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

*Technologies de l'information — Codage générique des images animées et
du son associé: Systèmes*

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Contents

	Page
SECTION 1 – GENERAL	1
1.1 Scope	1
1.2 Normative references.....	1
1.2.1 Identical Recommendations International Standards.....	1
1.2.2 Paired Recommendations International Standards equivalent in technical content.....	2
1.2.3 Additional references.....	2
SECTION 2 – TECHNICAL ELEMENTS	2
2.1 Definitions	2
2.2 Symbols and abbreviations	5
2.2.1 Arithmetic operators	5
2.2.2 Logical operators	6
2.2.3 Relational operators	6
2.2.4 Bitwise operators	6
2.2.5 Assignment	6
2.2.6 Mnemonics	6
2.2.7 Constants	7
2.3 Method of describing bit stream syntax	7
2.4 Transport Stream bitstream requirements	8
2.4.1 Transport Stream coding structure and parameters	8
2.4.2 Transport Stream system target decoder	9
2.4.2.1 System clock frequency	10
2.4.2.2 Input to the Transport Stream system target decoder	11
2.4.2.3 Buffering	12
2.4.2.4 Decoding	17
2.4.2.5 Presentation	17
2.4.2.6 Buffer management	17
2.4.2.7 T-STD extensions for carriage of ISO/IEC 14496 data	18
2.4.3 Specification of the Transport Stream syntax and semantics	18
2.4.3.1 Transport Stream	18
2.4.3.2 Transport Stream packet layer	18
2.4.3.3 Semantic definition of fields in Transport Stream packet layer	19
2.4.3.4 Adaptation field	20
2.4.3.5 Semantic definition of fields in adaptation field	21
2.4.3.6 PES packet	31
2.4.3.7 Semantic definition of fields in PES packet	31
2.4.3.8 Carriage of Program Streams and ISO/IEC 11172-1 Systems streams in the Transport Stream	40
2.4.4 Program specific information	41
2.4.4.1 Pointer	43
2.4.4.2 Semantics definition of fields in pointer syntax	43
2.4.4.3 Program association Table	43
2.4.4.4 Table_id assignments	44
2.4.4.5 Semantic definition of fields in program association section	44
2.4.4.6 Conditional access Table	45
2.4.4.7 Semantic definition of fields in conditional access section	45
2.4.4.8 Program Map Table	46
2.4.4.9 Semantic definition of fields in Transport Stream program map section	46
2.4.4.10 Syntax of the Private section	47
2.4.4.11 Semantic definition of fields in private section	48
2.4.4.12 Syntax of the Transport Stream section	49
2.4.4.13 Semantic definition of fields in the Transport Stream section	50

	Page
2.5 Program Stream bitstream requirements	50
2.5.1 Program Stream coding structure and parameters	50
2.5.2 Program Stream system target decoder	51
2.5.2.1 System clock frequency.....	52
2.5.2.2 Input to the Program Stream system target decoder	52
2.5.2.3 Buffering	53
2.5.2.4 PES streams.....	54
2.5.2.5 Decoding and presentation	54
2.5.2.6 P-STD extensions for carriage of ISO/IEC 14496 data.....	54
2.5.3 Specification of the Program Stream syntax and semantics	54
2.5.3.1 Program Stream	54
2.5.3.2 Semantic definition of fields in Program Stream.....	55
2.5.3.3 Pack layer of Program Stream	55
2.5.3.4 Semantic definition of fields in program stream pack.....	56
2.5.3.5 System header.....	56
2.5.3.6 Semantic definition of fields in system header.....	56
2.5.3.7 Packet layer of Program Stream	58
2.5.4 Program Stream map	59
2.5.4.1 Syntax of Program Stream map	59
2.5.4.2 Semantic definition of fields in Program Stream map.....	59
2.5.5 Program Stream directory.....	60
2.5.5.1 Syntax of Program Stream directory packet	60
2.5.5.2 Semantic definition of fields in Program Stream directory	60
2.6 Program and program element descriptors	62
2.6.1 Semantic definition of fields in program and program element descriptors	62
2.6.2 Video stream descriptor.....	62
2.6.3 Semantic definitions of fields in video stream descriptor.....	64
2.6.4 Audio stream descriptor.....	65
2.6.5 Semantic definition of fields in audio stream descriptor	65
2.6.6 Hierarchy descriptor	65
2.6.7 Semantic definition of fields in hierarchy descriptor.....	65
2.6.8 Registration descriptor	66
2.6.9 Semantic definition of fields in registration descriptor.....	66
2.6.10 Data stream alignment descriptor	67
2.6.11 Semantics of fields in data stream alignment descriptor	67
2.6.12 Target background grid descriptor	67
2.6.13 Semantics of fields in target background grid descriptor	68
2.6.14 Video window descriptor	68
2.6.15 Semantic definition of fields in video window descriptor	69
2.6.16 Conditional access descriptor	69
2.6.17 Semantic definition of fields in conditional access descriptor.....	70
2.6.18 ISO 639 language descriptor	70
2.6.19 Semantic definition of fields in ISO 639 language descriptor	70
2.6.20 System clock descriptor.....	70
2.6.21 Semantic definition of fields in system clock descriptor	71
2.6.22 Multiplex buffer utilization descriptor.....	71
2.6.23 Semantic definition of fields in multiplex buffer utilization descriptor.....	71
2.6.24 Copyright descriptor	72
2.6.25 Semantic definition of fields in copyright descriptor	72
2.6.26 Maximum bitrate descriptor	72
2.6.27 Semantic definition of fields in maximum bitrate descriptor	72
2.6.28 Private data indicator descriptor	73
2.6.29 Semantic definition of fields in Private data indicator descriptor	73
2.6.30 Smoothing buffer descriptor	73
2.6.31 Semantic definition of fields in smoothing buffer descriptor	74
2.6.32 STD descriptor	74
2.6.33 Semantic definition of fields in STD descriptor	74
2.6.34 IBP descriptor.....	74
2.6.35 Semantic definition of fields in IBP descriptor	74

	Page	
2.6.36	MPEG-4 video descriptor.....	75
2.6.37	Semantic definition of fields in MPEG-4 video descriptor	75
2.6.38	MPEG-4 audio descriptor.....	75
2.6.39	Semantic definition of fields in MPEG-4 audio descriptor	75
2.6.40	IOD descriptor.....	75
2.6.41	Semantic definition of fields in IOD descriptor.....	77
2.6.42	SL descriptor	77
2.6.43	Semantic definition of fields in SL descriptor.....	77
2.6.44	FMC descriptor.....	77
2.6.45	Semantic definition of fields in FMC descriptor	78
2.6.46	External_ES_ID descriptor.....	78
2.6.47	Semantic definition of fields in External_ES_ID descriptor	78
2.6.48	Muxcode descriptor	78
2.6.49	Semantics of fields in Muxcode descriptor	79
2.6.50	FmxBufferSize descriptor	79
2.6.51	Semantics of fields in FmxBufferSize descriptor	79
2.6.52	MultiplexBuffer descriptor	79
2.6.53	Semantics of fields in MultiplexBuffer descriptor	80
2.7	Restrictions on the multiplexed stream semantics	80
2.7.1	Frequency of coding the system clock reference.....	80
2.7.2	Frequency of coding the program clock reference	80
2.7.3	Frequency of coding the elementary stream clock reference.....	81
2.7.4	Frequency of presentation timestamp coding	81
2.7.5	Conditional coding of timestamps.....	81
2.7.6	Timing constraints for scalable coding.....	81
2.7.7	Frequency of coding P-STD_buffer_size in PES packet headers.....	82
2.7.8	Coding of system header in the Program Stream	82
2.7.9	Constrained system parameter Program Stream	82
2.7.10	Transport Stream	83
2.8	Compatibility with ISO/IEC 11172	84
2.9	Registration of copyright identifiers SIST ISO/IEC 13818-1:2005	84
2.9.1	General https://standards.iteh.ai/catalog/standards/sist/fa8c31b1-da51-4d0b-9bca-de9048024ab/sistiso-iec-13818-1-2005	84
2.9.2	Implementation of a Registration Authority (RA).....	84
2.10	Registration of private data format	85
2.10.1	General	85
2.10.2	Implementation of a Registration Authority (RA).....	85
2.11	Carriage of ISO/IEC 14496 data	85
2.11.1	Introduction	85
2.11.2	Carriage of individual ISO/IEC 14496-2 and 14496-3 Elementary Streams in PES packets.....	85
2.11.2.1	Introduction	85
2.11.2.2	STD extensions for individual ISO/IEC 14496 elementary streams	86
2.11.3	Carriage of audiovisual ISO/IEC 14496-1 scenes and associated ISO/IEC 14496 streams.....	87
2.11.3.1	Introduction	87
2.11.3.2	Assignment of ES_ID values.....	87
2.11.3.3	Timing of ISO/IEC 14496 scenes and associated streams.....	88
2.11.3.4	Delivery timing of SL-packetized streams	89
2.11.3.5	Delivery timing of FlexMux streams.....	89
2.11.3.6	Carriage of SL-packetized streams in PES packets	89
2.11.3.7	Carriage of FlexMux streams in PES packets	89
2.11.3.8	Carriage of SL packets and FlexMux packets in sections	90
2.11.3.9	T-STD extensions	91
2.11.3.10	Carriage within a Transport Stream.....	93
2.11.3.11	P-STD Model for 14496 content	94
2.11.3.12	Carriage within a Program Stream	96
Annex A – CRC Decoder Model	97	
A.0 CRC decoder model	97	

Annex B – Digital Storage Medium Command and Control (DSM-CC)	98
B.0 Introduction	98
B.0.1 Purpose	98
B.0.2 Future applications	98
B.0.3 Benefits.....	98
B.0.4 Basic functions	99
B.0.4.1 Stream selection	99
B.0.4.2 Retrieval	99
B.0.4.3 Storage.....	99
B.1 General elements	99
B.1.1 Scope	99
B.1.2 Overview of the DSM-CC application	99
B.1.3 The transmission of DSM-CC commands and acknowledgements.....	100
B.2 Technical elements	101
B.2.1 Definitions	101
B.2.2 Specification of DSM-CC syntax	101
B.2.3 Semantics of fields in specification of DSM-CC syntax	102
B.2.4 Control layer.....	102
Constraints on setting flags in DSM-CC control.....	102
B.2.5 Semantics of fields in control layer	103
B.2.6 Acknowledgement layer.....	104
Constraints on setting flags in DSM-CC control.....	104
B.2.7 Semantics of fields in Acknowledgement layer	105
B.2.8 Time code.....	106
Constraints on time code	106
B.2.9 Semantics of fields in time code.....	106
Annex C – Program Specific Information	107
C.0 Explanation of Program Specific Information in Transport Streams	107
C.1 Introduction	107
C.2 Functional Mechanism	107
C.3 The Mapping of Sections into Transport Stream Packets.....	108
C.4 Repetition Rates and Random Access	108
C.5 What is a Program?	108
C.6 Allocation of program_number	109
C.7 Usage of PSI in a Typical System	109
C.8 The Relationships of PSI Structures	110
C.8.1 Program Association Table	110
C.8.2 Program Map Table.....	110
C.8.3 Conditional Access Table.....	110
C.8.4 Network Information Table.....	111
C.8.5 Private_section().....	111
C.8.6 Descriptors.....	112
C.9 Bandwidth Utilization and Signal Acquisition Time	112
Annex D – Systems Timing Model and Application Implications of this Recommendation International Standard.....	115
D.0 Introduction	115
D.0.1 Timing Model.....	115
D.0.2 Audio and Video Presentation Synchronization.....	116
D.0.3 System Time Clock recovery in the decoder.....	118
D.0.4 SCR and PCR Jitter	120
D.0.5 Clock Recovery in the Presence of Network Jitter	121
D.0.6 System clock used for chroma sub-carrier generation.....	121
D.0.7 Component video and audio reconstruction	122
D.0.8 Frame Slipping	122
D.0.9 Smoothing of network jitter.....	123

	<i>Page</i>
Annex E – Data Transmission Applications	124
E.0 General considerations	124
E.1 Suggestion	124
Annex F – Graphics of Syntax for this Recommendation International Standard	125
F.0 Introduction	125
F.0.1 Transport Stream syntax	125
F.0.2 PES packet	126
F.0.3 Program Association Section	127
F.0.4 CA section	127
F.0.5 TS program map section	128
F.0.6 Private section	128
F.0.7 Program Stream	129
F.0.8 Program Stream map	130
Annex G – General Information	131
G.0 General Information	131
G.0.1 Sync Byte Emulation	131
G.0.2 Skipped picture status and decoding process	131
G.0.3 Selection of PID Values	131
G.0.4 PES start_code emulation	131
Annex H – Private Data	132
H.0 Private Data	132
Annex I – Systems conformance and real-time interface	133
I.0 Systems conformance and real-time interface	133
Annex J – Interfacing Jitter-Inducing Networks to MPEG-2 Decoders	134
J.0 Introduction	134
J.1 Network compliance models	134
J.2 Network specification for jitter smoothing	135
J.3 Example decoder implementations	136
J.3.1 Network adapter followed by an MPEG-2 decoder	136
J.3.2 Integrated decoder	136
<i>iTeh STANDARD PREVIEW</i> <i>(standards.iteh.ai)</i>	
Annex K – Splicing Transport Streams	137
K.0 Introduction	137
K.1 The different types of splicing point	137
K.1.1 Ordinary splicing points	137
K.1.2 Seamless splicing points	137
K.2 Decoder behaviour on splices	138
K.2.1 On non-seamless splices	138
K.2.2 On seamless splices	138
K.2.3 Buffer Overflow	138
Annex L – Registration procedure	140
L.1 Procedure for the request of a Registered Identifier (RID)	140
L.2 Responsibilities of the Registration Authority	140
L.2.1 Contact information of the Registration Authority	140
L.3 Responsibilities of parties requesting an RID	140
L.4 Appeal procedure for denied applications	141
Annex M – Registration application form	142
M.1 Contact information of organization requesting a Registered Identifier (RID)	142
M.2 Statement of an intention to apply the assigned RID	142
M.3 Date of intended implementation of the RID	142
M.4 Authorized representative	142
M.5 For official use only of the Registration Authority	142
Annex N	143

	<i>Page</i>
Annex O – Registration procedure.....	144
O.1 Procedure for the request of an RID	144
O.2 Responsibilities of the Registration Authority	144
O.3 Contact information for the Registration Authority	144
O.4 Responsibilities of parties requesting an RID	144
O.5 Appeal procedure for denied applications	145
Annex P – Registration application form.....	146
P.1 Contact information of organization requesting an RID.....	146
P.2 Request for a specific RID	146
P.3 Short description of RID that is in use and date system that was implemented	146
P.4 Statement of an intention to apply the assigned RID.....	146
P.5 Date of intended implementation of the RID	146
P.6 Authorized representative.....	146
P.7 For official use of the Registration Authority.....	146
Annex Q – T-STD and P-STD buffer models for ISO/IEC 13818-7 ADTS.....	147
Q.1 Introduction	147
Q.2 Leak Rate from Transport Buffer	147
Q.3 Buffer Size.....	147
Q.3.1 TBS _n : same as other audio	148
Q.3.2 BS _{mux} : different from other audio	148
Q.3.3 BS _{dec} : different from other audio	148
Q.3.4 BS _{oh} : different from other audio	148
Q.4 Conclusion.....	148
Annex R – Carriage of ISO/IEC 14496 scenes in ITU-T Rec. H.222.0 ISO/IEC 13818-1.....	150
R.1 Content access procedure for ISO/IEC 14496 program components within a Program Stream	150
R.2 Content access procedure for ISO/IEC 14496 program components within a Transport Stream.....	150
Annex S – Patents..... https://standards.iteh.ai/catalog/standards/sist/fa8c31b1-da51-4d0b-9bca-ded9048024ab/sist-iso-iec-13818-1-2005	153

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO/IEC 13818 may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 13818-1 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*, in collaboration with ITU-T. The identical text is published as ITU-T Rec. H.222.0.

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This second edition cancels and replaces the first edition (ISO/IEC 3818-1:1996), which has been technically revised.

ISO/IEC 13818 consists of the following parts, under the general title *Information technology — Generic coding of moving pictures and associated audio information*:

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- *Part 1: Systems*
- *Part 2: Video*
- *Part 3: Audio*
- *Part 4: Conformance testing*
- *Part 5: Software simulation*
- *Part 6: Extensions for DSM-CC*
- *Part 7: Advanced Audio Coding (ACC)*
- *Part 9: Extension for real time interface for systems decoders*
- *Part 10: Conformance extensions for Digital Storage Media Command and Control (DSM-CC)*

Annex A forms a normative part of this part of ISO/IEC 13818. Annexes B to S are for information only.

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 ITU-T Rec. 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.

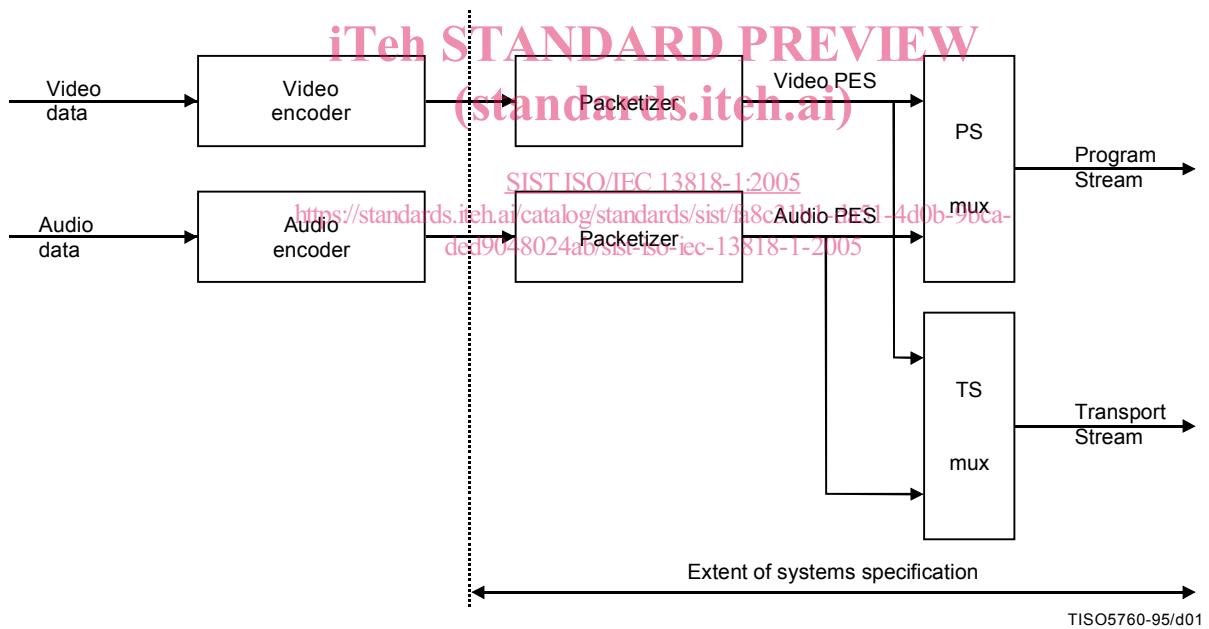


Figure Intro. 1 – Simplified overview of the scope of this Recommendation | International Standard

The **Program Stream** is analogous and similar to 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 which comprise a single program to be in separate streams which 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 differ: 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.

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Intro. 1 Transport Stream (standards.iteh.ai)

The Transport Stream is a stream definition which is tailored for communicating or storing one or more programs of coded data according to ITU-T Rec. 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.

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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 2.4.2.2.

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.

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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.

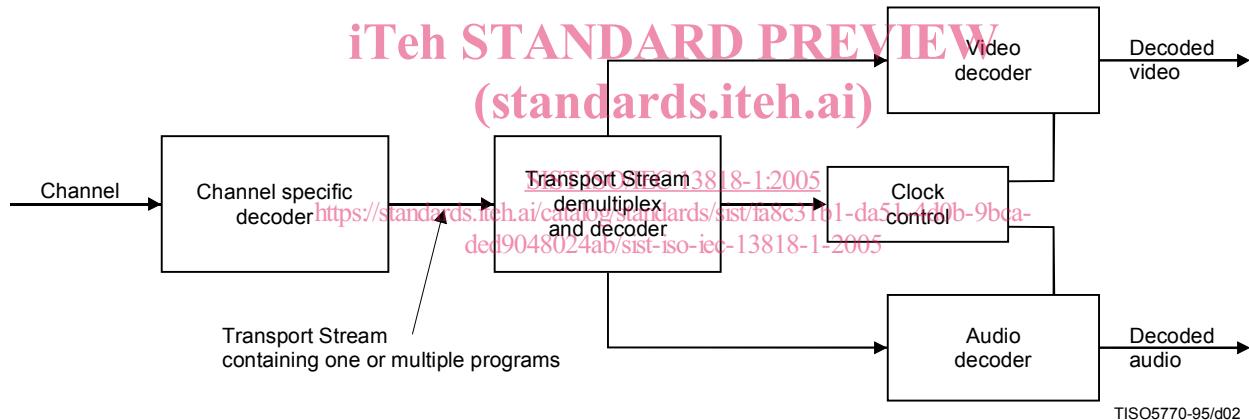


Figure Intro. 2 – Prototypical transport demultiplexing and decoding example

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.

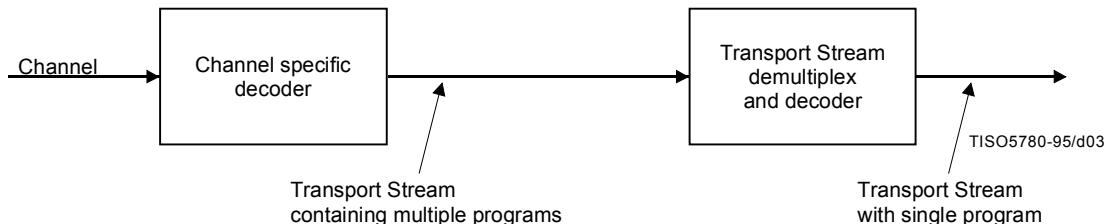


Figure Intro. 3 – Prototypical transport multiplexing example

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.

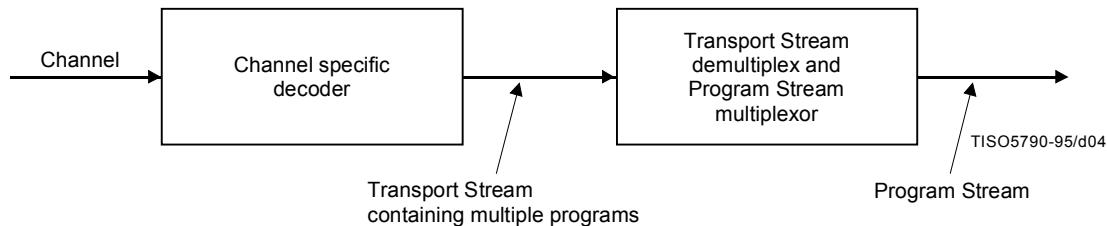


Figure Intro. 4 – Prototypical Transport Stream to Program Stream conversion

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.

(standards.iteh.ai)

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.

<https://standards.itehcatalog.sist-iso-iec-13818-1-2005/de9048024ab/sist-iso-iec-13818-1-2005>

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 an Program Stream decoder. Indeed non-audio/video data is also allowed, but not shown.

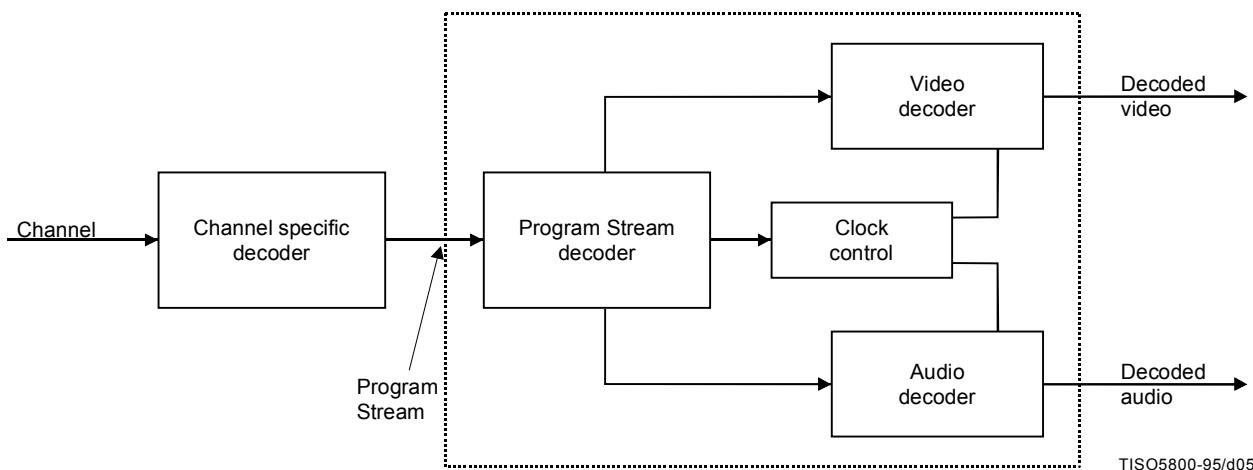


Figure Intro. 5 – Prototypical decoder for Program Streams

ISO/IEC 13818-1:2000(E)

The prototypical decoder for Program Streams shown in Figure Intro. 5 is composed of System, Video, and Audio decoders conforming to Parts 1, 2, and 3, respectively, of ISO/IEC 13818. In this decoder, the multiplexed coded representation of one or more audio and/or video streams is assumed to be stored or communicated on some channel in some channel-specific format. The channel-specific format is not governed by this Recommendation | International Standard, nor is the channel-specific decoding part of the prototypical decoder.

The prototypical decoder accepts as input a Program Stream and relies on a Program Stream Decoder to extract timing information from the stream. The Program Stream Decoder demultiplexes the stream, and the elementary streams so produced serve as inputs to Video and Audio decoders, whose outputs are decoded video and audio signals. Included in the design, but not shown in the figure, is the flow of timing information among the Program Stream decoder, the Video and Audio decoders, and the channel-specific decoder. The Video and Audio decoders are synchronized with each other and with the channel using this timing information.

Program Streams are constructed in two layers: a system layer and a compression layer. The input stream to the Program 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 either apply to the entire Program Stream ("multiplex-wide operations"), or to individual elementary streams ("stream-specific operations"). The Program Stream system layer is divided into two sub-layers, one for multiplex-wide operations (the pack layer), and one for stream-specific operations (the PES packet layer).

Intro. 3 Conversion between Transport Stream and Program Stream

It may be possible and reasonable to convert between **Transport Streams** and **Program Streams** by means of PES packets. This results from the specification of **Transport Stream** and **Program Stream** as embodied in 2.4.1 and 2.5.1 of the normative requirements of this Recommendation | International Standard. PES packets may, with some constraints, be mapped directly from the payload of one multiplexed bit stream into the payload of another multiplexed bit stream. It is possible to identify the correct order of PES packets in a program to assist with this if the `program_packet_sequence_counter` is present in all PES packets.

Certain other information necessary for conversion, e.g. the relationship between elementary streams, is available in tables and headers in both streams. Such data, if available, shall be correct in any stream before and after conversion.

<https://standards.iteh.ai/catalog/standards/sist/fa8c31b1-da51-4d0b-9bca-dad9048024ab/sist-iso-iec-13818-1-2005>

Intro. 4 Packetized Elementary Stream

Transport Streams and **Program Streams** are each logically constructed from PES packets, as indicated in the syntax definitions in 2.4.3.6. PES packets shall be used to convert between Transport Streams and Program Streams; in some cases the PES packets need not be modified when performing such conversions. PES packets may be much larger than the size of a Transport Stream packet.

A continuous sequence of PES packets of one elementary stream with one stream ID may be used to construct a PES Stream. When PES packets are used to form a PES stream, they shall include Elementary Stream Clock Reference (ESCR) fields and Elementary Stream Rate (ES_Rate) fields, with constraints as defined in 2.4.3.8. The PES stream data shall be contiguous bytes from the elementary stream in their original order. PES streams do not contain some necessary system information which is contained in Program Streams and Transport Streams. Examples include the information in the Pack Header, System Header, Program Stream Map, Program Stream Directory, Program Map Table, and elements of the Transport Stream packet syntax.

The PES Stream is a logical construct that may be useful within implementations of this Recommendation | International Standard; however, it is not defined as a stream for interchange and interoperability. Applications requiring streams containing only one elementary stream can use Program Streams or Transport Streams which each contain only one elementary stream. These streams contain all of the necessary system information. Multiple Program Streams or Transport Streams, each containing a single elementary stream, can be constructed with a common time base and therefore carry a complete program, i.e. with audio and video.

Intro. 5 Timing model

Systems, Video and Audio all have a timing model in which the end-to-end delay from the signal input to an encoder to the signal output from a decoder is a constant. This delay is the sum of encoding, encoder buffering, multiplexing, communication or storage, demultiplexing, decoder buffering, decoding, and presentation delays. As part of this timing model all video pictures and audio samples are presented exactly once, unless specifically coded to the contrary, and the inter-picture interval and audio sample rate are the same at the decoder as at the encoder. The system stream coding

contains timing information which can be used to implement systems which embody constant end-to-end delay. It is possible to implement decoders which do not follow this model exactly; however, in such cases it is the decoder's responsibility to perform in an acceptable manner. The timing is embodied in the normative specifications of this Recommendation | International Standard, which must be adhered to by all valid bit streams, regardless of the means of creating them.

All timing is defined in terms of a common system clock, referred to as a System Time Clock. In the Program Stream this clock may have an exactly specified ratio to the video or audio sample clocks, or it may have an operating frequency which differs slightly from the exact ratio while still providing precise end-to-end timing and clock recovery.

In the Transport Stream the system clock frequency is constrained to have the exactly specified ratio to the audio and video sample clocks at all times; the effect of this constraint is to simplify sample rate recovery in decoders.

Intro. 6 Conditional access

Encryption and scrambling for conditional access to programs encoded in the Program and Transport Streams is supported by the system data stream definitions. Conditional access mechanisms are not specified here. The stream definitions are designed so that implementation of practical conditional access systems is reasonable, and there are some syntactical elements specified which provide specific support for such systems.

Intro. 7 Multiplex-wide operations

Multiplex-wide operations include the co-ordination of data retrieval of the channel, the adjustment of clocks, and the management of buffers. The tasks are intimately related. If the rate of data delivery of the channel is controllable, then data delivery may be adjusted so that decoder buffers neither overflow nor underflow; but if the data rate is not controllable, then elementary stream decoders must slave their timing to the data received from the channel to avoid overflow or underflow.

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Program Streams are composed of packs whose headers facilitate the above tasks. Pack headers specify intended times at which each byte is to enter the Program Stream Decoder from the channel, and this target arrival schedule serves as a reference for clock correction and buffer management. The schedule need not be followed exactly by decoders, but they must compensate for deviations about it.

[SIST ISO/IEC 13818-1:2005](#)

<https://standards.iteh.ai/catalog/standards/sist/fa8c31b1-da51-4d0b-9bca>

Similarly, Transport Streams are composed of Transport Stream packets with headers containing information which specifies the times at which each byte is intended to enter a Transport Stream Decoder from the channel. This schedule provides exactly the same function as that which is specified in the Program Stream.

An additional multiplex-wide operation is a decoder's ability to establish what resources are required to decode a Transport Stream or Program Stream. The first pack of each Program Stream conveys parameters to assist decoders in this task. Included, for example, are the stream's maximum data rate and the highest number of simultaneous video channels. The Transport Stream likewise contains globally useful information.

The Transport Stream and Program Stream each contain information which identifies the pertinent characteristics of, and relationships between, the elementary streams which constitute each program. Such information may include the language spoken in audio channels, as well as the relationship between video streams when multi-layer video coding is implemented.

Intro. 8 Individual stream operations (PES Packet Layer)

The principal stream-specific operations are:

- 1) demultiplexing; and
- 2) synchronizing playback of multiple elementary streams.

Intro. 8.1 Demultiplexing

On encoding, Program Streams are formed by multiplexing elementary streams, and Transport Streams are formed by multiplexing elementary streams, Program Streams, or the contents of other Transport Streams. Elementary streams may include private, reserved, and padding streams in addition to audio and video streams. The streams are temporally subdivided into packets, and the packets are serialized. A PES packet contains coded bytes from one and only one elementary stream.