

# ISO/IEC 15444-2:2023-11 (E)

## Information technology - JPEG 2000 image coding system - Part 2: Extensions

---

<b>Contents</b>		<b>Page</b>
1	Scope .....	1
2	Normative references .....	1
3	Definitions .....	2
4	Abbreviations .....	4
5	Conventions .....	4
6	General description .....	4
6.1	Extensions specified by this Recommendation   International Standard .....	5
6.2	Relation between extensions .....	6
Annex A	Compressed data syntax, extension .....	8
A.1	Extended capabilities .....	8
A.2	Extensions to Rec. ITU-T T.800   ISO/IEC 15444-1 marker segment parameters .....	8
A.3	Extended marker segments .....	16
Annex B	Variable DC offset, extension .....	35
B.1	Variable DC offset flow .....	35
B.2	Inverse DC offset .....	35
B.3	Forward DC offset (informative) .....	35
Annex C	Variable scalar quantization, extension .....	37
C.1	Variable scalar quantization .....	37
C.2	Variable scalar dequantization for irreversible filters .....	37
C.3	Variable scalar quantization for irreversible filters (informative) .....	37
Annex D	Trellis coded quantization extensions .....	39
D.1	Introduction to TCQ .....	39
D.2	Sequence definition .....	40
D.3	Forward TCQ quantization (informative) .....	41
D.4	Inverse quantization (normative) .....	42
D.5	Lagrangian rate allocation (informative) .....	45
Annex E	Visual masking, extensions .....	50
E.1	Introduction to visual masking (informative) .....	50
E.2	Point-wise extended non-linearity (informative) .....	50
E.3	Decoding with visual masking .....	52
E.4	Encoding with visual masking (informative) .....	53
E.5	Setting parameters (informative) .....	53
E.6	Compatibility with other technologies (informative) .....	53
Annex F	Arbitrary decomposition of tile-components, extensions .....	54
F.1	Wavelet sub-bands .....	54
F.2	Equation, text and decomposition updates .....	55
F.3	Inverse discrete wavelet transformation for general decompositions .....	64
F.4	Forward discrete wavelet transformation for general decompositions (informative) .....	71
Annex G	Whole-sample symmetric transformation of images, extensions .....	78
G.1	Wavelet transformation parameters, definitions and normalizations .....	78
G.2	Whole-sample symmetric (WS) wavelet transformations reconstruction .....	78
G.3	Whole-sample symmetric (WS) wavelet transformation decomposition (informative) .....	81
G.4	Examples of WS wavelet transformations (informative) .....	82
Annex H	Transformation of images using arbitrary wavelet transformations .....	85
H.1	Wavelet transformation parameters and normalizations .....	85
H.2	Arbitrary (ARB) wavelet transformation reconstruction procedures .....	85
H.3	Arbitrary (ARB) wavelet transformation decomposition procedures (informative) .....	91
H.4	Examples of ARB wavelet transformations (informative) .....	94

Annex I – Single sample overlap discrete wavelet transform, code-block anchor point and progression order extensions .....	98
I.1 Introduction to single sample overlapping .....	98
I.2 The code-block anchor points (CBAP) extension .....	98
I.3 The SSO extension .....	102
I.4 The TSSO extension .....	110
I.5 Combining the SSO and TSSO extensions (informative) .....	111
Annex J – Multiple component transformations, extension.....	112
J.1 Introduction to multiple component transformation concepts.....	112
J.2 Overview of inverse processing .....	112
J.3 Transformations .....	118
Annex K – Non-linear transformation .....	128
K.1 Signalling the use of the non-linear transformations.....	128
K.2 Non-linear transformation specifications .....	129
Annex L – Region of interest coding and extraction, extensions.....	133
L.1 Decoding of ROI.....	133
L.2 Description of the Scaling based method .....	133
L.3 Region of interest mask generation .....	134
L.4 Remarks on region of interest coding.....	138
Annex M – JPX extended file format syntax.....	139
M.1 File format scope.....	139
M.2 Introduction to JPX .....	139
M.3 Greyscale/Colour/Palette/multi-component specification architecture .....	142
M.4 Fragmenting the codestream between one or more files .....	143
M.5 Combining multiple codestreams .....	145
M.6 Using reader requirements masks to determine how a file can be used .....	149
M.7 Extensions to the JPX file format.....	156
M.8 Differences from the JP2 binary definition .....	157
M.9 Conformance .....	157
M.10 Key to graphical descriptions (informative).....	161
M.11 Defined boxes .....	161
M.12 Dealing with unknown boxes.....	210
M.13 Using the JPX file format in conjunction with other multi-media standards (informative) .....	210
M.14 Decomposing an XML document into multiple boxes.....	211
Annex N – JPX file format extended metadata definition and syntax .....	213
N.1 Introduction to extended metadata .....	213
N.2 Additional references for extended metadata .....	213
N.3 Scope of metadata definitions .....	213
N.4 Metadata syntax .....	214
N.5 Defined boxes .....	215
N.6 Metadata definitions.....	217
N.7 Fundamental type and element definitions.....	258
N.8 JPX extended metadata document type definition .....	284
N.9 JPX extended metadata XML Schema.....	304
Annex O – Examples and guidelines, extensions .....	347
O.1 Arbitrary decomposition examples .....	347
O.2 Odd Tile Low Pass First (OTLPPF) convention .....	368
O.3 Multiple component collection example .....	369
O.4 Background to enhancement of quantization .....	379
O.5 Wrapping JPEG XR (Rec. ITU-T T.832   ISO/IEC 29199-2) Codestreams by the JPX file format ...	379
O.6 Representing floating point numbers within JPEG 2000 .....	382
O.7 Working with ROI Description boxes.....	383

Annex P – Block coder extensions .....	384
P.1 Selective arithmetic coding bypass (lazy mode) .....	384
P.2 Enhancement of selective arithmetic coding bypass (fast mode).....	384
Bibliography .....	386

### List of Tables

Table A.1 – Syntax support for extensions .....	8
Table A.2 – Capability Rsiz parameter, extended .....	9
Table A.3 – Start of tile-part parameter values, extended.....	9
Table A.4 – Number of tile-parts, TNsot, parameter value, extended .....	9
Table A.5 – Coding style parameter values for the Scod parameter.....	10
Table A.6 – Coding style parameter values of the SGcod parameter .....	11
Table A.7 – Coding style parameter values of the SPcod and SPcoc parameters, extended .....	11
Table A.7bis – Progression order for the SGcod and Ppoc parameters .....	11
Table A.8 – Multiple component transformation for the SGcod parameters .....	11
Table A.9 – Decomposition for the SPcod and SPcoc parameters, extended .....	12
Table A.10 – Transformation for the SPcod and SPcoc parameters, extended.....	12
Table A.11 – SSO parameters, extended .....	12
Table A.11bis – SXcod parameter.....	12
Table A.11ter – Progression order change, tile parameter values.....	13
Table A.12 – Quantization default values for the Sqcd, Sqcc, Sqpd, and Sqpc parameters, extended .....	14
Table A.13 – Quantization values (irreversible transformation only), extended .....	14
Table A.14 – SPqcd, SPqcc, SPqpd, and SPqpc parameters (irreversible transformation only), extended .....	14
Table A.15 – SPqcd, SPqcc, SPqpd, and SPqpc parameters (irreversible transformation only), extended .....	15
Table A.16 – Region-of-interest parameter values for the Srgn parameter .....	15
Table A.17 – Component index parameter value for the Crgn parameter .....	15
Table A.18 – Region-of-interest values from SPRgn parameter (Srgn = 1 or Srgn = 2) .....	15
Table A.19 – List of markers and marker segments .....	16
Table A.20 – Variable DC offset parameter values .....	17
Table A.21 – Variable DC offset parameter values for the Sdco parameter.....	17
Table A.22 – Visual masking parameter values .....	18
Table A.23 – Component parameter value for the Cvms parameter.....	18
Table A.24 – Visual masking for the Svms parameters.....	18
Table A.25 – Downsampling factor styles parameter values.....	19
Table A.26 – Arbitrary decomposition styles parameter values .....	20
Table A.27 – Arbitrary transformation parameter values .....	21
Table A.28 – Arbitrary transformation values for the Satk parameter.....	22
Table A.29 –Component bit depth definition parameter values .....	23
Table A.30 – Component bit depth definition values for the Ncbd parameter .....	23
Table A.31 – Component bit depth definition values for the BDcbdi parameter.....	23
Table A.32 – Multiple component transformation definition parameter values .....	24
Table A.33 – Multiple component transformation definition values for the Imct parameter .....	24
Table A.34 – Multiple component collection parameter values .....	26
Table A.35 – Multiple component collection values for the Xmcci parameter .....	26

Table A.36 – Multiple component collection values for the Nmcci parameter .....	26
Table A.37 – Multiple component collection values for the Mmcci parameter.....	27
Table A.38 – Multiple component collection values for the Tmcci parameter (array-based).....	27
Table A.39 – Multiple component collection values for the Tmcci parameter (wavelet-based) .....	27
Table A.40 – Multiple component intermediate collection parameter values .....	28
Table A.41 – Non-linearity transformation parameter values .....	29
Table A.42 – Non-linearity transformation parameter values for the Cnlt parameter .....	29
Table A.43 – Decoded image component bit depth parameter values for the BDnlt parameter.....	29
Table A.44 – Non-linearity transformation parameter values of the Tnlt parameter.....	30
Table A.45 – Non-linearity transformation parameter values of the STnlt parameter (Tnlt = 1) .....	30
Table A.46 – Non-linearity transformation parameter values of the STnlt parameter (Tnlt = 2) .....	30
Table A.47 – Quantization default, precinct parameter values .....	32
Table A.48 – Quantization precinct component parameter values .....	33
Table A.49 – Ccap2 syntax and semantics .....	33
Table A.50 – Precinct length, tile-part header parameter values .....	34
Table A.51 – Srlt values and semantics .....	34
Table A.52 – Semantics of JrItI values when Srlt is in the range [0, 231 – 1] .....	34
Table D.1 – Parent LUTs for $k > 0$ in the trellis of Figure D.3.....	42
Table D.2 – Description of functional blocks in Figure D.4.....	42
Table D.3 – Description of functional blocks in Figure D.5.....	43
Table D.4 – Look-up table for A(s) .....	44
Table D.5 – Look-up table for S(s,qk).....	44
Table D.6 – Description of functional blocks for Figure D.6.....	45
Table D.7 – Sub-band statistics required for LRA.....	46
Table D.8 – $\rho_b$ parameters for TCQ .....	46
Table D.9 – $\Delta_b$ parameters for TCQ .....	46
Table D.10 – $\rho_b$ parameters for SQ .....	47
Table D.11 – $\Delta_b$ parameters for SQ .....	47
Table D.12 – Description of functional blocks in Figure D.7.....	49
Table F.1 – Updates to contexts for significance propagation and cleanup coding passes.....	56
Table F.2 – Quantities for sub-band info calculation.....	60
Table F.3 – S(ab) and J(ab) as a function of dS(i) .....	64
Table F.4 – S(ab) and J(ab) as a function of dR(i).....	64
Table F.5 – Characteristics for sample wavelet decomposition in Figure F.14 .....	65
Table G.1 – Parameters for wavelet transformations.....	78
Table G.2 – Parameters of the 5-3 reversible wavelet transformation.....	83
Table G.3 – Parameters of the 13-7 reversible wavelet transformation .....	83
Table G.4 – Parameters of the 5-3 irreversible wavelet transformation .....	84
Table G.5 – Parameters of the irreversible 7-5 wavelet transformation .....	84
Table G.6 – Parameters of the irreversible 9-7 wavelet transformation .....	84
Table H.1 – Additional parameters for arbitrary wavelet transformations .....	85
Table H.2 – Minimum left extension length.....	89
Table H.3 – Minimum right extension length.....	89
Table H.4 – Parameters of the reversible Haar 2-2 wavelet transformation .....	95

Table H.5 – Parameters of the reversible 2-6 wavelet transformation.....	95
Table H.6 – Parameters of the reversible 2-10 wavelet transformation.....	95
Table H.7 – Parameters of the irreversible 6-10 wavelet transformation .....	96
Table H.8 – Parameters of the irreversible 10-18 wavelet transformation .....	96
Table M.1bis – Brand Values for JPEG XR Codestreams.....	142
Table M.1 – Example expression .....	151
Table M.2 – Expanded expression.....	151
Table M.3 – Example factored expression .....	151
Table M.4 – Example of a Reader Requirements expressions for Equations M-6 and M-7.....	153
Table M.5 – Example of a Reader Requirements box for Equations M-6 and M-7 .....	153
Table M.6 – Reader Requirements table for Equations M-10 and M-11.....	154
Table M.7 – Reader Requirements box data for Equations M-10 and M-11 .....	154
Table M.8 – Reader Requirements box data for Equations M-16 and M-17.....	155
Table M.9 – Example Reader Requirements box to test.....	155
Table M.10 – Table intentionally left blank .....	156
Table M.11 – Items which can be extended through Recommendations   International Standards.....	156
Table M.12 – Items which can be extended by registration .....	157
Table M.13 – Boxes defined within this Recommendation   International Standard.....	163
Table M.14 – Legal values of the SFi field .....	165
Table M.15 – Format of the contents of the Reader Requirements box .....	167
Table M.16 – Format of the contents of the Data Reference box .....	168
Table M.17 – Format of the contents of the Fragment List box .....	169
Table M.18 – Format of the contents of the Cross-Reference box .....	170
Table M.19 – Legal C values.....	171
Table M.20 – BPC and BPCi parameters .....	172
Table M.21 – Format of the contents of the Image Header box .....	172
Table M.22 – Legal METH values .....	176
Table M.23 – Legal APPROX values.....	177
Table M.24 – Format of the contents of the Colour Specification box.....	177
Table M.24bis – Nominal maximum sample values.....	177
Table M.25 – Additional legal EnumCS values .....	178
Table M.26 – Format of the contents of the METHDAT field for the Enumerated method .....	179
Table M.27 – Format of the contents of the METHDAT field for the Any ICC method .....	180
Table M.28 – Format of the contents of the METHDAT field for the Vendor Colour method.....	180
Table M.28bis – Format of the METHDAT field for the Parameterized method.....	181
Table M.29 – Standard illuminant values for CIELab.....	182
Table M.29bis – Default Offset Values and Encoding of Offsets for the CIELab Colourspace.....	182
Table M.30 – Format of the contents of the EP field for CIELab (EnumCS = 14) .....	183
Table M.30bis – Default Offset Values and Encoding of Offsets for the CIEJab Colourspace .....	184
Table M.31 – Format of the contents of the EP field for CIEJab (EnumCS = 19) .....	184
Table M.32 – Colours indicated by the Asoci field .....	185
Table M.33 – Otyp field values .....	186
Table M.34 – Format of the contents of the Opacity box .....	186
Table M.35 – Format of the contents of the Codestream Registration box .....	188

Table M.35bis – Allowed values for the pixel format .....	189
Table M.35ter – Common floating point formats (informative).....	189
Table M.36 – Format of the contents of the Composition box .....	190
Table M.37 – Format of the contents of the Composition Options box.....	191
Table M.38 – Ityp field values.....	192
Table M.39 – Format of the contents of the Instruction Set box .....	192
Table M.40 – Format of the contents of the INSTi parameter in the Instruction Set box.....	194
Table M.40bis – Encoding of the ROT field .....	194
Table M.41 – Format of the contents of the Association box .....	196
Table M.42 – ANi field values .....	196
Table M.43 – Format of the contents of the Number List box .....	196
Table M.44 – Legal Filter types.....	197
Table M.45 – Format of the contents of the Binary Filter box .....	198
Table M.46 – Format of the contents of the Graphics Technology Standard Output box .....	199
Table M.47 – Legal Ri values.....	199
Table M.48 – Allowed Rtypi values.....	200
Table M.49 – Format of the contents of the ROI Description box .....	200
Table M.49bis – Interpreting the 2 bit D field of Rtypi for quadrilateral refinements.....	201
Table M.50 – Legal Styp values .....	202
Table M.51 – Legal Ptyp values .....	203
Table M.52 – Format of the contents of the Digital Signature box .....	203
Table M.53 – Format of the contents of the Multiple Codestream box .....	208
Table M.54 – Format of the contents of the Multiple Codestream Info box .....	209
Table N.1 – Format of the contents of the Image Creation box.....	215
Table N.2 – Format of the contents of the Content Description box .....	216
Table N.3 – Format of the contents of the History box .....	216
Table N.4 – Format of the contents of the Intellectual Property Rights box .....	217
Table N.5 – Format of the contents of the Image Identifier box.....	217
Table N.6 – Image Source values .....	219
Table N.7 – Scene type values.....	219
Table N.8 – Sensor technology values.....	222
Table N.9 – Exposure program values.....	228
Table N.10 – Metering mode values.....	228
Table N.11 – Scene illuminant values .....	229
Table N.12 – Back light values.....	229
Table N.13 – Auto focus values.....	230
Table N.14 – Name description values .....	252
Table N.15 – Date description values .....	254
Table N.16 – Additional name description values.....	258
Table N.17 – Address component type values.....	264
Table N.18 – Address type values .....	264
Table N.19 – Phone number type values .....	265
Table N.20 – Name component type values .....	268
Table N.21 – Latitude reference values .....	276

Table N.22 – Latitude values.....	276
Table N.23 – Longitude reference values.....	276
Table N.24 – Longitude values.....	277
Table N.25 – GPS Status values.....	277
Table N.26 – GPS Measure mode values.....	277
Table N.27 – GPS Speed reference unit values.....	277
Table N.28 – Direction reference values.....	278
Table N.29 – GPS Destination distance reference unit values.....	278
Table O.1 – Sub-band labels for Figure O.15.....	352
Table O.2 – Mapping between ROT and SPATIAL_XFRM_SUBORDINATE.....	381
Table P.1 – Selective arithmetic coding bypass (default); (the same as Table D.9 of ITU-T T.800   ISO/IEC 15444-1)...	384
Table P.2 – Example of two bit planes (fast mode).....	385

### List of Figures

Figure 6-1 – Decoder block diagram.....	7
Figure A.1bis – Coding style default syntax.....	10
Figure A.1 – Variable DC offset syntax.....	16
Figure A.2 – Visual masking syntax.....	17
Figure A.3 – Downsampling factor styles syntax.....	18
Figure A.4 – Arbitrary decomposition styles syntax.....	19
Figure A.5 – Arbitrary transformation default syntax.....	20
Figure A.6 – Component bit depth definition syntax.....	22
Figure A.7 – Multiple component transformation definition syntax.....	23
Figure A.8 – Multiple component collection syntax.....	25
Figure A.9 – Multiple component transformation ordering syntax.....	28
Figure A.10 – Non-linearity point transformation syntax.....	28
Figure A.11 – Quantization default, precinct syntax.....	31
Figure A.12 – Quantization precinct component syntax.....	32
Figure A.13 – Precinct length, tile-part header syntax.....	34
Figure B.1 – Placement of the DC offset with multiple component transformation.....	35
Figure B.2 – Placement of the DC offset without multiple component transformation.....	35
Figure D.1 – Scalar quantizers used for TCQ.....	39
Figure D.2 – Union quantizers for TCQ.....	40
Figure D.3 – Trellis showing node indices.....	40
Figure D.4 – Forward TCQ processing.....	41
Figure D.5 – Full inverse processing for TCQ indices.....	43
Figure D.6 – Approximate dequantization of TCQ indices.....	45
Figure D.7 – Lagrangian rate allocation.....	48
Figure E.1 – System diagram for point-wise extended masking extension.....	50
Figure E.2 – Non-uniform quantization for self-contrast masking.....	51
Figure E.3 – Causal neighbourhood.....	52
Figure F.1 – Possible splits of sub-bands.....	55
Figure F.2 – Parameters for the GET_HOR_DEPTH and GET_VER_DEPTH procedures.....	56
Figure F.3 – The GET_HOR_DEPTH and GET_VER_DEPTH procedures.....	57

Figure F.4 – Parameters for the SET_SUBBAND_INFO procedure .....	58
Figure F.5 – The SET_SUBBAND_INFO procedure .....	58
Figure F.6 – Parameters for the RECUR_INFO procedure .....	59
Figure F.7 – The RECUR_INFO procedure .....	59
Figure F.8 – Parameters for the INIT_□ procedure.....	60
Figure F.9 – Procedure for setting maximum number of sub-levels, □(lev) .....	61
Figure F.10 – Parameters for the INIT_S_R procedure .....	61
Figure F.11 – Upper level procedure for defining S(ab) and R(lev).....	62
Figure F.12 – Parameters for the LEV_S procedure.....	63
Figure F.13 – Procedure for defining S(ab) .....	63
Figure F.14 – Sample wavelet decomposition with labelled sub-bands .....	64
Figure F.15 – Parameters for the MOD_IDWT procedure .....	65
Figure F.16 – The MOD_IDWT procedure .....	66
Figure F.17 – Parameters for the MOD_2D_SR procedure.....	66
Figure F.18 – The MOD_2D_SR procedure.....	67
Figure F.19 – Parameters for the MOD_2D_INTERLEAVE procedure.....	67
Figure F.20 – The MOD_2D_INTERLEAVE procedure .....	68
Figure F.21 – Parameters for the 2D_HV_INTERLEAVE procedure .....	68
Figure F.22 – The 2D_HV_INTERLEAVE procedure .....	69
Figure F.23 – Parameters for the 2D_H_INTERLEAVE procedure .....	70
Figure F.24 – The 2D_H_INTERLEAVE procedure .....	70
Figure F.25 – Parameters for the 2D_V_INTERLEAVE procedure .....	71
Figure F.26 – The 2D_V_INTERLEAVE procedure .....	71
Figure F.27 – Parameters for the MOD_FDWT procedure .....	71
Figure F.28 – The MOD_FDWT procedure .....	72
Figure F.29 – Parameters for the MOD_2D_SD procedure .....	72
Figure F.30 – The MOD_2D_SD procedure .....	73
Figure F.31 – Parameters for the MOD_2D_DEINTERLEAVE procedure.....	73
Figure F.32 – The MOD_2D_DEINTERLEAVE procedure .....	74
Figure F.33 – Parameters for the 2D_HV_DEINTERLEAVE procedure .....	74
Figure F.34 – The 2D_HV_DEINTERLEAVE procedure .....	75
Figure F.35 – Parameters for the 2D_H_DEINTERLEAVE procedure.....	76
Figure F.36 – The 2D_H_DEINTERLEAVE procedure .....	76
Figure F.37 – Parameters for the 2D_V_DEINTERLEAVE procedure.....	76
Figure F.38 – The 2D_V_DEINTERLEAVE procedure.....	77
Figure G.1 – Parameters of the 1D_SR_WS procedures .....	79
Figure G.2 – The 1D_SR_WS procedure .....	79
Figure G.3 – Parameters of the 1D_FILTR_WS procedure .....	80
Figure G.4 – Parameters of the 1D_FILTR_WS procedure .....	80
Figure G.5 – Parameters of the 1D_SD_WS procedure .....	81
Figure G.6 – The 1D_SD_WS procedure .....	81
Figure G.7 – Parameters of the 1D_FILTD_WS procedure .....	82
Figure G.8 – Parameters of the 1D_FILTD_WS procedure .....	82
Figure H.1 – Parameters of the extended 1D_SR_ARB procedure .....	86

Figure H.2 – Extended procedure 1D_SR_ARB .....	87
Figure H.3 – Parameters of the 1D_SCALER procedure .....	87
Figure H.4 – Parameters of the 1D_STEPR procedure.....	88
Figure H.5 – Procedure 1D_STEPR.....	88
Figure H.6 – Parameters of the 1D_EXT_WS procedure.....	89
Figure H.7 – Parameters of the 1D_EXT_CON procedure .....	89
Figure H.8 – Parameters of the 1D_UPDATER_REV procedure .....	90
Figure H.9 – Parameters of the 1D_UPDATER_IRR procedure.....	90
Figure H.10 – Parameters of the extended 1D_SD_ARB procedure .....	91
Figure H.11 – Extended procedure 1D_SD_ARB .....	92
Figure H.12 – Parameters of the 1D_STEPD procedure .....	92
Figure H.13 – Procedure 1D_STEPD.....	93
Figure H.14 – Parameters of the 1D_UPDATED_REV procedure.....	93
Figure H.15 – Parameters of the 1D_UPDATED_IRR procedure .....	94
Figure H.16 – Parameters of the 1D_SCALED procedure.....	94
Figure H.17 – Lifting implementation for forward half-sample symmetric wavelet transformations .....	97
Figure I.1 – Precincts of one reduced resolution (modified Figure B.8 of Rec. ITU-T T.800   ISO/IEC 15444-1) ..	99
Figure I.2 – Codeblocks and precincts in sub-band b from four different tiles .....	100
Figure I.3 – The IDWT_SSO Procedure.....	103
Figure I.4 – The 2D_SR_SSO procedure .....	104
Figure I.5 – Parameters of the 1D_FILTR_SSO procedure.....	104
Figure I.6 – The FDWT_SSO procedure.....	106
Figure I.7 – The 2D_SD_SSO procedure .....	107
Figure I.8 – Parameters of the 1D_FILTD_SSO procedure .....	108
Figure I.9 – Position of SSO blocks .....	109
Figure I.10 – Tiling of the reference grid diagram .....	111
Figure J.1 – Inverse multiple component transformation processing .....	113
Figure J.2 – Procedure MCO_TRANSFORM.....	114
Figure J.3 – A single multiple component collection transformation (MCC_TRANS) stage .....	115
Figure J.4 – Procedure MCC_TRANS .....	116
Figure J.5 – A single component collection transformation (CC_TRANS) stage .....	117
Figure J.6 – Procedure CC_TRANS.....	117
Figure J.7 – SERM implementation of reversible decorrelation transformation .....	121
Figure J.8 – SERM implementation of forward reversible decorrelation transformation.....	122
Figure J.9 – Irreversible dependency transformation.....	123
Figure J.10 – Forward irreversible dependency transformation .....	124
Figure J.11 – Reversible dependency transformation.....	125
Figure J.12 – Forward reversible dependency transformation.....	126
Figure K.1 – Non-linear transformation application during decoding.....	128
Figure K.2 – Example gamma-type forward non-linear transformation.....	130
Figure L.1 – Rectangular mask on the reference grid.....	135
Figure L.2 – Elliptic mask on the reference grid .....	135
Figure M.1 – Example fragmented JPX file where all fragments are in the same file .....	144
Figure M.2 – Example fragmented JPX file where some fragments are stored in other files or resources .....	145

Figure M.3 – Example combination of two codestreams into a single compositing layer.....	146
Figure M.4 – Example of the box description figures .....	161
Figure M.5 – Example of the superbox description figures.....	161
Figure M.6 – Boxes defined within a JPX file.....	162
Figure M.7 – Organization of the contents of the Reader Requirements box.....	165
Figure M.8 – Organization of the contents of a Data Reference box.....	168
Figure M.9 – Organization of the contents of a Fragment Table box.....	168
Figure M.10 – Organization of the contents of a Fragment List box.....	169
Figure M.11 – Organization of the contents of a Fragment table box .....	170
Figure M.12 – Organization of the contents of an Image Header box.....	171
Figure M.13 – Organization of the contents of a Codestream Header box.....	173
Figure M.14 – Organization of the contents of a Compositing Layer Header box.....	174
Figure M.15 – Organization of the contents of a Colour Group box.....	175
Figure M.16 – Organization of the contents of a Colour Specification box .....	176
Figure M.17 – Organization of the contents of the METHDAT field for the Enumerated method.....	178
Figure M.18 – Organization of the contents of the METHDAT field for the Any ICC method.....	180
Figure M.19 – Organization of the contents of the METHDAT field for the Vendor Colour method.....	180
Figure M.19bis – Organization of the METHDAT field for the Parameterized method.....	181
Figure M.20 – Organization of the contents of the EP field for the CIELab (EnumCS = 14).....	181
Figure M.21 – Organization of the contents of the EP field for the CIEJab (EnumCS = 19).....	183
Figure M.22 – Organization of the contents of an Opacity box.....	185
Figure M.23 – Organization of the contents of a Codestream Registration box.....	187
Figure M.23bis – Layout of the Pixel Format Box.....	188
Figure M.24 – Organization of the contents of a Composition box.....	190
Figure M.25 – Organization of the contents of a Composition Options box .....	191
Figure M.26 – Organization of the contents of an Instruction Set box.....	191
Figure M.27 – Organization of the contents of an INST field within an Instruction Set box.....	192
Figure M.28 – Example of ROI specific metadata associated with one or more images.....	195
Figure M.29 – Example of Multiple XML documents associated with one or more images .....	195
Figure M.30 – Example of a Labelled XML document.....	195
Figure M.31 – Example of a labelled image.....	195
Figure M.32 – Organization of the contents of an Association box .....	196
Figure M.33 – Organization of the contents of a Number List box.....	196
Figure M.34 – Organization of the contents of a Label box .....	197
Figure M.35 – Organization of the contents of a Binary Filter box.....	197
Figure M.36 – Organization of the contents of the Desired Reproductions box.....	198
Figure M.37 – Organization of the contents of the Graphics Technology Standard Output box.....	198
Figure M.38 – Organization of the contents of the ROI Description box.....	199
Figure M.39 – Organization of the contents of a Digital Signature box.....	202
Figure M.40 – Organization of the contents of a MPEG-7 Binary box .....	204
Figure M.41 – Organization of the contents of a Compositing Layer Extensions box.....	205
Figure M.42 – Organization of the Compositing Layer Extensions Info box.....	207
Figure M.43 – Organization of the contents of a Multiple Codestream box.....	208
Figure M.44 – Organization of the contents of a Multiple Codestream Offsets box .....	208

Figure M.45 – Organization of the contents of a Grouping box .....	209
Figure M.46 – Organization of the contents of a decomposed XML box .....	210
Figure M.47 – Organization of the contents of a XML header box.....	210
Figure M.48 – Example Box layout for a Decomposed XML box.....	212
Figure N.1 – Organization of the contents of Image Creation box .....	215
Figure N.2 – Organization of the contents of Content Description box .....	216
Figure N.3 – Organization of the contents of History box.....	216
Figure N.4 – Organization of the contents of Intellectual Property Rights box.....	216
Figure N.5 – Organization of the contents of Image Identifier box.....	217
Figure N.6 – Schema of the Image Creation metadata .....	217
Figure N.7 – Schema of the General Creation Information metadata.....	218
Figure N.8 – Schema of the Camera Capture metadata.....	220
Figure N.9 – Schema of the Device Characterization metadata .....	221
Figure N.10 – Schema of the Spatial Frequency Response metadata.....	223
Figure N.11 – Schema of the Colour Filter Array Pattern metadata.....	224
Figure N.12 – Schema of the Opto-electronic Conversion Function metadata.....	225
Figure N.13 – Schema of the Camera Capture Settings metadata .....	227
Figure N.14 – Schema of the Scanner Capture metadata.....	230
Figure N.15 – Schema of the Scanner Settings metadata .....	231
Figure N.16 – Schema of the Software Creation metadata.....	231
Figure N.17 – Schema of the Captured Item metadata .....	232
Figure N.18 – Schema of the Reflection Print metadata.....	233
Figure N.19 – Schema of the Film metadata .....	234
Figure N.20 – Schema of the Content Description metadata.....	235
Figure N.21 – Schema of the Person Description metadata.....	236
Figure N.22 – Schema of the Thing Description metadata.....	237
Figure N.23 – Schema of the Organization Description metadata.....	238
Figure N.24 – Schema of the Event Description metadata.....	239
Figure N.25 – Schema of the Participant metadata.....	240
Figure N.26 – Schema of the Event Relationship metadata.....	241
Figure N.27 – Schema of the Audio metadata.....	241
Figure N.28 – Schema of the Property metadata .....	242
Figure N.29 – Schema of the Dictionary Definition metadata.....	243
Figure N.30 – Schema of the History metadata .....	243
Figure N.31 – Schema of the Processing Summary metadata .....	244
Figure N.32 – Schema of the Image Processing Hints metadata .....	246
Figure N.33 – Schema of the Previous metadata .....	247
Figure N.34 – Schema of the Image Reference metadata.....	248
Figure N.35 – Schema of the Intellectual Property Rights metadata .....	249
Figure N.36 – Schema of the IPR Names metadata.....	252
Figure N.37 – Schema of the IPR Description metadata .....	252
Figure N.38 – Schema of the IPR Dates metadata.....	253
Figure N.39 – Schema of the IPR Exploitation metadata .....	254
Figure N.40 – Schema of the IPR Management Systems metadata.....	255

Figure N.41 – Schema of the IPR Identification metadata .....	256
Figure N.42 – Schema of the IPR Identifier metadata .....	256
Figure N.43 – Schema of the License Plate metadata.....	257
Figure N.44 – Schema of the IPR Contact Point metadata.....	257
Figure N.45 – Schema of the Image Identifier metadata .....	258
Figure N.46 – Schema of the non-negative double type.....	259
Figure N.47 – Schema of the rational type .....	259
Figure N.48 – Schema of the string including language attribute type.....	259
Figure N.49 – Schema of the degree type.....	260
Figure N.50 – Schema of the half degree type.....	260
Figure N.51 – Schema of the double size type .....	260
Figure N.52 – Schema of the integer size type .....	261
Figure N.53 – Schema of the DateTime type .....	262
Figure N.54 – Schema of the Address type .....	263
Figure N.55 – Schema of the Phone number type .....	264
Figure N.56 – Schema of the Email address type.....	265
Figure N.57 – Schema of the Web address type.....	266
Figure N.58 – Schema of the Person type.....	268
Figure N.59 – Schema of the Organization type.....	269
Figure N.60 – Schema of the Location type .....	270
Figure N.61 – Schema of the Coordinate location element .....	271
Figure N.62 – Schema of the Raw GPS Information element .....	273
Figure N.63 – Schema of the Raw GPS Information element (continued).....	275
Figure N.64 – Schema of the Raw GPS Information element (concluded).....	276
Figure N.65 – Schema of the Direction type .....	279
Figure N.66 – Schema of the Position type .....	280
Figure N.67 – Schema of the Point type.....	280
Figure N.68 – Schema of the Rect type .....	281
Figure N.69 – Schema of the Region type.....	282
Figure N.70 – Schema of the Product Details type.....	283
Figure N.71 – Schema of the Language attribute .....	283
Figure N.72 – Schema of the Timestamp attribute.....	283
Figure N.73 – Schema of the Comment element.....	284
Figure O.1 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 123; I_0 = 2, d_0() = 31; I_S = 9, d_S() = 320300203$ .....	347
Figure O.2 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = \underline{1}23; I_0 = 2, d_0() = 31; I_S = 9, d_S() = 320300203$ .....	347
Figure O.3 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 1\underline{2}3; I_0 = 2, d_0() = 31; I_S = 9, d_S() = 320300203$ .....	348
Figure O.4 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 12\underline{3}; I_0 = 2, d_0() = 31; I_S = 9, d_S() = 320300203$ .....	348
Figure O.5 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 123; I_0 = 2, d_0() = \underline{3}1; I_S = 9, d_S() = \underline{3}20300203$ .....	348
Figure O.6 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 123; I_0 = 2, d_0() = 3\underline{1}; I_S = 9, d_S() = 3\underline{2}0300203$ .....	348
Figure O.7 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 123; I_0 = 2, d_0() = 3\underline{1}; I_S = 9, d_S() = 32\underline{0}300203$ .....	349
Figure O.8 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 123; I_0 = 2, d_0() = 3\underline{1}; I_S = 9, d_S() = 320\underline{3}00203$ .....	349
Figure O.9 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 123; I_0 = 2, d_0() = 3\underline{1}; I_S = 9, d_S() = 3203\underline{0}0203$ .....	349

Figure O.10 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 123; I_\theta = 2, d_\theta() = \underline{31}; I_S = 9, d_S() = 320300\underline{203}$ .....	349
Figure O.11 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 123; I_\theta = 2, d_\theta() = \underline{31}; I_S = 9, d_S() = 320300\underline{203}$ .....	350
Figure O.12 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 123; I_\theta = 2, d_\theta() = \underline{31}; I_S = 9, d_S() = 3203002\underline{03}$ .....	350
Figure O.13 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 123; I_\theta = 2, d_\theta() = \underline{31}; I_S = 9, d_S() = 32030020\underline{3}$ .....	350
Figure O.14 – Sample wavelet decomposition: $N_L = 3; I_R = 3; d_R() = 123; I_\theta = 2, d_\theta() = 3\underline{1}; I_S = 9, d_S() = 320300203$ .....	351
Figure O.15 – FBI decomposition: $N_L = 5; I_R = 0; d_R() = 0$ (since $I_R = 0, I_R$ and $d_R()$ get reset in Figure F.11 to $I_R = 5$ and $d_R() = 11111$ ); $I_\theta = 4, d_\theta() = 2321; I_S = 17, d_S() = 1110111111111111111$ .....	351
Figure O.16 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = \underline{11111}; I_\theta = 4, d_\theta() = 2321; I_S = 17, d_S() = 1110111111111111111$ .....	353
Figure O.17 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 1\underline{1111}; I_\theta = 4, d_\theta() = 2321; I_S = 17, d_S() = 1110111111111111111$ .....	354
Figure O.18 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 11\underline{111}; I_\theta = 4, d_\theta() = 2321; I_S = 17, d_S() = 1110111111111111111$ .....	355
Figure O.19 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 1111\underline{1}; I_\theta = 4, d_\theta() = 2321; I_S = 17, d_S() = \underline{1110111111111111111}$ .....	356
Figure O.20 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 11111; I_\theta = 4, d_\theta() = \underline{2321}; I_S = 17, d_S() = 1\underline{1101111111111111111}$ .....	357
Figure O.21 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 11111; I_\theta = 4, d_\theta() = 2\underline{321}; I_S = 17, d_S() = 111\underline{0111111111111111111}$ .....	358
Figure O.22 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 11111; I_\theta = 4, d_\theta() = 2\underline{321}; I_S = 17, d_S() = 1110\underline{1111111111111111111}$ .....	359
Figure O.23 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 11111; I_\theta = 4, d_\theta() = 2\underline{321}; I_S = 17, d_S() = 11101\underline{1111111111111111111}$ .....	360
Figure O.24 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 11111; I_\theta = 4, d_\theta() = 2\underline{321}; I_S = 17, d_S() = 111011\underline{1111111111111111111}$ .....	361
Figure O.25 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 11111; I_\theta = 4, d_\theta() = 2\underline{321}; I_S = 17, d_S() = 1110111\underline{1111111111111111111}$ .....	362
Figure O.26 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 11111; I_\theta = 4, d_\theta() = 2\underline{321}; I_S = 17, d_S() = 11101111\underline{1111111111111111111}$ .....	363
Figure O.27 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 11111; I_\theta = 4, d_\theta() = 2\underline{321}; I_S = 17, d_S() = 111011111\underline{1111111111111111111}$ .....	364
Figure O.28 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 11111; I_\theta = 4, d_\theta() = 23\underline{21}; I_S = 17, d_S() = 111011111111111\underline{1111111111111111111}$ .....	365
Figure O.29 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 11111; I_\theta = 4, d_\theta() = 23\underline{21}; I_S = 17, d_S() = 11101111111111111\underline{1111111111111111111}$ .....	366
Figure O.30 – FBI decomposition: $N_L = 5; I_R = 5$ and $d_R() = 11111; I_\theta = 4, d_\theta() = 232\underline{1}; I_S = 17, d_S() = 1110111111111111111$ .....	367
Figure O.31 – SPACL decomposition: $N_L = 4; I_\theta = 2, d_\theta() = 21; I_R = 0, I_S = 0$ .....	368
Figure O.32 – Component collection example .....	370
Figure O.33 – Original image components .....	370
Figure O.34 – Encoder multiple component transformation decisions .....	371
Figure O.35 – Decorrelation transformation array (MCC0 component collection 0 parameters) .....	372
Figure O.36 – Dependency transformation (MCC0 component collection 1 parameters) .....	372

Figure O.37 – Passing through intermediate components (MCC0 component collection 2 parameters) .....	372
Figure O.38 – Component collections in MCC0, transformation processing stage 0.....	373
Figure O.39 – Decorrelation transformation array (MCC1 component collection 0 parameters) .....	373
Figure O.40 – MCC1 component collection 1 (7 components passed through) .....	374
Figure O.41 – Component collections in MCC1, transformation processing stage 1 .....	374
Figure O.42 – MCO marker segment for inverse multiple component transformation .....	374