

FINAL
DRAFT

INTERNATIONAL
STANDARD

ISO/IEC
FDIS
13818-1

ISO/IEC JTC 1/SC 29

Secretariat: JISC

Voting begins on:
2023-10-05

Voting terminates on:
2023-11-30

Information technology — Generic coding of moving pictures and associated audio information —

Part 1: Systems

iTeh STANDARD PREVIEW
Technologies de l'information — Codage générique des images animées et du son associé —
(standards.iteh.ai)
Partie 1: Systèmes

ISO/IEC FDIS 13818-1

<https://standards.iteh.ai/catalog/standards/sist/c03590a4-585d-4f22-98df-a746bbc0b0ff/iso-iec-fdis-13818-1>

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ISO/IEC FDIS 13818-1:2023(E)

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CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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This document was prepared by ITU-T (as ITU-T H.222.0) and drafted in accordance with its editorial rules, in collaboration with Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

This ninth edition cancels and replaces the eighth edition (ISO/IEC 13818-1:2022), which has been technically revised. It also incorporates the Amendment ISO/IEC 13818-1:2022/Amd 1:2023 and the Technical Corrigendum/Corrigenda ISO/IEC 13818-1:2022/Cor 1:2023.

The main changes are as follows:

- how VVC (ITU-T H.266 | ISO/IEC 23090-3) is carried over MPEG-2 systems;
- how EVC (ISO/IEC 23094-1) is carried over MPEG-2 systems;
- how compatible profile sets for MPEG-H 3D Audio (ISO/IEC 23008-3) are signalled in MPEG-2 systems;
- and an extension of the semantics for the ISO 639 language descriptor.

A list of all parts in the ISO/IEC 13818 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

CONTENTS

	<i>Page</i>
SECTION 1 – GENERAL	1
1.1 Scope	1
1.2 Normative references.....	1
SECTION 2 – TECHNICAL ELEMENTS	4
2.1 Definitions	4
2.2 Symbols and abbreviations.....	12
2.3 Method of describing bit stream syntax	14
2.4 Transport stream bitstream requirements	15
2.5 Program stream bitstream requirements.....	63
2.6 Program and program element descriptors.....	76
2.7 Restrictions on the multiplexed stream semantics.....	157
2.8 Compatibility with ISO/IEC 11172.....	169
2.9 Registration of copyright identifiers.....	169
2.10 Registration of private data format.....	169
2.11 Carriage of ISO/IEC 14496 data	170
2.12 Carriage of metadata.....	181
2.13 Carriage of ISO 15938 data.....	190
2.14 Carriage of Rec. ITU-T H.264 ISO/IEC 14496-10 video	190
2.15 Carriage of ISO/IEC 14496-17 text streams	206
2.16 Carriage of auxiliary video streams.....	208
2.17 Carriage of HEVC	208
2.18 Carriage of green access units	222
2.19 Carriage of ISO/IEC 23008-3 MPEG-H 3D audio data.....	224
2.20 Carriage of Quality Access Units in MPEG-2 sections.....	226
2.21 Carriage of sample variants.....	227
2.22 Carriage of Media Orchestration Access Units.....	228
2.23 Carriage of VVC.....	228
2.24 Carriage of EVC	233
Annex A CRC decoder model.....	238
A.1 CRC decoder model	238
Annex B Digital storage medium command and control (DSM-CC).....	239
B.1 Introduction	239
B.2 General elements	240
B.3 Technical elements	242
Annex C Program-specific information	248
C.1 Explanation of program-specific information in transport streams.....	248
C.2 Introduction	248
C.3 Functional mechanism.....	248
C.4 The mapping of sections into transport stream packets.....	249
C.5 Repetition rates and random access.....	249
C.6 What is a program?.....	250
C.7 Allocation of program_number	250
C.8 Usage of PSI in a typical system	250
C.9 The relationships of PSI structures.....	251
C.10 Bandwidth utilization and signal acquisition time	253
Annex D Systems timing model and application implications of this Recommendation International Standard	256
D.1 Introduction	256
Annex E Data transmission applications.....	265
E.1 General considerations	265
E.2 Suggestion	265
Annex F Graphics of syntax for this Recommendation International Standard.....	266
F.1 Introduction	266

Annex G	General information.....	270
G.1	General information.....	270
Annex H	Private data.....	271
H.1	Private data.....	271
Annex I	Systems conformance and real-time interface.....	272
I.1	Systems conformance and real-time interface.....	272
Annex J	Interfacing jitter-inducing networks to MPEG-2 decoders.....	273
J.1	Introduction.....	273
J.2	Network compliance models.....	273
J.3	Network specification for jitter smoothing.....	274
J.4	Example decoder implementations.....	275
Annex K	Splicing transport streams.....	276
K.1	Introduction.....	276
K.2	The different types of splicing point.....	276
K.3	Decoder behaviour on splices.....	277
Annex L	Registration procedure (see 2.9).....	279
L.1	Procedure for the request of a Registered Identifier (RID).....	279
L.2	Responsibilities of the Registration Authority.....	279
L.3	Responsibilities of parties requesting an RID.....	279
L.4	Appeal procedure for denied applications.....	279
Annex M	Registration application form (see 2.9).....	281
M.1	Contact information of organization requesting a Registered Identifier (RID).....	281
M.2	Statement of an intention to apply the assigned RID.....	281
M.3	Date of intended implementation of the RID.....	281
M.4	Authorized representative.....	281
M.5	For official use only of the Registration Authority.....	281
Annex N	Registration Authority Diagram of administration structure (see 2.9).....	282
Annex O	Registration procedure (see 2.10).....	283
O.1	Procedure for the request of an RID.....	283
O.2	Responsibilities of the Registration Authority.....	283
O.3	Contact information for the Registration Authority.....	283
O.4	Responsibilities of parties requesting an RID.....	283
O.5	Appeal procedure for denied applications.....	283
Annex P	Registration application form.....	285
P.1	Contact information of organization requesting an RID.....	285
P.2	Request for a specific RID.....	285
P.3	Short description of RID that is in use and date system that was implemented.....	285
P.4	Statement of an intention to apply the assigned RID.....	285
P.5	Date of intended implementation of the RID.....	285
P.6	Authorized representative.....	285
P.7	For official use of the Registration Authority.....	285
Annex Q	T-STD and P-STD buffer models for ISO/IEC 13818-7 ADTS.....	286
Q.1	Introduction.....	286
Q.2	Leak rate from transport buffer.....	286
Q.3	Buffer size.....	286
Q.4	Conclusion.....	287
Annex R	Carriage of ISO/IEC 14496 scenes in Rec. ITU-T H.222.0 ISO/IEC 13818-1.....	289
R.1	Content access procedure for ISO/IEC 14496 program components within a program stream.....	289
R.2	Content access procedure for ISO/IEC 14496 program components within a transport stream.....	290
Annex S	Carriage of JPEG 2000 part 1 video over MPEG-2 transport streams.....	294
S.1	Introduction.....	294
S.2	J2K video access unit, J2K video elementary stream, J2K video sequence and J2K still picture.....	294
S.3	Optional J2K block mode for high resolution support.....	294

	<i>Page</i>
S.4	Optional J2K stripe mode for Ultra-Low Latency 295
S.5	Elementary stream header (elsm) and mapping to PES packets 295
S.6	J2K transport constraints 298
S.7	Interpretation of flags in adaptation and PES headers for J2K video elementary streams 299
S.8	T-STD extension for J2K video elementary streams 299
Annex T	MIME type for MPEG-2 transport streams 302
T.1	Introduction 302
T.2	MIME type and subtype 302
T.3	Security considerations 303
T.4	Parameters 303
Annex U	Carriage of timeline and external media information over MPEG-2 transport streams 305
U.1	Introduction 305
U.2	TEMI access unit and TEMI elementary stream 306
U.3	AF descriptors 307
Annex V	Transport of HEVC tiles 316
V.1	Introduction 316
V.2	HEVC tile substream identification example 317
V.3	Subregion layout example 317
Annex W	Carriage of JPEG XS part 1 video over MPEG-2 Transport Streams 319
W.1	Introduction 319
W.2	JPEG XS video access unit, JPEG XS video elementary stream, JPEG XS video sequence and JPEG XS still picture 319
W.3	Elementary stream header (jxes) and mapping to PES packets 319
W.4	JPEG XS transport constraints 320
W.5	Interpretation of flags in adaptation field and PES packet for JPEG XS video elementary streams 321
W.6	T-STD extension for JPEG XS video elementary streams 321

ISO/IEC FDIS 13818-1

<https://standards.iteh.ai/catalog/standards/sist/c03590a4-585d-4f22-98df-a746bbc0b0ff/iso-iec-fdis-13818-1>

List of Tables

	<i>Page</i>
Table 2-1 – Transport stream	26
Table 2-2 – Transport packet of this Recommendation International Standard	26
Table 2-3 – PID table	27
Table 2-4 – Scrambling control values	27
Table 2-5 – Adaptation field control values	28
Table 2-6 – Transport stream adaptation field	28
Table 2-7 – Splice parameters Table 1 Simple Profile Main Level, Main Profile Main Level, SNR Profile Main Level (both layers), Spatial Profile High-1440 Level (base layer), High Profile Main Level (middle + base layers), Multi-view Profile Main Level (base layer) Video	35
Table 2-8 – Splice parameters Table 2 Main Profile Low Level, SNR Profile Low Level (both layers), High Profile Main Level (base layer), Multi-view Profile Low Level (base layer) Video	36
Table 2-9 – Splice parameters Table 3 Main Profile High-1440 Level, Spatial Profile High-1440 Level (all layers), High Profile High-1440 Level (middle + base layers), Multi-view Profile High-1440 Level (base layer) Video	36
Table 2-10 – Splice parameters Table 4 Main Profile High Level, High Profile High-1440 Level (all layers), High Profile High Level (middle + base layers), Multi-view Profile High Level (base layer) Video	36
Table 2-11 – Splice parameters Table 5 SNR Profile Low Level (base layer) Video	36
Table 2-12 – Splice parameters Table 6 SNR Profile Main Level (base layer) Video	37
Table 2-13 – Splice parameters Table 7 Spatial Profile High-1440 Level (middle + base layers) Video	37
Table 2-14 – Splice parameters Table 8 High Profile Main Level (all layers), High Profile High-1440 Level (base layer) Video	37
Table 2-15 – Splice parameters Table 9 High Profile High Level (base layer), Multi-view Profile Main Level (both layers) Video	37
Table 2-16 – Splice parameters Table 10 High Profile High Level (all layers), Multi-view Profile High-1440 Level (both layers) Video	38
Table 2-17 – Splice parameters Table 11 4:2:2 Profile Main Level Video	38
Table 2-18 – Splice parameters Table 12 Multi-view Profile Low Level (both layers) Video	38
Table 2-19 – Splice parameters Table 13 Multi-view Profile High Level (both layers) Video	38
Table 2-20 – Splice parameters Table 14 4:2:2 Profile High Level Video	39
Table 2-21 – PES packet	39
Table 2-22 – Stream_id assignments	42
Table 2-23 – PES scrambling control values	43
Table 2-24 – Trick mode control values	48
Table 2-25 – Field_id field control values	49
Table 2-26 – Coefficient selection values	49
Table 2-27 – Stream_id_extension assignments	51
Table 2-28 – Program-specific information	52
Table 2-29 – Program-specific information pointer	54
Table 2-30 – Program association section	54
Table 2-31 – table_id assignment values	55
Table 2-32 – Conditional access section	56
Table 2-33 – Transport stream program map section	57
Table 2-34 – Stream type assignments	58
Table 2-35 – Private section	61
Table 2-36 – The transport stream description table	62
Table 2-37 – Program stream	68
Table 2-38 – Program stream pack	68
Table 2-39 – Program stream pack header	68
Table 2-40 – Program stream system header	69
Table 2-41 – Program stream map	72
Table 2-42 – Program stream directory packet	74
Table 2-43 – Intra_coded indicator	76
Table 2-44 – Coding_parameters indicator	76
Table 2-45 – Program and program element descriptors	77
Table 2-46 – Video stream descriptor	78

	<i>Page</i>
Table 2-47 – Frame rate code.....	78
Table 2-48 – Audio stream descriptor.....	79
Table 2-49 – Hierarchy descriptor	80
Table 2-50 – Hierarchy_type field values.....	81
Table 2-51 – Registration descriptor.....	81
Table 2-52 – Data stream alignment descriptor.....	82
Table 2-53 – Video stream alignment values.....	82
Table 2-54 – AVC video stream alignment values	83
Table 2-55 – HEVC video stream alignment values.....	83
Table 2-56 – Audio stream alignment values	83
Table 2-57 – VVC video stream alignment values.....	84
Table 2-58 – EVC video stream alignment values.....	84
Table 2-59 – Target background grid descriptor.....	85
Table 2-60 – Video window descriptor.....	85
Table 2-61 – Conditional access descriptor	86
Table 2-62 – ISO 639 language descriptor	86
Table 2-63 – Audio type values	87
Table 2-64 – System clock descriptor.....	88
Table 2-65 – Multiplex buffer utilization descriptor.....	88
Table 2-66 – Copyright descriptor.....	89
Table 2-67 – Maximum bitrate descriptor	89
Table 2-68 – Private data indicator descriptor.....	90
Table 2-69 – Smoothing buffer descriptor.....	90
Table 2-70 – STD descriptor.....	91
Table 2-71 – IBP descriptor	91
Table 2-72 – MPEG-4 video descriptor.....	92
Table 2-73 – MPEG-4 audio descriptor.....	92
Table 2-75 – IOD descriptor	95
Table 2-76 – SL descriptor.....	95
Table 2-77 – FMC descriptor.....	96
Table 2-78 – External_ES_ID descriptor.....	96
Table 2-79 – Muxcode descriptor	97
Table 2-80 – M4MuxBufferSize descriptor.....	97
Table 2-81 – MultiplexBuffer descriptor	98
Table 2-82 – M4MuxTiming descriptor	98
Table 2-83 – Content labelling descriptor.....	99
Table 2-84 – Metadata_application_format.....	99
Table 2-85 – Content_time_base_indicator values.....	100
Table 2-86 – Metadata pointer descriptor.....	101
Table 2-87 – Metadata format values.....	101
Table 2-88 – MPEG_carriage_flags.....	102
Table 2-89 – Metadata descriptor	103
Table 2-90 – decoder_config_flags.....	104
Table 2-91 – Metadata STD descriptor.....	105
Table 2-92 – AVC video descriptor.....	105
Table 2-93 – AVC timing and HRD descriptor	107
Table 2-94 – MPEG-2 AAC_audio_descriptor.....	108
Table 2-95 – MPEG-2_AAC_additional_information field values	109
Table 2-96 – MPEG-4 text descriptor.....	109
Table 2-97 – MPEG-4 audio extension descriptor.....	109
Table 2-98 – Auxiliary video stream descriptor	110
Table 2-99 – SVC extension descriptor	111
Table 2-100 – MVC extension descriptor.....	112
Table 2-101 – J2K video descriptor.....	113

	<i>Page</i>
Table 2-102 – Example frame rates based on DEN_frame_rate and NUM_frame_rate values	115
Table 2-103 – MVC operation point descriptor	117
Table 2-104 – MPEG2_stereoscopic_video_format_descriptor syntax	118
Table 2-105 – Stereoscopic_program_info_descriptor syntax	118
Table 2-106 – Stereoscopic_service_type values	119
Table 2-107 – Stereoscopic_video_info_descriptor syntax	119
Table 2-108 – Upsampling factor values	120
Table 2-109 – Extension descriptor	120
Table 2-110 – Extension descriptor tag values	123
Table 2-111 – Transport_profile_descriptor syntax	124
Table 2-112 – Transport_profile values	124
Table 2-113 – HEVC video descriptor	125
Table 2-114 – Semantics of HDR_WGC_idc	127
Table 2-115 – HEVC timing and HRD descriptor	127
Table 2-116 – Adaptation field extension descriptor	128
Table 2-117 – HEVC operation point descriptor	129
Table 2-118 – HEVC hierarchy extension descriptor	131
Table 2-119 – Semantics of extension dimension bits	131
Table 2-120 – Green extension descriptor	132
Table 2-121 – MPEG-H 3D audio descriptor	133
Table 2-122 – MPEG-H 3D audio config descriptor	133
Table 2-123 – MPEG-H 3D audio scene descriptor	134
Table 2-124 – MPEG-H 3D audio text label descriptor	137
Table 2-125 – MPEG-H 3D audio multi-stream descriptor	139
Table 2-126 – MPEG-H 3D audio DRC and Loudness descriptor()	140
Table 2-127 – MPEG-H 3D audio command descriptor	142
Table 2-128 – Quality extension descriptor	143
Table 2-129 – Virtual segmentation descriptor	144
Table 2-130 – HEVC tile substream descriptor	145
Table 2-131 – HEVC subregion descriptor	146
Table 2-132 – JPEG XS video descriptor	147
Table 2-133 – VVC video descriptor	150
Table 2-134 – Semantics of HDR_WGC_idc	151
Table 2-135 – SDR widely used video property combinations	152
Table 2-136 – WCG widely used video property combinations	152
Table 2-137 – HDR/WCG widely used video property combinations	152
Table 2-138 – No Indication	153
Table 2-139 – VVC timing and HRD descriptor	153
Table 2-140 – EVC video descriptor	154
Table 2-141 – EVC timing and HRD descriptor	156
Table 2-142 – LCEVC video descriptor	157
Table 2-143 – LCEVC linkage descriptor	157
Table 2-144 – Media service kind descriptor	158
Table 2-145 – media_description_flag	159
Table 2-146 – Media type indicator	159
Table 2-147 – ID_length_code	159
Table 2-148 – ID_type	159
Table 2-149 – configuration type values	160
Table 2-150 – lang_len_indicator	160
Table 2-151 – Media service type values	160
Table 2-152 – Carriage of individual ISO/IEC 14496 streams in Rec. ITU-T H.222.0 ISO/IEC 13818-1	170
Table 2-153 – Section syntax for transport of ISO/IEC 14496 stream	175
Table 2-154 – ISO/IEC defined options for carriage of an ISO/IEC 14496 scene and associated streams in Rec. ITU-T H.222.0 ISO/IEC 13818-1	179
Table 2-155 – Metadata Access Unit Wrapper	185

	<i>Page</i>
Table 2-156 – Metadata AU cell.....	185
Table 2-157 – Cell fragment indication	185
Table 2-158 – Section syntax for transport of metadata	186
Table 2-159 – Section fragment indication.....	187
Table 2-160 – View and dependency representation delimiter NAL unit	196
Table 2-161 – Implied hierarchy_layer_index if no hierarchy descriptors are used.....	216
Table 2-162 – Green access unit section syntax	223
Table 2-163 – Green access unit	223
Table 2-164 – Quality Access Unit.....	226
Table B.1 – DSM-CC syntax	243
Table B.2 – Command_id assigned values	243
Table B.3 – DSM-CC control	244
Table B.4 – Select mode assigned values	245
Table B.5 – DSM-CC Acknowledgement	246
Table B.6 – Time code.....	247
Table C.1 – Composite_descriptor.....	253
Table C.2 – Sub-descriptor	253
Table C.3 – Program association table bandwidth usage (bit/s) Number of programs per transport stream.....	254
Table C.4 – Program map table bandwidth usage (bit/s) Number of programs per transport stream	254
Table D.1 – Re-multiplexing strategy.....	261
Table E.1 – PES packet header example.....	265
Table S.1 – J2K Access unit elementary stream header	296
Table S.2 – Operating levels and maximum buffer size for JPEG 2000 broadcast profiles (from Table A.49 in Rec. ITU-T T.800 (2015) ISO/IEC 15444-1:2016).....	301
Table T.1 – 'codecs' parameter values for some specific stream_type values	303
Table U.1 – Variable field length notation example	305
Table U.1bis – Table U.1 in equivalent full notation.....	306
Table U.2 – TEMI access unit.....	306
Table U.3 – AF descriptor tags	307
Table U.4 – TEMI location descriptor	308
Table U.5 – TEMI URL scheme types.....	308
Table U.6 – TEMI service types	309
Table U.7 – TEMI base URL descriptor	309
Table U.8 – TEMI timeline descriptor.....	310
Table U.9 – TEMI MPEG-H_3dAudio_extStreamID descriptor	312
Table U.10 – Boundary descriptor.....	313
Table U.11 – sequence_number_length_code interpretation.....	313
Table U.12 – Labelling Descriptor.....	314
Table U.13 – label_length_code interpretation.....	314
Table U.14 – label_type values.....	314
Table U.15 – HEVC tile substream af_descriptor	315
Table W.1 – JPEG XS Access unit elementary stream header (jxes header)	319

List of Figures

	<i>Page</i>
Figure Intro. 1 – Simplified overview of the scope of this Recommendation International Standard.....	xiv
Figure Intro. 2 – Prototypical transport demultiplexing and decoding example.....	xvi
Figure Intro. 3 – Prototypical transport multiplexing example.....	xvi
Figure Intro. 4 – Prototypical transport stream to program stream conversion.....	xvi
Figure Intro. 5 – Prototypical decoder for program streams.....	xvii
Figure 2-1 – Transport stream system target decoder notation.....	16
Figure 2-2 – Program stream system target decoder notation.....	63
Figure 2-3 – Target background grid descriptor display area.....	84
Figure 2-4 – Media Service Kind Descriptor semantics at program level.....	163
Figure 2-5 – Media Program Kind Descriptor semantics at elementary stream level.....	164
Figure 2-6 – T-STD model extensions for individual ISO/IEC 14496 elementary streams.....	171
Figure 2-7 – T-STD model for ISO/IEC 14496 content.....	176
Figure 2-8 – P-STD model for ISO/IEC 14496 Systems stream.....	179
Figure 2-9 – Timing model for delivery of content and metadata.....	182
Figure 2-10 – Delivery of metadata in PES packets.....	183
Figure 2-11 – Metadata signalling and referencing.....	189
Figure 2-12 – Metadata decoding in the STD.....	189
Figure 2-13 – T-STD model extensions for Rec. ITU-T H.264 ISO/IEC 14496-10 video.....	193
Figure 2-14 – P-STD model extensions for Rec. ITU-T H.264 ISO/IEC 14496-10 video.....	195
Figure 2-15 – T-STD model extensions for Rec. ITU-T H.264 ISO/IEC 14496-10 Video with scalable video sub-bitstreams.....	196
Figure 2-16 – P-STD model extensions for Rec. ITU-T H.264 ISO/IEC 14496-10 Video with scalable video sub-bitstreams.....	199
Figure 2-17 – T-STD model extensions for Rec. ITU-T H.264 ISO/IEC 14496-10 Video with MVC video sub-bitstreams.....	201
Figure 2-18 – P-STD model extensions for Rec. ITU-T H.264 ISO/IEC 14496-10 Video with MVC video sub-bitstreams.....	205
Figure 2-19 – T-STD model extensions for ISO/IEC 14496-17 text streams.....	207
Figure 2-20 – T-STD model extensions for single layer HEVC.....	210
Figure 2-21 – T-STD model extensions for layered transport of HEVC temporal video subsets.....	212
Figure 2-22 – T-STD model extensions for bitstream-partition-specific CPB operation.....	214
Figure 2-23 – T-STD model extensions for transport of HEVC tiles through individual ESs.....	218
Figure 2-24 – T-STD model extensions for transport of HEVC tiles in a common ES using AF descriptors.....	220
Figure 2-25 – T-STD model extension for transport of HEVC tiles in a common ES ignoring AF descriptors.....	222
Figure 2-26 – T-STD model extension for green access units.....	224
Figure 2-27 – Transport stream system target decoder for multiple audio elementary streams.....	226
Figure 2-28 – Quality Access Unit decoder processing model.....	227
Figure 2-29 – T-STD model extensions for single layer VVC.....	229
Figure 2-30 – T-STD model extensions for layered transport of VVC temporal video subsets.....	231
Figure 2-31 – T-STD model extensions for single layer EVC.....	234
Figure A.1 – 32-bit CRC decoder model.....	238
Figure B.1 – Configuration of DSM-CC application.....	241
Figure B.2 – BSM-CC bitstream decoded as a stand-alone bitstream.....	241
Figure B.3 – DSM-CC bitstream decoded as part of the system bitstream.....	242
Figure C.1 – Program and network mapping relationships.....	251
Figure D.1 – Constant delay model.....	256
Figure D.2 – STC recovery using PLL.....	260
Figure F.1 – Transport stream syntax diagram.....	266
Figure F.2 – PES packet syntax diagram.....	267
Figure F.3 – Program association section diagram.....	267
Figure F.4 – Conditional access section diagram.....	267
Figure F.5 – TS program map section diagram.....	268
Figure F.6 – Private section diagram.....	268
Figure F.7 – Program stream diagram.....	269

	<i>Page</i>
Figure F.8 – Program stream map diagram.....	269
Figure J.1 – Sending system streams over a jitter-inducing network	274
Figure J.2 – Jitter-smoothing using network-layer timestamps	274
Figure J.3 – Integrated dejittering and MPEG-2 decoding	275
Figure R.1 – Example of ISO/IEC 14496 content in a program stream	290
Figure R.2 – Example of ISO/IEC 14496 content in a transport stream.....	291
Figure R.3 – Usage of MPEG-4 in a transport stream with BIFS scene referring to native PES	292
Figure R.4 – Usage of MPEG-4 in a transport stream with an ODUpdate_descriptor carrying an image ObjectDescriptor in the PMT.....	293
Figure S.1 – Structure and order of JPEG 2000 access units.....	298
Figure S.2 – T-STD model extensions for J2K Video.....	299
Figure U.1 – Stream partitioning into 2 and 5 second segments	313
Figure V.1 – Illustration of HEVC tiled encoding of panoramic content beyond UHD	316
Figure V.2 – Example of HEVC tile substream identification	317
Figure V.3 – Example of subregion layout for a 3 x 3 RoI.....	317
Figure W.1 – Structure and order of JPEG XS access units	320
Figure W.2 – T-STD model extensions for JPEG XS Video.....	322

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Introduction

The systems part of this Recommendation | International Standard addresses the combining of one or more elementary streams of video and audio, as well as other data, into single or multiple streams which are suitable for storage or transmission. Systems coding follows the syntactical and semantic rules imposed by this Specification and provides information to enable synchronized decoding of decoder buffers over a wide range of retrieval or receipt conditions.

System coding shall be specified in two forms: the transport stream and the program stream. Each is optimized for a different set of applications. Both the transport stream and program stream defined in this Recommendation | International Standard provide coding syntax which is necessary and sufficient to synchronize the decoding and presentation of the video and audio information, while ensuring that data buffers in the decoders do not overflow or underflow. Information is coded in the syntax using time stamps concerning the decoding and presentation of coded audio and visual data and time stamps concerning the delivery of the data stream itself. Both stream definitions are packet-oriented multiplexes.

The basic multiplexing approach for single video and audio elementary streams is illustrated in Figure Intro. 1. The video and audio data is encoded as described in Rec. ITU-T H.262 | ISO/IEC 13818-2 and ISO/IEC 13818-3. The resulting compressed elementary streams are packetized to produce PES packets. Information needed to use PES packets independently of either transport streams or program streams may be added when PES packets are formed. This information is not needed and need not be added when PES packets are further combined with system level information to form transport streams or program streams. This systems standard covers those processes to the right of the vertical dashed line.

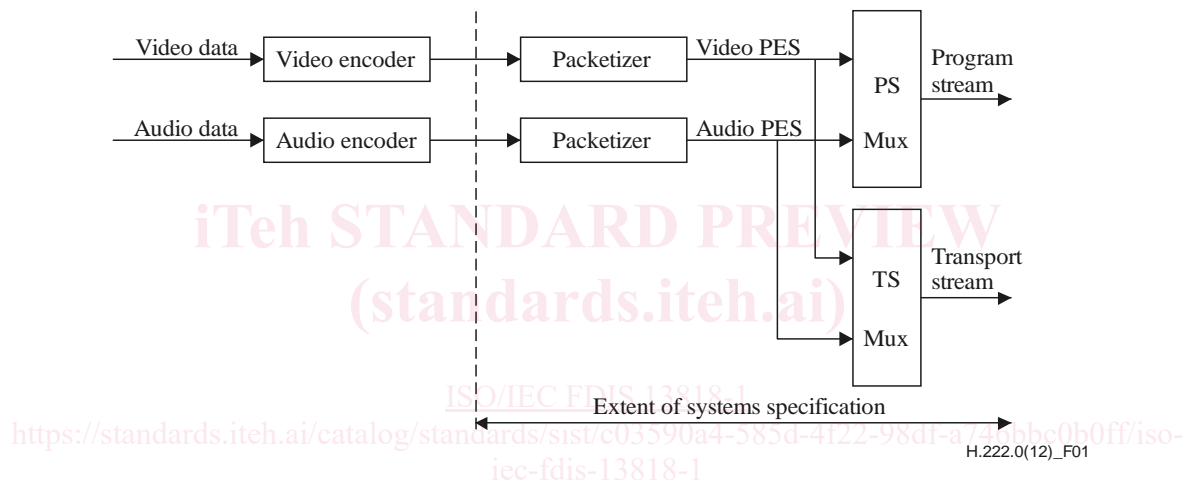


Figure Intro. 1 – Simplified overview of the scope of this Recommendation | International Standard

The program stream is analogous and similar to the ISO/IEC 11172 systems layer. It results from combining one or more streams of PES packets, which have a common time base, into a single stream.

For applications that require the elementary streams that comprise a single program to be in separate streams that are not multiplexed, the elementary streams can also be encoded as separate program streams, one per elementary stream, with a common time base. In this case the values encoded in the SCR fields of the various streams shall be consistent.

Like the single program stream, all elementary streams can be decoded with synchronization.

The program stream is designed for use in relatively error-free environments and is suitable for applications which may involve software processing of system information such as interactive multi-media applications. Program stream packets may be of variable and relatively great length.

The transport stream combines one or more programs with one or more independent time bases into a single stream. PES packets made up of elementary streams that form a program share a common timebase. The transport stream is designed for use in environments where errors are likely, such as storage or transmission in lossy or noisy media. Transport stream packets are 188 bytes in length.

Program and transport streams are designed for different applications and their definitions do not strictly follow a layered model. It is possible and reasonable to convert from one to the other; however, one is not a subset or superset of the other. In particular, extracting the contents of a program from a transport stream and creating a valid program stream is possible and is accomplished through the common interchange format of PES packets, but not all of the fields needed in a program stream are contained within the transport stream; some must be derived. The transport stream may be used to span a range of layers in a layered model, and is designed for efficiency and ease of implementation in high bandwidth applications.

The scope of syntactical and semantic rules set forth in the systems specification differs: the syntactical rules apply to systems layer coding only, and do not extend to the compression layer coding of the video and audio specifications; by contrast, the semantic rules apply to the combined stream in its entirety.

The systems specification does not specify the architecture or implementation of encoders or decoders, nor those of multiplexors or demultiplexors. However, bit stream properties do impose functional and performance requirements on encoders, decoders, multiplexors and demultiplexors. For instance, encoders must meet minimum clock tolerance requirements. Notwithstanding this and other requirements, a considerable degree of freedom exists in the design and implementation of encoders, decoders, multiplexors, and demultiplexors.

Intro. 1 Transport stream

The transport stream is a stream definition which is tailored for communicating or storing one or more programs of coded data according to Rec. ITU-T H.262 | ISO/IEC 13818-2 and ISO/IEC 13818-3 and other data in environments in which significant errors may occur. Such errors may be manifested as bit value errors or loss of packets.

Transport streams may be either fixed or variable rate. In either case the constituent elementary streams may either be fixed or variable rate. The syntax and semantic constraints on the stream are identical in each of these cases. The transport stream rate is defined by the values and locations of program clock reference (PCR) fields, which in general are separate PCR fields for each program.

There are some difficulties with constructing and delivering a transport stream containing multiple programs with independent time bases such that the overall bit rate is variable. Refer to 2.4.2.3.

The transport stream may be constructed by any method that results in a valid stream. It is possible to construct transport streams containing one or more programs from elementary coded data streams, from program streams, or from other transport streams which may themselves contain one or more programs.

The transport stream is designed in such a way that several operations on a transport stream are possible with minimum effort. Among these are:

- 1) Retrieve the coded data from one program within the transport stream, decode it and present the decoded results as shown in Figure Intro. 2.
- 2) Extract the transport stream packets from one program within the transport stream and produce as output a different transport stream with only that one program as shown in Figure Intro. 3.
- 3) Extract the transport stream packets of one or more programs from one or more transport streams and produce as output a different transport stream (not illustrated).
- 4) Extract the contents of one program from the transport stream and produce as output a program stream containing that one program as shown in Figure Intro. 4.
- 5) Take a program stream, convert it into a transport stream to carry it over a lossy environment, and then recover a valid, and in certain cases, identical program stream.

Figure Intro. 2 and Figure Intro. 3 illustrate prototypical demultiplexing and decoding systems which take as input a transport stream. Figure Intro. 2 illustrates the first case, where a transport stream is directly demultiplexed and decoded. Transport streams are constructed in two layers:

- a system layer; and
- a compression layer.

The input stream to the transport stream decoder has a system layer wrapped about a compression layer. Input streams to the video and audio decoders have only the compression layer.

Operations performed by the prototypical decoder which accepts transport streams either apply to the entire transport stream ("multiplex-wide operations"), or to individual elementary streams ("stream-specific operations"). The transport stream system layer is divided into two sub-layers, one for multiplex-wide operations (the transport stream packet layer), and one for stream-specific operations (the PES packet layer).

A prototypical decoder for transport streams, including audio and video, is also depicted in Figure Intro. 2 to illustrate the function of a decoder. The architecture is not unique – some system decoder functions, such as decoder timing control, might equally well be distributed among elementary stream decoders and the channel-specific decoder – but this figure is useful for discussion. Likewise, indication of errors detected by the channel-specific decoder to the individual audio and video decoders may be performed in various ways and such communication paths are not shown in the diagram. The prototypical decoder design does not imply any normative requirement for the design of a transport stream decoder. Indeed non-audio/video data is also allowed, but not shown.

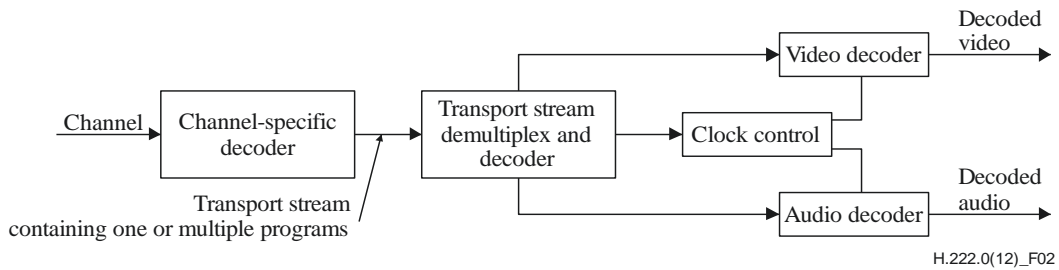


Figure Intro. 2 – Prototypical transport demultiplexing and decoding example

Figure Intro. 3 illustrates the second case, where a transport stream containing multiple programs is converted into a transport stream containing a single program. In this case the re-multiplexing operation may necessitate the correction of program clock reference (PCR) values to account for changes in the PCR locations in the bit stream.

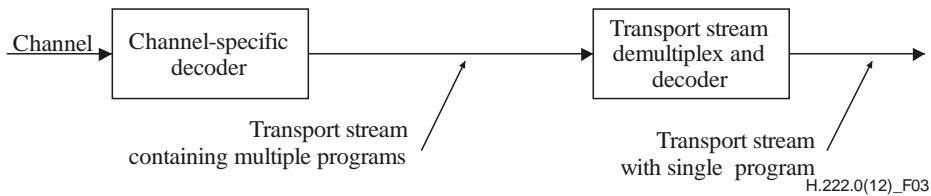


Figure Intro. 3 – Prototypical transport multiplexing example

Figure Intro. 4 illustrates a case in which a multi-program transport stream is first demultiplexed and then converted into a program stream.

Figures Intro. 3 and Intro. 4 indicate that it is possible and reasonable to convert between different types and configurations of transport streams. There are specific fields defined in the transport stream and program stream syntax which facilitate the conversions illustrated. There is no requirement that specific implementations of demultiplexors or decoders include all of these functions.

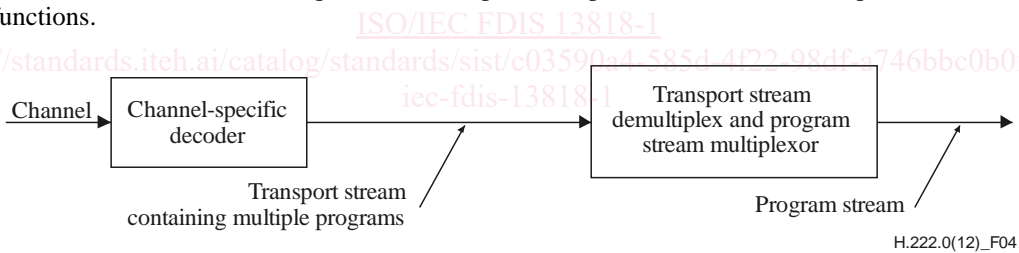


Figure Intro. 4 – Prototypical transport stream to program stream conversion

Intro. 2 Program stream

The program stream is a stream definition which is tailored for communicating or storing one program of coded data and other data in environments where errors are very unlikely, and where processing of system coding, e.g., by software, is a major consideration.

Program streams may be either fixed or variable rate. In either case, the constituent elementary streams may be either fixed or variable rate. The syntax and semantics constraints on the stream are identical in each case. The program stream rate is defined by the values and locations of the system clock reference (SCR) and mux_rate fields.

A prototypical audio/video program stream decoder system is depicted in Figure Intro. 5. The architecture is not unique – system decoder functions including decoder timing control might as equally well be distributed among elementary stream decoders and the channel-specific decoder – but this figure is useful for discussion. The prototypical decoder design does not imply any normative requirement for the design of a program stream decoder. Indeed non-audio/video data is also allowed, but not shown.