FINAL
DRAFT

AMENDMENT

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ISO/IEC JTC **1**

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Information technology — JPEG 2000 image coding system: Extensions

AMENDMENT 1: Enhancement to quantization method

Technologies de l'information — Système de codage d'image JPEG 2000: Extensions
AMENDEMENT 1: Amélioration de la méthode d'échantillonnage

Please see the administrative notes on page iii

Reference number
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Foreword

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

Amendment 1 to ISO/IEC 15444-2 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.801/Amd.1.

INTERNATIONAL STANDARD

ITU-T RECOMMENDATION

INFORMATION TECHNOLOGY – JPEG 2000 IMAGE CODING SYSTEM: EXTENSIONS

AMENDMENT 1
Enhancement to quantization method

1. Background

Remote sensing applications require a low-memory, high-throughput implementation of JPEG 2000 for use on board spacecraft and aircraft. This implementation, known as the scan-based mode, has already been demonstrated for JPEG 2000 Part 1. Images are processed as collections of a small number of lines, known as scan elements. In tests of the scan-based mode, it has been shown that the use of precincts rather than tiles as scan elements gives better image quality, because small tiles tend to produce boundary artifacts.

For high-quality lossy compression, it is desirable to add Part 2 quantization methods to the scan-based mode. In order to maintain high throughput, the quantization must be performed with single-pass rate control (no iteration). But effective single-pass rate control over the image as a whole can be achieved only if trellis-coded quantization (or explicit scalar quantization) is performed on a precinct-by-precinct basis, with different step sizes for each precinct.

In order to enable this procedure, a change to Part 2 syntax is required to signal the step sizes on a precinct-by-precinct basis. Since a long image divided into short precincts may contain many tile parts, it is also desirable to increase the maximum value of the tile part index (currently 254).

2. Changes to Annex A.1

Table A-1 from ITU-T T.801 | ISO/IEC 15444-2 should be replaced with the table below.

Table A-1 – Syntax support for extensions

Extension	Extended ITU-T T.800 | ISO/IEC 15444-1 marker segments	New marker segments
All extensions	SIZ, SOT	—
Variable DC offset	—	DCO
Variable scalar quantization	QCD, QCC	QPD, QPC
Trellis coded quantization	QCD, QCC	QPD, QPC
Visual masking	—	VMS
Single sample offset transform	SIZ, COD, COC	—
Arbitrary decomposition styles	COD, COC	DFS, ADS
Arbitrary transformation kernels	COD, COC	ATK
Multiple component transform	COD	CBD, MCT, MCC, MIC
Non-linearity point transformation	—	CBD, NLT
Arbitrary shaped region of interest	RGN	—

Table A-2 from ITU-T T.801 | ISO/IEC 15444-2 (Rsiz marker) should have an added line:

11xx xxxx xxxx xxxx Precinct-dependent quantization is required to decode this code stream

3. Changes to Annex A.2.3, Annex C and Annex D

General references to QCD/QCC or qcd/qcc should be replaced with QCD/QCC/QPD/QPC or qcd/qcc/qpd/qpc respectively.

4. New Annex A.2.5 should be added as follows

A.2.5 Start of tile-part (SOT) extended

Function: Marks the beginning of a tile-part, the index of its tile, and the index of its tile-part. The tile-parts of a given tile shall appear in order (see TPsot) in the codestream. However, tile-parts from other tiles may be interleaved in the codestream. Therefore, the tile-parts from a given tile may not appear contiguously in the codestream.

Usage: Every tile-part header. Shall be the first marker segment in a tile-part header. There shall be at least one SOT in a codestream. There shall be only one SOT per tile-part.

Length: Variable depending on the maximum number of tile-parts in the tile.

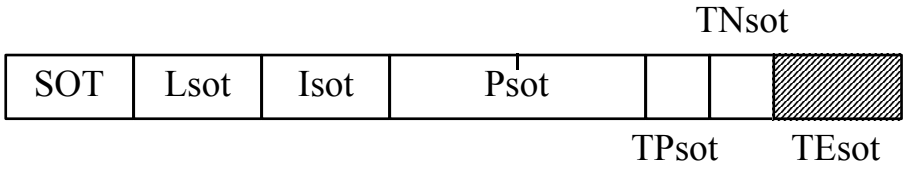

Figure 1 – Start of tile-part syntax

SOT: Marker code. Table 1 shows the sizes and values of the symbol and parameters for start of tile-part marker segment.

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

Isot: Tile index. This number refers to the tiles in raster order starting at the number 0.

Psot: Length, in bytes, from the beginning of the first byte of this SOT marker segment of the tile-part to the end of the data of that tile-part. Figure A-16 from ITU-T T.800 | ISO/IEC 15444-1 shows this alignment. Only the last tile-part in the codestream may contain a 0 for Psot. If the Psot is 0, this tile-part is assumed to contain all data until the EOC marker.

TPsot: Tile-part index. There is a specific order required for decoding tile-parts; this index denotes the order from 0. If there is only one tile-part for a tile then this value is zero. If this value is 255 then the TEsot marker segment contains the tile-part index. The tile-parts of this tile shall appear in the codestream in this order, although not necessarily consecutively.

TNsot: Number of tile-parts of a tile in the codestream. Two values are allowed: the correct number of tile-parts for that tile and zero. A zero value indicates that the number of tile-parts of this tile is not specified in this tile-part. If any TPsot marker segments for this tile are 255, this value must be 0.

TEsot: Tile-part index when TPsot is 255. The length of this marker segment parameter will be 16 bits when TPsot is 255, but 0 when TPsot<255.

Table 1 – Start of tile-part parameter values

Parameter	Size (bits)	Values
SOT	16	0xFF90
Lsot	16	10 OR 12
Isot	16	0 – 65 534
Psot	32	$12 – (2^{32} – 1)$
TPsot	8	0 – 255
TNsot	8	Table A-6 from ITU-T T.800 | ISO/IEC 15444-1
TEsot	0 16	NA; if TPsot < 255 0 – 65 534; if TPsot = 255

5. Changes to Annex A.3

Table A-17 from ITU-T T.801 | ISO/IEC 15444-2 should be replaced with the table below.

Table A-17 – List of markers and marker segments

	Symbol	Code	Main header[a]	Tile-part header[a]
Default quantization for precinct	QPD	0xFF5A	optional	optional
Component quantization for precinct	QPC	0xFF5B	optional	optional
Variable DC offset	DCO	0xFF70	optional	optional
Visual masking	VMS	0xFF71	optional	optional
Downsampling factor style	DFS	0xFF72	optional	optional
Arbitrary decomposition style	ADS	0xFF73	optional	optional
Arbitrary transformation kernels	ATK	0xFF72	optional	optional
Component bit depth	CBD	0xFF78	optional	optional
Multiple component transformation definition	MCT	0xFF74	optional	optional
Multiple component collection	MCC	0xFF75	optional	optional
Multiple component intermediate collection	MIC	0xFF77	optional	optional
Non-linearity point transformation	NLT	0xFF76	optional	optional

a) Optional means it may be used in the header if this extension is used.

6. New Annex A.3.11 should be added as follows

A.3.11 Default Quantization for Precinct (QPD)

Function: Describes the quantization default used for compressing all components of a particular (resolution level, precinct) pair. The parameter values can be overridden for an individual (component, resolution level, precinct) triplet by a QPC marker segment which must appear in a tile-part header prior to any packets for that triplet.

Usage: Main and any tile-part header. Several QPD marker segments may appear in any tile-part header, but only one for each (resolution level, precinct) pair. If a QPD is used in a tile-part header it overrides the quantization characteristics defined by either QCD or QCC marker segments for all components of the (resolution level, precinct) pair indexed by the QPD within the scope of the particular tile. Thus, the quantization characteristics of a particular (resolution level, precinct) pair is determined by the presence of QCD, QCC, QPD or QPC markers in the following order of precedence:

Any tile-part QPC > Any tile-part QPD > First tile-part QCC > First tile-part QCD >
Main QPC > Main QPD > Main QCC > Main QCD

When QPD marker segments are used, they must appear in tile-part headers before any packets are found for the indexed (resolution level, precinct) pair.

Length: Variable depending on the number of quantized subbands within the resolution level indexed.

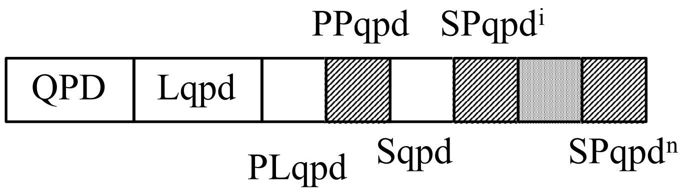

Figure 2 – Default quantization for precinct syntax

QPD: Marker code. Table 2 shows the size and parameter values for the QPD marker segment.

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

$$Lqpd = \begin{cases} 5 + \text{number\_of\_subbands\_at\_lev} & \text{no\_quantization AND PLqpd} < 128 \\ 7 & \text{quantization\_derived AND PLqpd} < 128 \\ 5 + 2 \bullet \text{number\_of\_subbands\_at\_lev} & \text{quantization\_expounded AND PLpqd} < 128 \\ 6 + \text{number\_of\_subbands\_at\_lev} & \text{no\_quantization AND PLqpd} \geq 128 \\ 8 & \text{quantization\_derived AND PLqpd} \geq 128 \\ 6 + 2 \bullet \text{number\_of\_subbands\_at\_lev} & \text{quantization\_expounded AND PLqpd} \geq 128 \end{cases} \quad (1)$$

where number_of_subbands_at_lev is defined in Annex F.2.4 of ITU-T T.801 | ISO/IEC 15444-2 for each resolution level, and no_quantization, quantization_derived, or quantization_expounded is signalled in the Sqpd parameter.

Note: The Lqpd can be used to determine how many quantization step sizes are present in the marker segment. However, there is not necessarily a correspondence with the number of subbands present because the subbands can be truncated with no requirement to correct this marker segment.

PLqpd: The resolution level index for the pair signaled. Equation 2 shows how this marker segment is constructed based on the resolution level index *lev* as well as the precinct index *prec* for the pair.

$$PLqpd = \begin{cases} lev & prec < 256 \\ 128 + lev & prec \geq 256 \end{cases} \quad (2)$$

As in ITU-T T.800 | ISO/IEC 15444-1, the resolution level index *lev* can range from 0 to N_L, where N_L is the number of decomposition levels defined in ITU-T T.800 | ISO/IEC 15444-1.

PPqpd: The precinct index for the pair signaled. The size of this marker segment parameter will be one byte when the PLqpd parameter is less than 128, but two bytes when PLqpd is greater than or equal to 128. This parameter will then just hold the precinct index *prec*. The precinct index *prec* can range from 0 to *numprecincts*-1, where *numprecincts* is the number of precincts at resolution level *lev* and is also defined in ITU-T T.800 | ISO/IEC 15444-1.

Sqpd: Quantization style for all components of the (resolution level, precinct) pair.

SPqpd^i: Quantization step size value for the *i*-th subband at resolution level *lev* in the order defined for *lev* in Annex F.2.4 of ITU-T T.801 | ISO/IEC 15444-2. The number of parameters is the same as the number of subbands in the resolution level *lev*.

Table 2 – Default quantization for precinct parameter values

Parameter	Size (bits)	Values
QPD	16	0xFF5A
Lqpd	16	6 — 101
PLqpd	8	0 — 32 OR 128 — 160
PPqpd	8 16	0 — 255 if PLqpd < 128 0 — 65 535 if PLqpd ≥ 128
Sqpd	8	Table A-10 from ITU-T T.801 | ISO/IEC 15444-2
SPqpdi	variable	Table A-10 from ITU-T T.801 | ISO/IEC 15444-2

7. New Annex A.3.12 should be added as follows

A.3.12 Component Quantization for Precinct (QPC)

Function: Describes the quantization used for compressing a particular (component, resolution level, precinct) triplet.

Usage: Main and any tile-part header. Several QPC marker segments may appear in any tile-part header, but only one for each (component, resolution level, precinct) triplet. If a QPC is used in a tile-part header it overrides the quantization characteristics defined by QCD, QCC, or QPD marker segments for the triplet indexed by the QPC within the scope of the particular tile. Thus, the quantization characteristics of a particular (component, resolution level, precinct) triplet is determined by the presence of QCD, QCC, QPD or QPC markers in the following order of precedence:

Any tile-part QPC > Any tile-part QPD > First tile-part QCC > First tile-part QCD >
Main QPC > Main QPD > Main QCC > Main QCD

When QPC marker segments are used, they must appear in tile-part headers before any packets are found for the indexed (component, resolution level, precinct) triplet.

Length: Variable depending on the number of quantized subbands within the resolution level indexed.

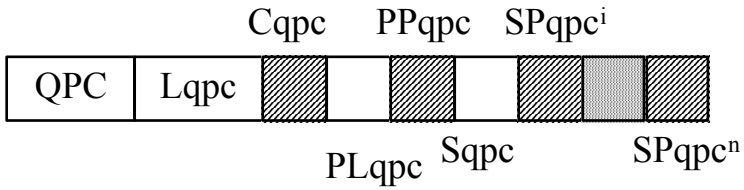

Figure 3 – Component quantization for precinct syntax

QPC: Marker code. Table 3 shows the size and parameter values for QPC marker segment.

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

$$Lqpd = \begin{cases} 6 + num\_of\_subbands\_at\_lev & no\_quant\ AND\ Csiz < 257\ AND\ PLqpc < 128 \\ 8 & quant\_derived\ AND\ Csiz < 257\ AND\ PLqpc < 128 \\ 6 + 2 \bullet num\_of\_subbands\_at\_lev & quant\_expounded\ AND\ Csiz < 257\ AND\ PLqpc < 128 \\ 7 + num\_of\_subbands\_at\_lev & no\_quant\ AND\ Csiz \geq 257\ AND\ PLqpc < 128 \\ 9 & quant\_derived\ AND\ Csiz \geq 257\ AND\ PLqpc < 128 \\ 7 + 2 \bullet num\_of\_subbands\_at\_lev & quant\_expounded\ AND\ Csiz \geq 257\ AND\ PLqpc < 128 \\ 7 + num\_of\_subbands\_at\_lev & no\_quant\ AND\ Csiz < 257\ AND\ PLqpc \geq 128 \\ 9 & quant\_derived\ AND\ Csiz < 257\ AND\ PLqpc \geq 128 \\ 7 + 2 \bullet num\_of\_subbands\_at\_lev & quant\_expounded\ AND\ Csiz < 257\ AND\ PLqpc \geq 128 \\ 8 + num\_of\_subbands\_at\_lev & no\_quant\ AND\ Csiz \geq 257\ AND\ PLqpc \geq 128 \\ 10 & quant\_derived\ AND\ Csiz \geq 257\ AND\ PLqpc \geq 128 \\ 8 + 2 \bullet num\_of\_subbands\_at\_lev & quant\_expounded\ AND\ Csiz \geq 257\ AND\ PLqpc \geq 128 \end{cases} \quad (3)$$

where number_of_subbands_at_lev is defined in Annex F.2.4 of ITU-T T.801 | ISO/IEC 15444-2 for each resolution level, Csiz is signaled according to ITU-T T.800 | ISO/IEC 15444-1, and no_quantization, quantization_derived, or quantization_expounded is signalled in the Sqpc parameter.

Note: The Lqpc can be used to determine how many quantization step sizes are present in the marker segment. However, there is not necessarily a correspondence with the number of subbands present because the subbands can be truncated with no requirement to correct this marker segment.

Cqpc: The index of the component to which this marker segment relates. The components are indexed 0, 1, 2, etc. (Either 8 or 16 bits depending on Csiz value).

PLqpc: The resolution level index for the pair signaled. Equation 4 shows how this marker segment is constructed based on the resolution level index *lev* as well as the precinct index *prec* for the pair.

$$PLqpc = \begin{cases} lev & prec < 256 \\ 128 + lev & prec \geq 256 \end{cases} \qquad (4)$$

As in ITU-T T.800 | ISO/IEC 15444-1, the resolution level index *lev* can range from 0 to N_L, where N_L is the number of decomposition levels defined in ITU-T T.800 | ISO/IEC 15444-1.

PPqpc: The precinct index for the pair signaled. The size of this marker segment parameter will be one byte when the PLqpc marker segment parameter is less than 128, but two bytes when PLqpc is greater than or equal to 128. This parameter will then just hold the precinct index *prec*. The precinct index *prec* can range from 0 to *numprecincts*-1, where *numprecincts* is the number of precincts at resolution level *lev* and is also defined in ITU-T T.800 | ISO/IEC 15444-1.

Sqpc: Quantization style for all components of the (component, resolution level, precinct) triplet.

SPqpc^i: Quantization step size value for the *i*-th subband at resolution level *lev* in the order defined for *lev* in Annex F.2.4 of ITU-T T.801 | ISO/IEC 15444-2. The number of parameters is the same as the number of subbands in the resolution level *lev*.

Table 3 – Default quantization for precinct parameter values

Parameter	Size (bits)	Values
QPC	16	0xFF5B
Lqpc	16	7 — 103
Cqpc	8 16	0 —255; if Csiz < 257 0 — 16 383; if Csiz ≥ 257
PLqpc	8	0 — 32 OR 128 — 160
PPqpc	8 16	0 — 255; if PLqpc < 128 0 — 65 535; if PLqpc ≥ 128
Sqpc	8	Table A-10 from ITU-T T.801 | ISO/IEC 15444-2
SPqpc[1]	variable	Table A-10 from ITU-T T.801 | ISO/IEC 15444-2