ 14 + 2 \cdot \text{number\_of\_resolution\_levels} & \text{user\_defined\_precincts AND } Csiz < 257 \\ 15 + 2 \cdot \text{number\_of\_resolution\_levels} & \text{user\_defined\_precincts AND } Csiz \geq 257 \end{cases} \quad \text{(A-3)}$$

Ccoc: The index of the component to which this marker segment relates. The components are indexed 0, 1, 2, etc.

Scoc: Coding style for this component. Table A.11 shows the values for each *Scoc* parameter.

SPcoc: Parameters for coding style designated in *Scoc*. The coding style parameters within the *SPcoc* field appear in the order sequence shown in Figure A.5.



A Number of decomposition levels along X-axis
B Number of decomposition levels along Y-axis
C Number of decomposition levels along Z-axis
D Code-block width
E Code-block height
F Code-block depth
G Code-block style
H Transformation kernel along X-axis
I Transformation kernel along Y-axis
J Transformation kernel along Z-axis
K^i-K^n Precinct sizes

Figure A.5 – Coding style parameter diagram of the SPcoc parameter

Table A.10 – Coding style component parameter values, extended

Parameter	Size (bits)	Values
COC	16	0xFF53
Lcoc	16	4-102
Ccoc	8 16	0-255; if Csiz < 257 0-16383; if Csiz ≥ 257
Scoc	8	Table A.11
$SPcoc^i$	variable	Table A.6

Table A.11 – Coding style parameter values for the Scoc parameter, extended

Values (bits) MSB LSB	Coding style
xxxx xxx0	Entropy coder with maximum precinct values $PPx = PPy = PPz = 15$
xxxx xxx1	Entropy coder with precinct values defined in *SPcoc*
	All other values reserved

A.2.4 Region of Interest (RGN), ITU-T Rec. T.801 | ISO/IEC 15444-2 extended

Function: Signals the presence of a region of interest (ROI) in the codestream.

Usage: Main and first tile-part header of a given tile. If there is RGN marker segment in the main header with a Srgn = 0, there shall not be any RGN marker segment anywhere in the codestream with a non-zero Srgn value for the component given by the corresponding Crgn value. Likewise, if there is RGN marker segment in the main header with a non-zero Srgn value, there shall not be any RGN marker segment anywhere in the codestream with a Srgn = 0 for the component given by the corresponding Crgn value.

When used in both the main header and the first tile-part header, the RGN in the first tile-part header overrides the main RGN for that tile. Also, an RGN specifying a single component (Crgn ≠ 65 535) overrides on specifying all components (Crgn = 65 535). Thus the order of precedence is the following:

Tile-part RGN (Crgn ≠ 65 535) > Tile-part RGN (Crgn = 65 535) > Main RGN (Crgn ≠ 65 535) > Main RGN (Crgn = 65 535)

where the "greater than" sign, >, means that the greater overrides the lesser marker segment.

Length: Variable.

Figure A.6 – Region of interest syntax

RGN: Marker code. Table A.12 shows the size and values of the symbol and parameters for the region of interest marker segment.

Lrgn: Length of the marker segment in bytes (not including the marker).

Crgn: The index of the component to which this marker segment relates. The components are indexed 0, 1, 2, etc.

Srgn: ROI style for the current ROI. ITU-T Rec. T.801 | ISO/IEC 15444-2 Table A.16 shows the value for the Srgn parameter.

SPrgn: Parameter for ROI style designated in *Srgn*. *SPrgn* is only signalled for *Srgn* = 1 or *Srgn* = 2.

Table A.12 – Region of interest parameter values, extended

Parameter	Size (bits)	Values
RGN	16	0xFF5E
Lrgn	16	5-30
Crgn	16	ITU-T Rec. T.801 | ISO/IEC 15444-2 Table A.17
Srgn	8	ITU-T Rec. T.801 | ISO/IEC 15444-2 Table A.16
SPrgn	variable	Table A.13