
**Information technology — Scalable
compression and coding of
continuous-tone still images —**

**Part 1:
Scalable compression and coding of
continuous-tone still images**

*Technologies de l'information — Compression échelonnable et codage
d'images plates en ton continu —*

Partie 1: Codage des images à gamme dynamique élevée

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/IEC JTC 1, *Information technology, SC 29, Coding of audio, picture, multimedia and hypermedia information*.

ISO/IEC 18477 consists of the following parts, under the general title: *JPEG HDR image coding system*:

- *Part 1: Coding of high dynamic range images*
- *Part 2: Extensions for high dynamic range images*
- *Part 3: Box file format*
- *Part 6: IDR Integer Coding*
- *Part 7: HDR Floating-Point Coding*

The following parts are under preparation:

- *Part 4: Conformance testing*
- *Part 5: Reference software*
- *Part 8: Coding of high dynamic range images*
- *Part 9: Encoding of alpha channels*

Introduction

This part of ISO/IEC 18477 specifies a coded codestream format for storage of continuous-tone photographic content. JPEG XT is a scalable image coding system that builds on top of the legacy Rec. ITU-T T.81 | ISO/IEC 10918-1 coding system, also known as JPEG, but extends it in a backwards compatible way. This part of ISO/IEC 18477 specifies the commonly deployed components of the JPEG coding system. Additional parts of ISO/IEC 18477 will extend on this baseline.

JPEG XT has been designed to be backwards compatible to legacy applications while at the same time having a small coding complexity; JPEG XT uses, whenever possible, functional blocks of Rec. ITU-T T.81 | ISO/IEC 10918-1, Rec. ITU-T T.86 | ISO/IEC 10918-4 and Rec. ITU-T T.871 | ISO/IEC 10918-5 to extend the functionality of the legacy JPEG Coding System. It is optimized for good image quality and compression efficiency while also enabling low-complexity encoding and decoding implementations.

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Information technology — Scalable compression and coding of continuous-tone still images —

Part 1: Scalable compression and coding of continuous-tone still images

1 Scope

This part of ISO/IEC 18477 specifies a coding format, referred to as JPEG XT, which is designed primarily for continuous-tone photographic content.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 10918-1, *Information technology — Digital compression and coding of continuous-tone still images — Requirements and guidelines*

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)*

ISO/IEC 10918-5, *Information technology — Digital compression and coding of continuous-tone still images: JPEG File Interchange Format (JFIF)*

3 Terms and definitions

For the purposes of this document, the following definitions apply.

3.1

bit stream

partially encoded or decoded sequence of bits comprising an entropy-coded segment

3.2

block

8×8 array of samples or an 8×8 array of DCT coefficient values of one component

3.3

byte

group of 8 bits

3.4

coder

embodiment of a coding process

3.5

coding

encoding or decoding

3.6

compression

reduction in the number of bits used to represent source image data

3.7

component

two-dimensional array of samples having the same designation in the output or display device

Note 1 to entry: An image typically consists of several components, e.g. red, green and blue.

3.8

continuous-tone image

image whose components have more than one bit per sample

3.9

discrete cosine transform

DCT

either the forward discrete cosine transform or the inverse discrete cosine transform

3.10

downsampling

procedure by which the spatial resolution of a component is reduced

3.11

entropy-coded (data) segment

independently decodable sequence of entropy encoded bytes of compressed image data

3.12

entropy decoder

embodiment of an entropy decoding procedure

3.13

entropy decoding

lossless procedure which recovers the sequence of symbols from the sequence of bits produced by the entropy encoder

3.14

entropy encoder

embodiment of an entropy encoding procedure

3.15

entropy encoding

lossless procedure which converts a sequence of input symbols into a sequence of bits such that the average number of bits per symbol approaches the entropy of the input symbols

3.16

grayscale image

continuous-tone image that has only one component

3.17

joint photographic experts group

JPEG

informal name of the committee which created this International Standard

Note 1 to entry: The “joint” comes from the ITU-T and ISO/IEC collaboration.

3.18

legacy decoder

embodiment of a decoding process conforming to Rec. ITU-T T.81 | ISO/IEC 10918-1 operating in baseline, sequential or progressive mode with a sample resolution of eight bits

3.19**marker**

two-byte code in which the first byte is hexadecimal FF and the second byte is a value between 1 and hexadecimal FE

3.20**marker segment**

marker and associated set of parameters

3.21**pixel**

collection of sample values in the spatial image domain having all the same sample coordinates

Note 1 to entry: A pixel may consist of three samples describing its red, green and blue value

3.22**precision**

number of bits allocated to a particular sample or DCT coefficient

3.23**procedure**

set of steps which accomplishes one of the tasks which comprise an encoding or decoding process

3.24**quantization value**

integer value used in the quantization procedure

3.25**quantize**

act of performing the quantization procedure for a DCT coefficient

3.26**sample**

one element in the two-dimensional array which comprises a component

3.27**sample grid**

common coordinate system for all samples of an image with the samples at the top left edge of the image having the coordinates (0, 0), the first coordinate increases towards the right, the second to the bottom

3.28**scan**

single pass through the data for one or more of the components in an image

3.29**scan header**

marker segment that contains a start-of-scan marker and associated scan parameters that are coded at the beginning of a scan

3.30**upsampling**

procedure by which the spatial resolution of a component is increased

3.31**vertical sampling factor**

relative number of vertical data units of a particular component with respect to the number of vertical data units in the other components in the frame

4 Symbols and abbreviated terms

4.1 Symbols

X	width of the sample grid in positions
Y	height of the sample grid in positions
N_f	number of components in an image
$S_{i,x}$	subsampling factor of component i in horizontal direction
$S_{i,y}$	subsampling factor of component i in vertical direction
H_i	subsampling indicator of component i in the frame header
V_i	subsampling indicator of component i in the frame header
$v_{x,y}$	sample value at the sample grid position x, y

4.2 Abbreviated terms

ASCII	American Standard Code for Information Interchange
DC	Lowpass
AC	Highpass
LSB	Least Significant Bit
MSB	Most Significant Bit
DCT	Discrete Cosine Transformation

5 Conventions

5.1 Conformance language

The keyword “reserved” indicates a provision that is not specified at this time, shall not be used, and may be specified in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be specified in the future.

5.2 Operators

NOTE Many of the operators used in this part of ISO/IEC 18477 are similar to those used in the C programming language.

5.2.1 Arithmetic operators

+	Addition
–	Subtraction (as a binary operator) or negation (as a unary prefix operator)
×	Multiplication
/	Division without truncation or rounding

5.2.2 Assignment operators

= Assignment operator

5.2.3 Precedence order of operators

Operators are listed below in descending order of precedence. If several operators appear in the same line, they have equal precedence. When several operators of equal precedence appear at the same level in an expression, evaluation proceeds according to the associativity of the operator either from right to left or from left to right.

Operators	Type of operation	Associativity
() , [] , .	Expression	Left to Right
-	Unary negation	
× , /	Multiplication	Left to Right
+, -	Addition and Subtraction	Left to Right
< , > , <= , >=	Relational	Left to Right

5.2.4 Mathematical functions

$\lceil x \rceil$	Ceiling of x. Returns the smallest integer that is greater than or equal to x.
$\lfloor x \rfloor$	Floor of x. Returns the largest integer that is lesser than or equal to x.
$ x $	Absolute value, is $-x$ for $x < 0$, otherwise x.
$\text{sign}(x)$	Sign of x, zero if x is zero, +1 if x is positive, -1 if x is negative.
$\text{clamp}(x, \text{min}, \text{max})$	Clamps x to the range [min, max]: returns min if $x < \text{min}$, max if $x > \text{max}$ or otherwise x.

6 General

6.1 General definitions

The purpose of this clause is to give an informative overview of the elements specified in this part of ISO/IEC 18477. Another purpose is to introduce many of the terms which are defined in [Clause 3](#). These terms are printed in *italics* upon first usage in this clause.

There are three elements specified in this part of ISO/IEC 18477:

- An *encoder* is an embodiment of an *encoding process*. An encoder takes as input *digital source image data* and *encoder specifications*, and by means of a specified set of *procedures* generates as output a *codestream*.
- A *decoder* is an embodiment of a *decoding process*. A decoder takes as input a *codestream*, and by means of a specified set of *procedures* generates as output *digital reconstructed image data*.
- The *codestream* is a compressed image data representation which includes all necessary data to allow a (full or approximate) reconstruction of the sample values of a digital image. Additional data might be required that define the interpretation of the sample data, such as the spatial dimensions of the samples.

6.2 Functional overview on the decoding process

The high-level algorithm for decoding is as follows: The samples are first reconstructed following the decoder specifications defined in Rec. ITU-T T.81 | ISO/IEC 10918-1. If the resulting component arrays are subsampled, they are upsampled on a common sample grid following the specifications in [Annex A](#). Following that, the output data is processed by an inverse decorrelation transformation. If the data is already in an RGB type colour space, e.g. RGB with ITU-R Recommendation BT.601 primaries, this transformation will be the identity transformation. Otherwise, either the ICT is used to transform the data into RGB. The inverse decorrelation transformation is defined in [Annex C](#), and the markers that are required to select the transformation are defined in [Annex B](#).

6.3 Encoder requirements

An encoding process converts source image data to compressed image data. This includes first generating a low dynamic range image, and representing it by a coding process specified in Annex F or Annex G of Rec. ITU-T T.81 | ISO/IEC 10918-1, and then generating a residual image which is encoded by one of the processes defined in this part of ISO/IEC 18477.

In order to comply with this part of ISO/IEC 18477, an encoder shall satisfy at least one of the following two requirements. An encoder shall with appropriate accuracy, convert source image data to compressed image data which comply with the codestream format syntax specified in [Annex B](#) for the encoding process(es) embodied by the encoder. A limited accuracy sufficient to match the error bounds specified in the compliance tests is acceptable.

There is no requirement in this part of ISO/IEC 18477 that any encoder which embodies one of the encoding processes specified here shall be able to operate for all ranges of the parameters which are allowed for that process. An encoder is only required to meet the compliance tests and to generate the compressed data format according to [Annex B](#) for those parameter values which it does use.

6.4 Decoder requirements

A decoding process converts compressed image data to reconstructed image data. For that, it has to follow the decoding operation specified in Rec. ITU-T T.81 | ISO/IEC 10918-1 with sufficient accuracy, using either the Baseline, Sequential or Progressive Scan process of the earlier Recommendation | International Standard defined there in Annexes F and G. This process generates sample values on a sample grid, which are then converted into a digital image by following the upsampling specifications in [Annex B](#) and the multi-component decorrelation (ICT) process in [Annex C](#).

Annex A (normative)

Component subsampling and expansion of subsampling

In this Annex and all of its subclauses, the flow charts and tables are normative only in the sense that they are defining an output that alternative implementations shall duplicate.

A.1 Component dimensions and subsampling factors (normative)

An image is defined to consist of N_f components, each of which is identified by a unique identifier C_i defined in the frame header of the codestream format specified in [Annex B](#). The number of components N_f shall be either one or three. A component consists of a rectangular array of samples x_i wide and y_i samples high. The component dimensions are derived from the image dimensions X and Y , also parameters recorded in the frame header. These two parameters define a sample grid of X grid points wide and Y grid points high, where the left topmost grid coordinate is $(0, 0)$ and coordinates increase from left to right and from top to bottom. However, the dimensions of the component do not need to coincide with the dimensions of the image. For each component, two subsampling factors $s_{i,x}$ and $s_{i,y}$ define the spacing between sample points of component i relative to the sample grid and the size of the component array. If X and Y are the dimensions of the sample grid, the size of component i with subsampling factors $s_{i,x}$ and $s_{i,y}$ is

$$\lceil X / s_{i,x} \rceil \text{ and } \lceil Y / s_{i,y} \rceil$$

Upsampling by interpolation from surrounding samples as specified in [Annex A](#) generates then sample values on all grid points of the sample grid.

The subsampling factors $s_{i,x}$ and $s_{i,y}$ are not directly represented in the binary codestream or any of its markers, but shall be derived from the parameters H_i and V_i recorded in the frame header. If N_f equals one, i.e. the image consists of a single component, H_1 and V_1 shall be one, and $s_{1,x}$ and $s_{1,y}$ are both one. If N_f equals three, [Table A.1](#) defines the relation between H_i , V_i and $s_{i,x}$ and $s_{i,y}$. No other combinations of H_i and V_i than those listed in [Table A.1](#) shall be used.

Table A.1 — Subsampling values

H_1	V_1	H_2	V_2	H_3	V_3	$s_{1,x}$	$s_{1,y}$	$s_{2,x}$	$s_{2,y}$	$s_{3,x}$	$s_{3,y}$
1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	1	2	1	1	1	1	2	1	2
2	2	1	2	1	2	1	1	2	1	2	1
2	2	1	1	1	1	1	1	2	2	2	2
All other values reserved for ITU/ISO purposes.											

NOTE Rec. ITU-T T.81 | ISO/IEC 10918-1 allowed other component arrangements and relations between grid positions and sample positions that are not valid in this part of ISO/IEC 18477. However, the definitions given here are special cases of the more general relations provided in Rec. ITU-T T.81 | ISO/IEC 10918-1 and both definitions agree whenever both are defined.

A.2 Expansion of subsampled components

Whenever the subsampling factors $s_{i,x}$ and $s_{i,y}$ are not both one, interpolation is required to populate all grid positions of the image sample grid. The precise algorithm of how this interpolation has to be performed is not specified in this part of ISO/IEC 18477 and various implementation choices exist. This

subclause provides an example for a simple bi-linear interpolation that is sufficient for most applications, though more sophisticated choices may provide better subjective image quality.

A.3 Bilinear expansion of subsampled components (informative)

In a first step, check for each component i whether $s_{i,y}$ is two or one. If $s_{i,y}$ is one, perform no activity. If $s_{i,y}$ equals two, interpolate samples v at odd lines from even lines as follows:

$$v_{x, 2y+1} = [(v_{x, 2y} + v_{x, 2y+2} + (y \bmod 2)) / 2]$$

If $2y+2$ is larger or equal to Y , the horizontal sample grid dimension, set $v_{x, 2y+1}$ equal to $v_{x, 2y}$.

In a second step, check for each component i whether $s_{i,x}$ is two or one. If $s_{i,x}$ is one, no further activity is required and the algorithm terminates. Otherwise, if $s_{i,x}$ is equal to two, interpolate samples at odd positions from samples at even positions accordingly:

$$v_{2x+1, y} = [(v_{2x, y} + v_{2x+2, y} + (x \bmod 2)) / 2]$$

Again, if $2x+2$ is larger or equal than X , the vertical sample grid dimension, set $v_{2x+1, y}$ to $v_{2x, y}$.

A.4 Downsampling of components (informative)

This part of ISO/IEC 18477 does not define a normative procedure by which the resolution of components whose $s_{i,x}$ and $s_{i,y}$ factors are not both one shall be reduced. Any procedure that generates components of the size $\lceil X / s_{i,x} \rceil$ and $\lceil Y / s_{i,y} \rceil$ is acceptable as long as it is compatible with the upsampling procedure defined above. A very simple downsampling filter is given in the next subclause.

A.5 Downsampling by a box filter (informative)

The box filter is the simplest possible downsampling filter and provides only poor quality. Even though better alternatives exist, the box filter is nevertheless presented here as an example. The input of the box filter is a $X \times Y$ component array of samples, where the sample value at position x, y is denoted by $v_{x,y}$. Set now

$$x_{\min} := s_{i,x} \times x_s \quad x_{\max} := \min(s_{i,x} \times x_s + s_{i,x} - 1, X - 1) \quad y_{\min} := s_{i,y} \times y_s \quad y_{\max} := \min(s_{i,y} \times y_s + s_{i,y} - 1, Y - 1)$$

The output of the box filter at position x_s, y_s is then defined as

$$v_{x_s, y_s}^s = (\sum_{x=x_{\min}..x_{\max}} \sum_{y=y_{\min}..y_{\max}} v_{x,y}) / ((x_{\max} - x_{\min} - 1) \times (y_{\max} - y_{\min} - 1))$$

i.e. the average over the box $x_{\min}, y_{\min}$ to $x_{\max}, y_{\max}$. The array of downsampled sample values v_{x_s, y_s}^s is then subject to further processing, e.g. DCT transformation and entropy coding.

Annex B (normative)

Codestream syntax

This Annex defines the compressed bitstream syntax which, structurally, consists of an ordered collection of marker segments and entropy coded data segments. Marker segments specify parameters necessary to reconstruct the sample values from the entropy coded data segments. Because all of these constituent parts are represented with byte-aligned codes, each compressed data format consists of an ordered sequence of 8-bit bytes. For each byte, a most significant bit (MSB) and a least significant bit (LSB) are defined.

NOTE The codestream syntax defined here agrees mostly with the “interchange format” defined in Rec. ITU-T T.81 | ISO/IEC 10918-1, with some additional constraints on the parameters in the marker segments and some additional markers carrying information that is irrelevant for the older standard.

B.1 Parameters

Parameters are integers, with values specific to the encoding process, source image characteristics, and other features selectable by the application. Parameters are assigned either 4-bit, 1-byte, 2-byte or 4-byte codes. Except for certain optional groups of parameters, parameters encode critical information without which the decoding process cannot properly reconstruct the image. The code assignment for a parameter shall be an unsigned integer of the specified length in bits with the particular value of the parameter.

For parameters which are 2 bytes (16 bits) in length, the most significant byte shall come first in the compressed data's ordered sequence of bytes. The same holds for parameters that are 4 bytes (32 bit) in length, where bits are ordered in the codestream in decreasing significance. Parameters which are 4 bits in length always come in pairs, and the pair shall always be encoded in a single byte. The first 4-bit parameter of the pair shall occupy the most significant 4 bits of the byte. Within any 32-, 16-, 8-, or 4-bit parameter, the MSB shall come first and LSB shall come last. This encoding is commonly known as “big endian” representation of unsigned integers.

B.2 Markers

Markers serve to identify the various structural parts of the compressed data formats. Most markers start marker segments containing a related group of parameters; some markers stand alone. All markers are assigned two-byte codes: an 0xff byte followed by a byte which is not equal to 0x00 or 0xff. Any marker may optionally be preceded by any number of fill bytes, which are bytes of the value 0xff.

NOTE Because of this special code-assignment structure, markers make it possible for a decoder to parse the compressed data and locate its various parts without having to decode other segments of image data.

B.3 Marker assignments

All markers shall be assigned two-byte codes: a 0xff byte followed by a second byte which is not equal to 0x00 nor 0xff. The second byte is specified in [Table B.1](#) for each defined marker. An asterisk (*) indicates a marker which stands alone, that is, which is not the start of a marker segment. Most of the marker segments used by this part of ISO/IEC 18477 are defined in Rec. ITU-T T.81 | ISO/IEC 10918-1, though some marker segments defined there shall not be used in this part of ISO/IEC 18477. For completeness, these markers are also included in [Table B.1](#). Furthermore, care must be taken that the parameters of some markers are more constraint than in the earlier Recommendation | International Standard, and the meaning of several markers changed slightly. Such changes are also indicated in the [Table B.1](#), and a full specification of the changes follows.

Table B.1 — Markers and marker segments

Code assignment	Symbol	Description	Defined in
Start of Frame markers valid in this part of ISO/IEC 18477			
0xFFC0	SOF ₀	Baseline DCT Process	This part of ISO/IEC 18477
0xFFC1	SOF ₁	Extended Sequential DCT Process limited to 8 bit sample precision (extended sequential, Huffman coding, 8-bit sample precision)	
0xFFC2	SOF ₂	Progressive DCT Process limited to 8 bit sample precision (spectral selection only, Huffman coding, 8-bit sample precision or full progression, Huffman coding, 8-bit sample precision)	
Start of Frame markers defined in Rec. ITU-T T.81 ISO/IEC 10918-1 that shall not be used in this part of ISO/IEC 18477			
0xFFC3	SOF ₃	Additional Start of Frame Markers, shall not be used.	Rec. ITU-T T.81 ISO/IEC 10918-1
0xFFC5	SOF ₅		
0xFFC6	SOF ₆		
0xFFC7	SOF ₇		
0xFFC9	SOF ₉		
0xFFCA	SOF ₁₀		
0xFFCB	SOF ₁₁		
0xFFCD	SOF ₁₂		
0xFFCE	SOF ₁₄		
0xFFCF	SOF ₁₅		
Table specifications			
0xFFC4	DHT	Define Huffman Tables	Rec. ITU-T T.81 ISO/IEC 10918-1
0xFFDB	DQT	Define Quantization Tables	Rec. ITU-T T.81 ISO/IEC 10918-1
Restart interval termination			
0xFFD0 through 0xFFD7	RST _m *	Restart modulo 8 count 'm'	Rec. ITU-T T.81 ISO/IEC 10918-1
0xFFDD	DRI	Define Restart Interval	Rec. ITU-T T.81 ISO/IEC 10918-1
Other markers			
0xFFD8	SOI*	Start of Image	Rec. ITU-T T.81 ISO/IEC 10918-1
0xFFD9	EOI*	End of Image	
0xFFDA	SOS	Start of Scan	
0xFFFE	COM	Comment	
JPEG extension markers			
0xFFE0	APP ₀	JFIF Application Marker	Rec. ITU-T T.86 ISO/IEC 10918-4 and Rec. ITU-T T.871 ISO/IEC 10918-5
0xFFE1	APP ₁	EXIF Application Marker	Rec. ITU-T T.86 ISO/IEC 10918-4
0xFFE2	APP ₂	ICC Profile Marker	Rec. ITU-T T.86 ISO/IEC 10918-4 and Rec. ITU-T T.871 ISO/IEC 10918-5
0xFFE3 through 0xFFE8	APP ₃ through APP ₁₀	Application Markers 3 through 10	Rec. ITU-T T.86 ISO/IEC 10918-4
0xFFEB	APP ₁₁	JPEG XT Marker	This part of ISO/IEC 18477
0xFFEC	APP ₁₂	Application Marker 12	Rec. ITU-T T.86 ISO/IEC 10918-4
0xFFED	APP ₁₃	Component Decorrelation Control marker	This part of ISO/IEC 18477
0xFFEE through 0xFFEF	APP ₁₄ through APP ₁₅	Application Markers 14 and 15	Rec. ITU-T T.86 ISO/IEC 10918-4
Markers defined in other specifications that shall not be used in this part of ISO/IEC 18477			

Table B.1 (continued)

Code assignment	Symbol	Description	Defined in
Start of Frame markers valid in this part of ISO/IEC 18477			
0xFFC8	JPG	Reserved for JPEG Extensions	Rec. ITU-T T.81 ISO/IEC 10918-1
0xFFCC	DAC	Define Arithmetic Coding Conditions	
0xFFDC	DNL	Define Number of Lines	
0xFFDE	DHP	Define Hierarchical Progression	
0xFFDF	EXP	Expand Reference Components	
All other values		Reserved for ITU/ISO purposes, shall not be used in this part of ISO/IEC 18477	

B.4 Marker segments

A marker segment consists of a marker followed by a sequence of related parameters. The first parameter in a marker segment is the two-byte length parameter. This length parameter encodes the number of bytes in the marker segment, including the length parameter and excluding the two-byte marker. The marker segments identified by the SOF and SOS marker codes are referred to as headers: the frame header and the scan header respectively.

B.5 Entropy-coded data segments

An entropy-coded data segment contains the output of an entropy-coding procedure. It consists of an integer number of bytes created by the Huffman coding procedure. An entropy coded data segment stands for itself and is started by an SOS marker.

Entropy coded segments shall be always a multiple of eight bits long, and shall be padded by one bits at the end of the segment to fill an entire byte. In order to ensure that a marker does not occur within an entropy-coded segment, the encoder shall insert a zero byte into the output bitstream following any 0xff byte generated by either the Huffman encoder or by the above termination algorithm. Decoders shall remove such “stuffed” zero bytes before feeding the resulting bitstream into the Huffman decoder.

B.6 High-level syntax

The high-level syntax of the codestream defined in this part of ISO/IEC 18477 shall follow the syntax of the Interchange Format specified in [B.2](#) and [B.3](#) of Rec. ITU-T T.81 | ISO/IEC 10918-1 where only the subset of the markers specified in [Table B.1](#) shall be used.

Specifically, conforming codestreams shall start with an SOI marker, followed by a single frame, followed by a single EOI marker. The high level syntax is depicted in [Table B.2](#).

Table B.2 — High-level syntax of the codestream

SOI Marker	Frame	EOI
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NOTE Rec. ITU-T T.81 | ISO/IEC 10918-1 allowed multiple frames for the hierarchical coding mode, though this mode is not applicable in this part of ISO/IEC 18477.

A frame consists of zero or more table definitions containing the coding parameters of the image data, followed by the frame header, followed by one or more scans over the image. The scan type is indicated by the type of the SOF (Start of Frame) marker starting the frame header, see [Table B.1](#). The frame header syntax is defined in [B.2](#). The syntax of a frame is indicated in [Table B.3](#).

Table B.3 — Syntax of a frame

[Tables/JPEG Extensions Markers/Misc]	Frame header	Scan ₁	...	Scan _{Last}
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The Tables consist of zero or more of the following marker segments:

- zero or more DHT marker segments defining the Huffman code required for decoding the entropy coded segment,
- zero or more DQT marker segments defining the quantization matrix required to reconstruct the DCT coefficients,
- at most one DRI marker segment defining the restart interval,
- an optional Component Decorrelation Control marker, defining the inverse multi-component decorrelation transformation for the bitstream,
- optionally, additional application specific data encoded in APP_n markers, defined in other parts of ISO/IEC 18477.
- optionally, one or more COM markers including additional codestream comments.

NOTE Unlike Rec. ITU-T T.81 | ISO/IEC 10918-1, DNL markers are not valid in this part of ISO/IEC 18477. The size of the image is thus to be completely defined by the frame header.

A scan consists of zero or more table definitions including coding parameters, followed by a scan header starting with an SOS marker, and one or more entropy coded segments. If restart markers are disabled, a scan shall only contain a single entropy coded segment. Otherwise, the scan may contain multiple entropy coded segments separated by restart markers. The syntax of the restart markers shall follow the definitions found in Rec. ITU-T T.81 | ISO/IEC 10918-1. The syntax of a scan is indicated in [Table B.4](#).

There shall be at most one DQT table for each table destination in the codestream, replacing an already defined quantization matrix by inserting a DQT marker segment with a table destination already defined earlier in the codestream is invalid. Furthermore, the codestream shall include sufficient information to be self-contained, i.e. to allow reconstruction of the sample values with information contained in the codestream only.

Additional requirements may apply to other marker segments found in the Tables/Extensions/Misc segment, they are defined together with the corresponding marker segment in this Annex.

Table B.4 — Syntax of a scan

[Tables/JPEG Extensions Markers/Misc]	Scan header	ECS ₀	RST ₀	...	ECS _{Last-1}	RST _{Last}	ECS _{Last}
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B.7 Frame header syntax

[Table B.5](#) specifies the frame header which shall be present at the start of a frame. Frame headers always start with a SOF_n marker, where n defines the type of the LDR scans contained in the frame. See [Table B.1](#) for scan types supported by this part of ISO/IEC 18477.

The frame header specifies the dimensions of the image, the components in the frame, and the sampling factors for each component, and specifies the destinations from which the quantized tables to be used with each component are retrieved.

Table B.5 — Frame header parameters and values

Parameter	Size (in Bits)	Value	Meaning
SOF _n	16	0xFFC0 through 0xFFC2	Start of Frame Marker, indicating this marker segment and the type of the LDR scans
Lf	16	8+3*Nf	Size of the marker segment not including the marker
P	8	8	Precision of the low dynamic range representation of the image contained in the legacy codestream
Y	16	1-65535	Height of the sample grid in lines
X	16	1-65535	Width of the sample grid in lines
Nf	8	1 or 3	Number of visible components in the image
C _i	8	0-255	Component identifiers
H _i	4	1 or 2	Specification of the component subsampling factors, see Table A.1 for allowable values and the relation between H _i V _i and s _{i,x} and s _{i,y}
V _i	4	1 or 2	
Tq _i	8	0-3	Quantization Table Destination selector

NOTE The frame header syntax defined here is identical to the syntax defined in Rec. ITU-T T.81 | ISO/IEC 10918-1 except that some parameters are restricted. Specifically, the bit precision of the components must always be eight, the height must be greater than zero indicating that the number of lines of the image is known, the number of components must be either one or three and the horizontal and vertical sampling factors are constraint to the values listed in [Table A.1](#).

B.8 Scan header syntax

The scan header defines the parameters necessary to decode a single scan over the image. For the baseline or sequential frame syntax, this is the only scan that represents the low dynamic range version of the image. Multiple scans are possible in the progressive mode.

The syntax of the scan header follows the definition for the same marker in Rec. ITU-T T.81 | ISO/IEC 10918-1, though some of the parameters are here more constrained than in the older Recommendation | International Standard. The parameters and sizes of the scan header are defined in [Table B.6](#).

Table B.6 — Scan header parameters and values

Parameter	Size (in Bits)	Values			Meaning
		Baseline	Extended Sequential	Progressive	
SOS	16	0xFFDA			SOS marker, identifies the start of the scan
Ls	16	6+2×Ns			Size of the marker segment (not including the marker)
Ns	8	1 or 3		1 or 3 (if the progressive scan is a subsequent scan and includes AC components, only 1 is allowed here)	Number of components in the scan

Table B.6 (continued)

Parameter	Size (in Bits)	Values			Meaning
		Baseline	Extended Sequential	Progressive	
Cs _j	8	0-255 (shall be a subset of the component identifiers defined in the frame header)			Component identifiers of the components defined by the scan
Td _j	4	0-1	0-3		Huffman DC table specification
Ta _j	4	0-1	0-3		Huffman AC table specification
Ss	8	0		0-63	Start of Spectral Selection
Se	8	63		Ss-63	End of Spectral Selection
Ah	4	0		0-9 If nonzero, must be equal to Al+1	Successive Approximation high bit position
Al	4	0		0-8	Successive Approximation low bit position

NOTE The scan header syntax defined here is identical to the syntax defined in Rec. ITU-T T.81 | ISO/IEC 10918-1, though a scan may contain at most three components.

B.9 Component Decorrelation Control marker

The APP₁₃ controls whether the Multi-Component Decorrelation Transformation described in [Annex C](#) is applied to the components before subsampling and entropy coding. This transformation typically improves the compression performance by representing data in an RGB type colorspace, e.g. RGB with primaries defined by ITU-R Recommendation BT.601 in a luma/chroma format that is close to YCbCr, e.g. ITU-R Recommendation BT.601. This marker shall only be inserted into the codestream as parts of the Table/misc segment if the number of components in the frame (Nf) is three, and there shall be at most one such marker in the codestream. The marker parameters and sizes are defined in [Table B.8](#), the organization of the marker is shown in [Table B.7](#).

NOTE This marker is identical to the “Adobe Color Management” marker defined in Rec. ITU-T T.86 | ISO/IEC 10918-4, though the possible values of the parameters inside the marker segment are more restricted.

Table B.7 — Organization of the Component Decorrelation Control marker

0xFFED	La	ACid	ver	f1	f2	cc
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