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Digital Video Subcommittee

SCTE STANDARD

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**Digital Video Service Multiplex and Transport System
Standard for Cable Television**

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1. Introduction

1.1. Scope

This document describes the transport subsystem characteristics and normative specifications of the in-band Service Multiplex and Transport Subsystem Standard for Cable Television.¹

2. Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of this document. At the time of Subcommittee approval, the editions indicated were valid. All documents are subject to revision; and while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

1. SCTE 128-1 (2020) AVC Video Constraints for Cable Television Part 1: Coding
2. ANSI/SCTE 194-1 (2018) DTS-HD Audio System – Part 1: Coding Constraints for Cable Television
3. SCTE 193-1 (2020) MPEG-4 AAC Family Audio System – Part 1 Coding Constraints for Cable Television
4. ANSI/SCTE 242-1 (2017) Next Generation Audio Coding Constraints for Cable Systems: Part 1 – Introduction and Common Constraints
5. ANSI/SCTE 242-2 (2017) Next Generation Audio Coding Constraints for Cable Systems: Part 2 – AC-4 Audio Coding Constraints
6. ANSI/SCTE 242-3 (2017) Next Generation Audio Coding Constraints for Cable Systems: Part 3 –MPEG-H Audio Carriage Constraints
7. ANSI/SCTE 242-4 (2018) Next Generation Audio Coding Constraints for Cable Systems: Part 4 – DTS-UHD Audio Coding Constraints

2.2. Standards from Other Organizations

8. ATSC A/52:2018, Digital Audio Compression (AC-3, E-AC-3) Standard.
9. ATSC A/53 Part 3:2013, Service Multiplex and Transport Subsystem Characteristics
10. ATSC A/53 Part 4:2009, MPEG-2 Video System Characteristics
11. ATSC A/65: 2013, Program and System Information Protocol (PSIP) for Terrestrial Broadcast and Cable.
12. ISO/IEC 13818-1, (2019), “Information Technology—Generic coding of moving pictures and associated audio—Part1: Systems.”
13. ISO/IEC IS 13818-2, (2013), “Information Technology—Generic coding of moving pictures and associated audio—Part 2: Video.”
14. ANSI-J-STD-42-C-2018, Emergency Alert Messaging for Cable.
15. ATSC A/53 Part 5:2014, AC-3 Audio System Characteristics
16. ATSC A/53 Part 6:2013, Enhanced AC-3 Audio System Characteristics

¹ Informative note: This standard applies only to Transport Streams transmitted on cable using 64-QAM or 256-QAM in accordance with ANSI/SCTE 07 [17] *Digital Video Transmission Standard for Cable Television*.

2.3. Published Materials

- No normative references are applicable.

3. Informative References

The following documents might provide valuable information to the reader but are not required when complying with this document.

3.1. SCTE References

17. ANSI/SCTE 07 2018, Digital Video Transmission Standard for Cable Television
18. SCTE 128-2 2018 AVC Video Constraints for Cable Television Part 2: Transport
19. SCTE 193-2 (2020) MPEG-4 AAC Family Audio System – Part 2 Constraints for Carriage over MPEG-2 Transport
20. ANSI/SCTE 194-2 (2018) DTS-HD Audio System – Part 2: Constraints for Carriage over MPEG-2 Transport
21. SCTE 215-1 2020 HEVC Video Constraints for Cable Television Part 1- Coding
22. SCTE 215-1-1 2020 HEVC Video Constraints for Cable Television Part 1-1 HDR10 Coding
23. ANSI/SCTE 215-2 2018 HEVC Video Constraints for Cable Television Part 2- Transport
24. ANSI/SCTE 243-1 2017 Next Generation Audio Carriage Constraints for Cable Systems: Part 1 – Common Transport Signaling
25. ANSI/SCTE 243-2 2017 Next Generation Audio Carriage Constraints for Cable Systems: Part 2 – AC-4 Audio Carriage Constraints
26. ANSI/SCTE 243-3 2017 Next Generation Audio Carriage Constraints for Cable Systems: Part 3 – MPEG-H Audio Carriage Constraints
27. ANSI/SCTE 243-4 2018 Next Generation Audio Carriage Constraints for Cable Systems: Part 4 – DTS-UHD Audio Carriage Constraints

3.2. Standards from Other Organizations

28. ANSI/CEA-766-D (2013), U.S. and Canadian Rating Region Tables (RRT) and Content Advisory Descriptors for Transport of Content Advisory Information Using ATSC Program and System Information Protocol (PSIP).
29. ATSC A/71:2012 Parameterized Services Standard
30. ATSC Code Point Registry, available at <https://www.atsc.org/standards/code-point-registry/>
31. ETSI TS 103 190-2 V1.2.1 Digital Audio Compression (AC-4) Standard; Part 2: Immersive and personalized audio (2018-02).

3.3. Published Materials

- No informative references are applicable.

4. Compliance Notation

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<i>shall not</i>	This phrase means that the item is an absolute prohibition of this document.
<i>forbidden</i>	This word means the value specified shall never be used.
<i>should</i>	This word or the adjective “ <i>recommended</i> ” means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighted before choosing a different course.
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5. Abbreviations and Definitions

5.1. Abbreviations

64-QAM	64-state quadrature amplitude modulation
256-QAM	256-state quadrature amplitude modulation
AAC	advanced audio coding
AC-3	Audio Codec 3 or Advanced Codec 3 (also Dolby Digital)
ADTS	audio data transport stream
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
ATSC	Advanced Television Systems Committee
AVC	advanced video coding
bps	bits per second
CA	conditional access
CEA	Consumer Electronics Association (now known as CTA, see below)
CM	complete main [audio service]
CRC	cyclic redundancy check
CTA	Consumer Technology Association (formerly known as CEA, see above) URL https://www.cta.tech/
CVCT	cable virtual channel table
E-AC-3	Enhanced AC-3 (also Dolby Digital Plus)
ECM	entitlement control message
e.g.	for example (exempli gratia)
EIT	event information table
ES	elementary stream

ETT	extended text table
ID	identifier
i.e.	that is (id est)
IEC	International Electrotechnical Commission
ITU-T	ITU Telecommunication Standardization Sector
IS	international standard
ISO	International Organization for Standardization
LATM	low overhead audio transport multiplex
LBR	low bit rate
LLC	limited liability company
LOAS	low overhead audio stream
Mbps	megabits per second
ME	music and effects
MGT	master guide table
MPEG	Moving Picture Experts Group
MRD	MPEG-2 Registration Descriptor
ms	millisecond
Msp	megasymbols per second
PAT	program association table
PES	packetized elementary stream
PID	packet identifier
PMT	program map table (more properly, TS program map section())
PSI	program specific information
PSIP	program and system information protocol
PTS	presentation time stamp
QAM	quadrature amplitude modulation
RRT	rating region table
SCTE	Society of Cable Telecommunications Engineers
SI	service information
SMPTE	Society of Motion Picture and Television Engineers
STT	system time table
TS	Transport Stream
T-STD	Transport Stream system target decoder
TVCT	terrestrial virtual channel table

5.2. Definitions

MPEG-2 program	As defined by ISO/IEC 13818-1 [12] Section 2.1.59 “A program is a collection of program elements,” and may be further constrained by the terms of this present document. The word “program” may or may not be capitalized but means the same regardless.
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6. System Overview

The transport format and protocol for the Service Multiplex and Transport Subsystem Standard for Cable Television is a compatible subset of the MPEG-2 Systems specification defined in ISO/IEC 13818-1 [12]. It is based on a fixed-length packet Transport Stream approach which has been defined and optimized for digital television delivery applications.

As illustrated in Figure 1, the transport function resides between the application (e.g., audio or video) encoding and decoding functions and the transmission subsystem. The encoder’s transport subsystem is responsible for formatting the coded elementary streams and multiplexing the different components of the program for transmission. The receiver is responsible for recovering the elementary streams for the individual application decoders and for the corresponding error signaling. The transport subsystem also incorporates other higher protocol layer functionality related to synchronization of the receiver.

One approach to system multiplexing approach may be to consider it a combination of multiplexing at two different layers. In the first layer, single program Transport Streams are formed by multiplexing Transport Stream (TS) packets from one or more Packetized Elementary Stream (PES) and/or private section (see ISO/IEC 13818-1 [12] Table 2-30) sources. In the second layer, a single program Transport Stream forms (or two or more may be combined to form) a service multiplex (also known as a multi-program Transport Stream in the MPEG-2 Systems standard, and a digital television standard multiplexed bit stream in this SCTE standard). Program Specific Information (PSI) identifies programs and the components of programs.

Not shown explicitly in Figure 1, but essential to the practical implementation of this Standard, is a control system that manages the transfer and processing of the elementary streams from the application encoders. The rules followed by this control system are not a part of this Standard. The output of the control system implementation shall conform to the MPEG-2 Transport Stream coding as specified in ISO/IEC 13818-1 [12] with the additional constraints specified in this Standard.

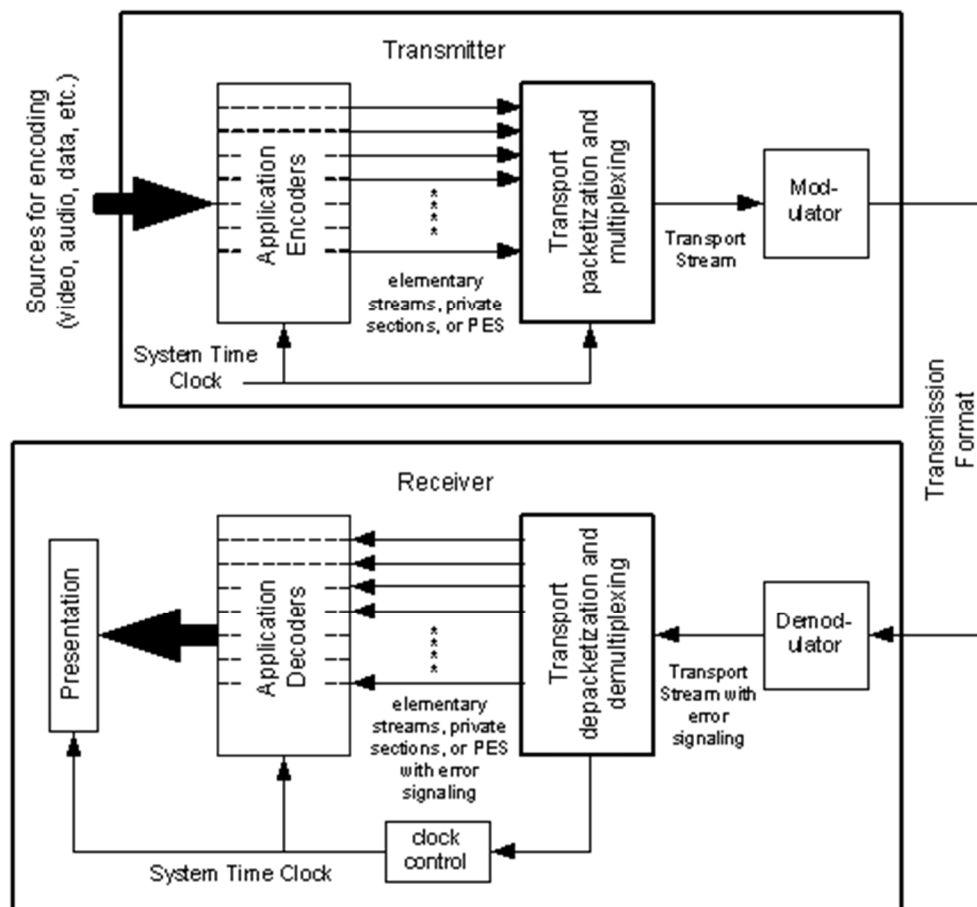


Figure 1 - Sample organization of functionality in a transmitter-receiver pair for a single program.

7. Specification

This Section constitutes the normative specification for the transport subsystem of the Service Multiplex and Transport Subsystem Standard for Cable Television. The syntax and semantics of the specification conform to ISO/IEC 13818-1 [12], subject to the constraints and conditions specified in this Standard. This Section of the Standard describes the coding constraints that apply to the use of the MPEG-2 Systems specification in the digital television system.

7.1. MPEG-2 Systems standard

The Transport Stream shall comply with normative elements of ISO/IEC 13818-1 [12], subject to the constraints in Section 10 of this standard.

All Transport Streams conforming to this Standard shall conform to the ISO/IEC 13818-1 [12] T-STD conceptual model which is used to define several minimum buffer sizes and decoding rate terms precisely. The T-STD model is needed to reflect the decoding process during the construction or verification of Transport Streams.

7.1.1. Video T-STD

The video Transport Stream System Target Decoder (T-STD) for MPEG-2 video is based on Section 2.4.2.3 of ISO/IEC 13818-1 [12] and follows the constraints for the level encoded in the video elementary stream. The video T-STD for AVC video is specified in SCTE 128-2 [18] Section 6.2.1. The video T-STD for HEVC video is specified in SCTE 215-2 [23] Section 6.2.1.

7.1.2. Audio T-STD and Buffering Models

The audio T-STD for AC-3 audio is specified in Section 4.4 of Annex A of ATSC Standard A/52 [8] and Section 5.7 of ATSC Standard A/53 Part 5 [15]. The audio T-STD for E-AC-3 (“Enhanced AC-3”) is specified in Section G3.6.1 of Annex G of ATSC Standard A/52 [8]. The buffering model for DTS-HD audio is specified in ANSI/SCTE 194-2 [20] Section 4.1.2. The buffer size for AAC audio is specified in SCTE 193-2 [19] Section 6.6. The buffer size for AC-4 audio is specified in ETSI TS 103 190-2 [31] Section D.2.4. The buffer size for MPEG-H audio is specified in ANSI/SCTE 243-3 [26] Section 7.5. The buffering model for DTS-UHD audio is specified in ANSI/SCTE 243-4 [27] Section 6.2.1.

7.2. Identification of MPEG-2 Private Ranges

ATSC coordinates code point assignments in the MPEG-2 user-private range and SCTE may define code points within this coordinated range. See ATSC Code Point Registry [30].

7.2.1. MPEG-2 Registration Descriptor (MRD)

Under circumstances as defined below, this Standard uses the MPEG-2 Registration Descriptor (MRD) described in Section 2.6.8 and 2.6.9 of ISO/IEC 13818-1 [12] to identify the contents of programs and program elements to decoding equipment. No more than one MRD shall appear in any given descriptor loop.

7.2.2. Program Identifier

Subject to the restriction in Sec. 5.2.1 against multiple MRDs, as defined in Section 2.6.8 and 2.6.9 of ISO/IEC 13818-1 [12], in a given descriptor loop, an MRD with any registered value of `format_identifier` may be present in the descriptor loop immediately following the `program_info_length` field of the

TS_program_map_section(). The element(s) scoped by the MRD are described by the owner of the registered value in the format_identifier field.

When an MRD with format identifier values 0x5343 5445 (“SCTE” in ASCII), or 0x4741 3934 (“GA94” in ASCII), is present in the descriptor loop immediately following the program_info_length field of the TS_program_map_section() describing the program, the program elements are as described by SCTE or ATSC standards respectively.

Informative note: The absence of an MPEG-2 Registration Descriptor having a value of 0x5343 5445 or 0x4741 3934 should not be taken as an indication that the corresponding program does or does not conform to ATSC and/or SCTE standards.

7.2.3. AC-3 Audio Elementary Stream Identifier

Presence of audio program elements that conform to ATSC and SCTE standards may be indicated by use of an MPEG-2 Registration Descriptor (as defined in Section 2.6.8 and 2.6.9 of ISO/IEC 13818-1 [12]) placed in the descriptor loop immediately following the ES_info_length field in the TS_program_map_section() for each such audio program element. The format_identifier field of this MPEG-2 Registration Descriptor, when used to signal the presence of AC-3 or E-AC-3 audio, shall have a format_identifier field value of 0x4143 2D33 (“AC-3” in ASCII).

Informative note: The absence of an MPEG-2 Registration Descriptor having a value of 0x4143 2D33 should not be taken as an indication that the corresponding program does or does not conform to ATSC and/or SCTE standards.

7.2.4. Other Program Element Identifiers

Any program element carrying content not described by an approved ATSC or SCTE standard shall be identified with an MPEG-2 Registration Descriptor (as defined in Section 2.6.8 and 2.6.9 of ISO/IEC 13818-1 [12]). The format_identifier field of the MPEG-2 Registration Descriptor shall be registered with the SMPTE Registration Authority, LLC²². The descriptor shall be placed in the descriptor loop immediately following the ES_info_length field in the TS_program_map_section() for each such non-standard program element.

The presence of an MPEG-2 Registration Descriptor in any descriptor loop shall not affect the meaning of any other descriptor(s) in the same descriptor loop. The ATSC Private Information Descriptor (defined in section 7.9.3.12) shall be the standard method to carry descriptor-based information associated with a private entity.

An MPEG-2 Registration Descriptor shall be placed in the descriptor loop immediately following the ES_info_length field in the TS_program_map_section() for each program element having a stream_type value in the user private range, 0xC4 to 0xFF, to establish the private entity associated with that program element.

An MPEG-2 Registration Descriptor present in the program information descriptor loop in the TS_program_map_section() (the descriptor loop immediately following the program_info_length field) shall apply to all program elements described in the TS_program_map_section(). An MPEG-2

²² The ISO/IEC-designated registration authority for the format_identifier is SMPTE Registration Authority, LLC. See (<http://www.smp-te-ra.org/html>).

Registration Descriptor may be present in the program information descriptor loop of the TS_program_map_section() only if it is applicable to all program elements described in that TS_program_map_section().

7.3. Audio Constraints

The audio elementary streams based on the formats listed below shall comply with the associated reference specification:

- AC-3 (see ATSC A/53 Part 5 [15]).
- E-AC-3 (see ATSC A/53 Part 6 [16]).
- DTS-HD (see ANSI/SCTE 194-1 [2]).
- AAC (see SCTE 193-1 [3]).
- AC-4 (see ANSI/SCTE 242-2 [5]).
- MPEG-H (see ANSI/SCTE 242-3 [6]).
- DTS-UHD (see ANSI/SCTE 242-4 [7]).

Audio coded with AC-4, MPEG-H, or DTS-UHD shall also comply with the requirements of ANSI/SCTE 242-1 [4]. Audio coded with AC-3 or E-AC-3 may also contain optional Extensible Metadata Delivery Format (EMDF) structures compliant with ATSC A/52 [8]; further, if a program contains audio components, at least one shall be a complete main audio service (CM).³

Audio coded with AC-4, MPEG-H, or DTS-UHD is transported per the requirements of ANSI/SCTE 243-1 [24] as well as the requirements of ANSI/SCTE 243-2 [25] (for AC-4), ANSI/SCTE 243-3 [26] (for MPEG-H), or ANSI/SCTE 243-4 [27] (for DTS-UHD), as appropriate.

7.4. Video Constraints

MPEG-2 programs shall be constrained to carry at most one video Elementary Stream component. The video elementary streams based on the formats listed below shall comply with the associated reference specification:

- MPEG-2 (ATSC A/53 Part 4 [10]).
- AVC (SCTE 128-1 [1]).
- HEVC without HDR (ANSI/SCTE 215-1 [21]).
- HDR (SCTE 215-1-1 [22]).

7.5. Constraints on PSI

The program constituents for all programs are described in the PSI according to ISO/IEC 13818-1 [12]. The following constraints shall apply to the PSI information:

- Transport Stream packets identified by a particular PMT_PID value shall be constrained to carry only one program definition, as described by a single TS_program_map_section().

³ The terms Complete Main audio service, main audio service and associated audio service are used in the respective audio service standards such as A/52 [8] and A/53 Part 5 [15] (which may be consulted for more details) but are not necessarily formally defined there. A Complete Main audio service contains all necessary program elements which typically includes dialog, music, silence, and effects. A main audio service can be decoded and rendered by a receiver. An associated audio service must be combined with a main audio service in a receiver having two (or more) decoders.

- The Transport Stream shall be constructed such that the time interval between the byte containing the last bit of the TS_program_map_section() containing television program information and successive occurrences of the same TS_program_map_section() shall be less than or equal to 400 milliseconds.
- The program_number values shall be associated with the corresponding PMT_PIDs in the Program Association Table (PAT). The Transport Stream shall be constructed such that the time interval between the byte containing the last bit of the program_association_section() and successive occurrences of the program_association_section() shall be less than or equal to 100 milliseconds. However, when program_association_section(s), CA_section(s), and TS_program_map_section(s) are approaching their maximum allowed sizes, the potential exists to exceed the 80,000 bps rate for system data specified in ISO/IEC 13818-1 [12] Sec. 2.4.2.3. In cases where the table section sizes are such that the 100 millisecond repetition rate of the program_association_section() would cause the 80,000 bps maximum rate to be exceeded, the time interval between the byte containing the last bit of the program_association_section() may be increased but in no event shall exceed 140 milliseconds, so that under no circumstances the limit of 80,000 bps is exceeded.
- Adaptation headers shall not occur in TS packets identified by a program_map_PID value for purposes other than for signaling with the discontinuity_indicator that the version_number (Section 2.4.4.5 of ISO/IEC 13818-1 [12]) may be discontinuous.
- Adaptation headers shall not occur in TS packets identified by PID 0x0000 (the PAT PID) for purposes other than for signaling with the discontinuity_indicator that the version_number (Section 2.4.4.5 of ISO/IEC 13818-1 [12]) may be discontinuous.
- Private table sections in addition to Program Map Tables may be present in TS packets PMT_PID identified by a program_map_PID value.

7.6. Constraints on Mixed Format Audio Services

When a Program includes two or more main audio services (for example, two main audio services encoded using different audio formats), each audio service shall be uniquely identified.

For AC-3, E-AC-3 and AAC, the value of each mainid in the respective audio stream descriptor shall be unique within the Program.

As an example, when an AC-3 CM and an E-AC-3 CM in English and an AC-3 CM and an E-AC-3 CM in Spanish are all present in a Program, the four values of mainid could be set to 1, 2, 3, and 4; they are not permitted to be set to 1, 2, 1, 2.

E-AC-3 associated services associated with non-E-AC-3 main audio services shall be delivered in independent substream 0, which is specified in A/52 [8].

Informative Note: A single E-AC-3 stream may carry both main and associated services. In such cases, the main service is in independent substream 0, and associated services may be carried in independent substreams 1, 2, or 3, as specified in A/52 [8]. When a non-E-AC-3 CM stream has an associated service carried in an E-AC-3 stream, the associated service is required (by A/52 [8]) to be carried only in independent substream 0 of such E-AC-3 bitstream.

DTS-HD uses substream number to identify the streams. Further, within each substream, DTS-HD supports the signaling of up to 8 assets. Each asset can be coded using different coding methods (different DTS-HD coding profiles such as LBR, CORE and Lossless), as signaled in “asset_construction”. Each asset can also signal component-type (e.g. “complete main” or “dialog”) and language (ISO 639 24-bit code).

7.7. PES constraints

Packetized Elementary Stream syntax and semantics shall be used to encapsulate the audio and video elementary stream information according to ISO/IEC 13818-1 [12]. The Packetized Elementary Stream syntax is used to convey the Presentation Time-Stamp (PTS) and Decoding Time-Stamp information required for decoding audio and video information with synchronism. This Section describes the coding constraints for this system layer.

Within the PES packet header, the following restrictions shall apply:

- PES_scrambling_control shall be coded as '00'.
- ESCR_flag shall be coded as '0'.
- ES_rate_flag shall be coded as '0'.
- PES_CRC_flag shall be coded as '0'.

Within the PES packet extension, the following restrictions shall apply.

- PES_private_data_flag shall be coded as '0'.
- pack_header_field_flag shall be coded as '0'.
- program_packet_sequence_counter_flag shall be coded as '0'.
- P-STD_buffer_flag shall be coded as '0'.

7.7.1. Audio PES constraints

The audio decoder may be capable of simultaneously decoding more than one elementary stream containing different program elements, and then combining the program elements into a complete program. In this case, the audio decoder may sequentially decode audio frames (or audio blocks) from each elementary stream and do the combining (mixing together) on a frame (or block) basis. In order to have the audio from the two elementary streams reproduced in exact sample synchronism, the original audio elementary stream encoders should encode the two audio program elements frame synchronously; i.e., if audio program 1 has sample 0 of frame n at time t0, then audio program 2 should also have frame n beginning with its sample 0 at the identical time t0. If the encoding is done frame synchronously, then matching audio frames should have identical values of PTS.

If PES packets from two audio services that are to be decoded simultaneously contain identical values of PTS then the corresponding encoded audio frames contained in the PES packets should be presented to the audio decoder for simultaneous synchronous decoding. If the PTS values do not match (indicating that the audio encoding was not frame synchronous) then the audio frames which are closest in time may be presented to the audio decoder for simultaneous decoding. In this case the two services may be reproduced out-of-sync by as much as 1/2 of a frame time (which is often satisfactory, e.g., a voice-over does not require precise timing).

The value of stream_id for AC-3 audio, E-AC-3 audio and DTS-HD audio is 0xBD or 1011 1101 (private_stream_1). The value of stream_id for AAC audio is specified in Section 6.5 of SCTE 193-2 [19].

7.8. Services and features

7.8.1. System information and program guide

Transport Streams containing one or more unscrambled programs that include navigation data shall include service information defined in 7.8.1.1 below, describing the unscrambled programs. Timing aspects of the delivery of service information tables are defined in Sec. 7.8.1.2. The policy question of who is responsible for creating this service information (and its accuracy, completeness, formatting, and compliance with A/65 [11]) is outside the scope of this standard.

Informative note: In the absence of descrambling capability, receivers are expected to support navigation only to unscrambled services that are referenced in an in-band Virtual Channel Table present in the Transport Stream that carries the program.

When present, system information shall be formatted according to the structure and syntax described in ATSC A/65 [11]. System information data, when present, shall be transported in TS packets of PID 0x1FFB (the base_PID per [11]). PID 0x1FFB shall be reserved exclusively for this purpose (as well as for Emergency Alert messages).

At the option of the cable operator, data supporting construction of an Electronic Program Guide in the receiver in conformance with ATSC A/65 [11] may also be present.

Informative note: The following sub-sections describe the structure and syntax for system information, when present.

7.8.1.1. Service information tables

When present, the service information shall include the following tables at a minimum: the Master Guide Table (MGT), System Time Table (STT), and the Cable Virtual Channel Table (CVCT) or the Terrestrial Virtual Channel Table (TVCT). If any Program Map Table or Event Information Table on the Transport Stream includes a content_advisory_descriptor() quoting a rating_region other than region 0x01 (U.S. plus possessions), the Rating Region Table (RRT) describing that region shall be transmitted. Delivery of the RRT corresponding to region 0x01 (U.S. and possessions) is optional because this table is standardized in CEA-766 [28].

Those transmitted tables shall describe the unscrambled digital services multiplexed in the Transport Stream carrying those tables. The tables may optionally include information about analog channels, scrambled channels, as well as other digital channels available in different Transport Streams. The methods of ATSC Parameterized Services Standard A/71 [29] may be used for announcement of the technical attributes of program elements that must be supported in a receiving device to render the programming on a particular virtual channel.

The 10-bit major_channel_number and minor_channel_number fields in the Cable Virtual Channel table represent either a two-part or a one-part virtual channel number associated with the virtual channel being defined. The one- or two-part number acts as the user's reference number for the virtual channel. Some channels in the CVCT may be represented with a one-part number while others are represented with two-part numbers.

To specify a two-part channel number both the major_channel_number and the minor_channel_number fields shall be below 1000. To specify a one-part channel number, the six most significant bits of major_channel_number shall be '11 1111'. Values and combinations of major_channel_number and minor_channel_number falling outside these ranges are reserved.

The one-part channel number is a 14-bit quantity that shall be computed by the following formula, represented in C syntax:

$$\text{one_part_number} = (\text{major_channel_number} \& 0x00F) \ll 10 + \text{minor_channel_number}$$

Any given cable programming service may be represented either by a two-part channel number in a CVCT or a TVCT, or by a one-part channel number in the CVCT.

7.8.1.2. System information and program guide T-STD model

Table 2 lists the maximum cycle time for the SI tables required for in-band cable.

Table 1 - Maximum cycle time for the STT, MGT, CVCT and RRT

Table	STT	MGT	CVCT	RRT (when present)
Cycle time (ms)	10000	150	400	60000

Table 3 lists the maximum transmission rate for SI streams according to their PIDs. The recommended maximum cycle time for EIT-0, if present, shall be 500 ms.

Table 2 - Maximum rate for each PSIP packet stream

PID	base_PID	EIT_PID	ETT_PID
Rate (bps)	250,000	250,000	250,000

In cable applications, the SI streams identified by Transport Stream packets with PID 0x1FFB (base_PID) and EIT PIDs and ETT PIDs (if present) shall adhere to a T-STD model with the following parameters:

- sb_leak_rate shall be 625 (indicating a leak rate of 250,000 bps)
- sb_size shall be 1024 (indicating a smoothing buffer size of 1024 bytes)

7.8.2. Emergency alerts

Transport Streams may include Emergency Alert information. When present, Emergency Alert information shall conform to ANSI-J-STD-42-C [14], Emergency Alert Message for Cable. When present, the cable_emergency_alert() table section shall be carried in TS packets with PID 0x1FFB (base_PID).

7.8.3. Specification of private data services

Private data may be transported by various means:

1. Data services—Carriage of data services including system information shall be as documented in applicable ATSC or SCTE Standards.
2. Private program elements—The stream_type codes in the range 0xC4 to 0xFF shall be available for stream types defined privately (not described by ATSC or SCTE Standards). Such privately-defined program elements shall include an MPEG-2 Registration Descriptor (see Sec. 5.2.4).

3. Adaptation fields— Private data may be transmitted within the adaptation field headers of TS packets (Sections 2.4.3.4 and 2.4.3.5 of ISO/IEC 13818-1 [12]). Program elements that include private data in the adaptation fields of their TS packets shall include an MPEG-2 Registration Descriptor (see Sec. 5.2.4).

7.8.4. Still Pictures

Certain services may include video elementary streams conforming to the ISO/IEC 13818-1 [12] Still Picture Model. Any MPEG-2 video elementary stream containing still picture data shall include a `video_stream_descriptor()` in accordance with ISO/IEC 13818-1 [12] Section 2.6.2.

AVC and HEVC video still picture data (when present) shall comply with the requirements of ISO/IEC 13818-1 [12].

7.9. Assignment of identifiers

This document utilizes a number of identifiers and codes that are assigned fixed values, e.g. `stream_type` values and descriptor tags. This section summarizes, and identifies the references for, those identifiers and codes.

`stream_type` codes for program element types managed by the ATSC Code Points Registrar [30] (currently assigned or available for future assignment) shall be in the range 0x80 to 0xC3. `descriptor_tag` codes managed by the ATSC Code Points Registrar (currently assigned or available for future assignment) shall be in the range 0x40 to 0xEF.

7.9.1. Table IDs

Table ID values applicable to this standard are listed in the ATSC Code Point Registry [30].

7.9.2. Stream Types

Some stream type code values relevant to this standard are indicated in Table 3.

Table 3 - Stream Type Codes (Informative)

Value	Description
0x01	ISO/IEC 11172 video
0x02	ITU-T Rec. H.262 ISO/IEC 13818-2 video [13]
0x05	ITU-T Rec. H.222.0 ISO/IEC 13818-1 private sections
0x06	ITU-T Rec. H.222.0 ISO/IEC 13818-1 PES packets containing private data (used for DTS-UHD audio per ANSI/SCTE 243-4 [27])
0x0F	ADTS formatted AAC streams
0x11	LATM/LOAS formatted AAC streams
0x1B	AVC video (ANSI/SCTE 128-2 [18])
0x24	HEVC video (ANSI/SCTE 215-2 [23])
0x2D	MPEG-H audio single-stream (ANSI/SCTE 243-3 [26])
0x2E	MPEG-H audio auxiliary streams (ANSI/SCTE 243-3 [26])
0x80	Identical to ITU-T Rec. H.262 ISO/IEC 13818-2 video [13]
0x81	AC-3 audio (ATSC A/53 Part 3 [9])
0x87	E-AC-3 audio (ATSC A/53 Part 3 [9])
0x88	DTS-HD audio (ANSI/SCTE 194-2 [20])

7.9.2.1. Video Stream Type

The stream_type codes 0x02 or 0x80 are used for MPEG-2 video elementary streams carried in transport packets defined by this standard. The stream_type code 0x1B is used for AVC video elementary streams. (per ISO/IEC 13818-1 [12] and SCTE 128-2 [18]). The stream_type code 0x24 is used for HEVC video elementary streams. (per ISO/IEC 13818-1 [12] and ANSI/SCTE 215-2 [23]).

7.9.2.2. Audio Stream Type

The stream_type code 0x81 is used for AC-3 audio elementary streams carried in transport packets defined by this standard (see ATSC A/52 [8]). The stream_type code 0x87 is used for E AC-3 audio elementary streams (see ATSC A/52[8]). The stream_type code 0x88 is used for DTS-HD audio elementary streams (see ANSI/SCTE 194-2 [20]). The stream_type code 0x11 is used for LATM/LOAS formatted AAC audio elementary streams and 0x0F is used for ADTS formatted AAC audio elementary streams (see ISO/IEC 13818-1 [12]).

7.9.3. Descriptors

Descriptor tag values are listed in the ATSC Code Point Registry [30].

7.9.3.1. AC-3 audio descriptor

When an Elementary Stream of stream_type 0x81 (AC-3 audio) is present in the digital television Transport Stream, an AC-3 Audio Descriptor (AC-3_audio_stream_descriptor()) shall be included in the descriptor loop immediately following the ES_info_length field in the TS_program_map_section() describing that Elementary Stream. The syntax is given in Table A4.1 of Annex A of ATSC Standard A/52 [8]. The following constraints apply to the AC-3 Audio Descriptor:

1. The value of the `descriptor_tag` is 0x81. (see ATSC A/52 [8])
2. The `num_channels` field has a value in the range 1 to 13. (see ATSC A/53 Part 3 [9])
3. The `langcod` field is a reserved field.
4. Audio language shall be indicated using the language field of the AC-3 Audio Descriptor and may also be indicated using the ISO 639 Language Descriptor in the PMT (see Sec. 7.9.3.2 below).
5. The descriptor identifies the type of the audio service in the `bsmod` field. The `bsmod` field in the descriptor is required to be the same as the `bsmod` field in the elementary stream associated with this descriptor (see ATSC A/53 Part 3 [9]).

The use of the AC-3 Audio Descriptor to signal the Video Description audio track is discussed in Section 8.2 below.

7.9.3.2. Use of the ISO 639 Language Descriptor with AC-3 Audio

The ISO 639 Language Descriptor defined in ISO/IEC 13818-1 [12] Section 2.6.18 may be used to indicate the language of audio Elementary Stream components. If used, the ISO 639 Language Descriptor shall be included in the descriptor loop immediately following the `ES_info_length` field in the `TS_program_map_section()` for each Elementary Stream of `stream_type` 0x81 (AC 3 audio) when the number of audio Elementary Streams in the `TS_program_map_section()` having the same value of bit stream mode (`bsmod` in the AC-3 Audio Descriptor) is two or more.

The `audio_type` field in any ISO 639 Language Descriptor used in this Standard shall be set to 0x00 (meaning “undefined”).

The use of the ISO 639 Language Descriptor to signal the Video Description audio track is discussed in Section 8.1 below.

An ISO 639 Language Descriptor may be present in the `TS_program_map_section()` in other positions as well, for example to indicate the language or languages of a textual data service program element.

7.9.3.3. E-AC-3 Audio Descriptor

When an elementary stream of `stream_type` 0x87 (E-AC-3 audio) is present in the digital television Transport Stream, an E-AC-3 Audio Descriptor (`E-AC-3_audio_descriptor()`) shall be included in the descriptor loop immediately following the `ES_info_length` field in the `TS_program_map_section()` describing that elementary stream. The syntax is given in Table G.1 of Annex G of ATSC Standard A/52 [8]. The value of the `descriptor_tag` is 0xCC. The constraints specified in sections 5.8.1.3 and 5.8.1.4 of ATSC Standard A/53 Part 3 [9] apply to the E-AC-3 Audio Descriptor.

7.9.3.4. DTS-HD Audio Descriptor

The DTS-HD Audio Descriptor is defined in ANSI/SCTE 194-2 [20]. When an Elementary Stream of `stream_type` 0x88 (DTS-HD audio) is present in the digital television Transport Stream, a DTS-HD Audio Descriptor shall be included in the descriptor loop immediately following the `ES_info_length` field in the `TS_program_map_section()` describing that Elementary Stream.

7.9.3.5. AAC Descriptor

The AAC Descriptor is defined in SCTE 193-2 [19]. When an Elementary Stream of `stream_type` 0x0F or 0x11 (AAC audio) is present in the digital television Transport Stream, an MPEG AAC Descriptor shall

be included in the descriptor loop immediately following the ES_info_length field in the TS_program_map_section() describing that Elementary Stream.

7.9.3.6. Additional Constraints on Audio Descriptors

When two or more audio services are present in the Program (each service comprising a stream or substream structure), with each carrying the same type of audio service, the 3-byte language code for each audio service shall be included in the corresponding audio descriptor, and one audio service may be designated to be the preferred stream to be decoded.

For services using AC-3 or E-AC-3 coding, at most one audio elementary stream in a given Program shall be labeled “Primary” in the relevant audio descriptor.

7.9.3.7. Program smoothing buffer descriptor.

The Program Map Table of each program may contain a smoothing buffer descriptor pertaining to that program in accordance with Section 2.6.30 of ISO/IEC 13818-1 [12]. During the continuous existence of a program, the value of the elements of the smoothing buffer descriptor, if present, shall not change.

If present, the fields of the smoothing buffer descriptor shall meet the following constraints:

- The field sb_leak_rate shall be allowed to range up to the maximum transport rates specified in Section 11.
- The field sb_size shall have a value less than or equal to 2048. The size of the smoothing buffer is thus 2048 bytes.

7.9.3.8. Video stream descriptor

Any elementary stream containing still picture data shall include a video_stream_descriptor() in accordance with ISO/IEC 13818-1 [12] Sec. 2.6.2 in the TS_program_map_section() describing that elementary stream.

7.9.3.9. Component name descriptor

Whenever a service includes two or more audio components labeled with the same ISO_639_language_code (in the ISO 639 Language Descriptor or the respective audio descriptors), and same audio service type (as defined in the respective audio descriptors), a unique component_name_descriptor() (as defined in Sec. 6.7.8 of ATSC A/65 [11]) shall be placed into the descriptor loop immediately following the ES_info_length field in the TS_program_map_section() to describe each such audio component.

Whenever a service includes an audio component whose audio service type is music and effects (ME), and the component is a full service suitable for presentation (as indicated by the full_svc flag in the AC-3 Audio Descriptor or the full_service_flag in the E-AC-3 Audio Descriptor being set) a unique component_name_descriptor() should be placed into the Elementary Stream information (inner) loop of the TS_program_map_section() to describe that component.

7.9.3.10. Caption service descriptor

When caption services are delivered within the picture user_data() construct defined in ATSC A/53 Part 4 [10], the caption_service_descriptor(), as defined in Sec. 6.7.3 of ATSC A/65 [11], shall be present in:

- the TS_program_map_section() (as defined in ISO/IEC 13818-1 [12] sections 2.4.4.8 and 2.4.4.9) in the ES_info descriptor loop for the video program element; and
- the EIT-0 for that program, when EIT-0 is present in the Transport Stream.

7.9.3.11. Content advisory descriptor

For current programs, the content_advisory_descriptor(), as defined in ATSC A/65 [11] section 6.7.4, when present, shall be carried in the TS_program_map_section() (as defined in ISO/IEC 13818-1 [12] sections 2.4.4.8 and 2.4.4.9) in the descriptor loop immediately following the program_info_length field. When content advisories are present for a current program and EIT-0 is present in the Transport Stream, the content_advisory_descriptor() shall be present in EIT-0 for that program. Content advisories for future programs may be carried in the appropriate EIT, if EIT data is present in the Transport Stream. The only rating regions currently defined for cable use are Region One, the US plus possessions (value 0x01 for the rating_region field) and Region Two, Canada (value 0x02 for the rating_region field).

7.9.3.12. ATSC private information descriptor

The ATSC_private_information_descriptor() provides a method to carry and unambiguously label private information. More than one ATSC_private_information_descriptor() may appear within a single descriptor loop. Table 4 defines the bit-stream syntax of the ATSC_private_information_descriptor().

Table 4 - ATSC Private Information Descriptor

Syntax	Bits	Format
ATSC_private_information_descriptor() {		
descriptor_tag	8	0xAD
descriptor_length	8	uimsbf
format_identifier	32	uimsbf
for (i = 0; i < N; i++) {		
private_data_byte	8	bslbf
}		
}		

descriptor_tag – This 8-bit field is set to 0xAD.

descriptor_length – This 8-bit field specifies the number of bytes of the descriptor immediately following the descriptor_length field.

format_identifier – The format_identifier is a 32-bit field as defined in ISO/IEC 13818-1 [12], section 2.6.8 and 2.6.9 for the registration_descriptor(). Only format_identifier values registered and recognized by the SMPTE Registration Authority, LLC shall be used (see <http://www.smpte-ra.org/mpegreg.html>). Its use in this descriptor shall scope and identify only the private information contained within this descriptor.

private_data_byte – The syntax and semantics of this field is defined by the assignee of the format_identifier value.

7.9.3.13. Other A/65 descriptors

Inclusion in the Transport Stream of descriptors defined in ATSC A/65 [11] shall conform to the requirements specified in ATSC A/65 [11] for table sections carried on cable.

7.9.4. PID Assignments

PID assignments values are listed in the ATSC Code Point Registry [30].

PID values used to identify Transport Stream packets carrying TS_program_map_section() or program elements shall not be set less than 0x0030 or greater than 0x1FEF.

8. Signaling Of Video Description Audio Tracks

This Section provides additional details regarding the signaling of Video Description audio (also called Descriptive Video or visually impaired audio). Video Description audio is the insertion of audio narrated descriptions of a television programs key visual elements into natural pauses between the programs dialogue.

8.1. Signaling using the ISO 639 Language Descriptor

The ISO 639 Language Descriptor is used by deployed set top boxes to allow users to select the second AC-3 audio track. This is compatible with cable systems that support the delivery of only two audio tracks within a program, and with programs that carry only two audio tracks. The second audio track, when present, might actually be Spanish language audio, or it might be Video Description audio. The second audio track might be signaled using the language value of “spa” (Spanish) in the ISO 639 Language Descriptor, even if it is Video Description audio. It might also be signaled using the language code for Portuguese or Middle English.

ATSC A/53 Part 3 [9] has made optional the carriage in the PMT of the ISO 639 Language Descriptor. Many broadcasters nonetheless transmit the ISO 639 Language Descriptor to accommodate deployed set top boxes, in addition to transmitting the AC-3 Audio Descriptor. Many deployed set top boxes do not process the AC-3 Audio Descriptor. Note that signaling for audio codecs other than AC-3 prescribed in Sections 8.3, 8.4 and 8.5 below.

8.2. Signaling using the AC-3 Audio Descriptor

Per Section 7.9.3.1 above, audio language is required to be indicated using the language field of the AC-3 Audio Descriptor. The AC-3 Audio Descriptor also identifies the type of audio service in the bsmo field. Video Description audio is signaled as bsmo=2.

As noted in Section 8.1, language may also be indicated using the ISO 639 Language Descriptor in the PMT. In order to accomplish a transition from the method of signaling the Video Description audio track in use today (as Spanish in the ISO 639 Language Descriptor) to a more flexible method, the language in the AC-3 Audio Descriptor should correctly reflect the language of the Video Description audio track. It need not agree with the language in the ISO 639 Language Descriptor during the transition period. The more flexible method uses the only the language and bsmo value in the AC-3 Audio Descriptor.

As an example, consider a program that includes two AC-3 audio components, an English Complete Main audio track and an English Video Description audio track. In the AC-3 Audio Descriptor, they are signaled as (language = “eng”, bsmo = 0) for the Complete Main audio and (language = “eng”, bsmo = 2) for the Video Description audio. For use with deployed set top boxes, in the ISO 639 Language Descriptor they are signaled as (language = “eng”) for the Complete Main audio and (language = “spa”) for the Video Description audio. Thus, the language of the Video Description audio in the AC-3 Audio Descriptor does not agree with the language of the second audio track in the ISO 639 Language Descriptor. This accommodates set top boxes that do not process the AC-3 Audio Descriptor.

8.3. Signaling using the E-AC-3 Audio Descriptor

The Video Description audio track is signaled as audio_service_type=2 in the E-AC-3 Audio Descriptor.

8.4. Signaling using the DTS-HD Audio Descriptor

The Video Description audio track is signaled as service_type_flag='010' in bits b5 to b3 of component_type in Table 3 of the DTS-HD Audio Descriptor

8.5. Signaling using the AAC Descriptor

The Video Description audio track is signaled as AAC_service_type=2 in the AAC Descriptor

9. Extensions to the MPEG-2 Systems Specification

This Section covers extensions to the MPEG-2 Systems specification (ISO/IEC 13818-1 [12]).

9.1. Scrambling control

The scrambling control field within the TS packet header shall have the meaning shown in Table 5.

Table 5 - Transport Scrambling Control Field

transport_scrambling_control	Function
00	packet payload not scrambled
01	not scrambled, state may be used as a flag for private use defined by the service provider.
10	packet payload scrambled with “even” key
11	packet payload scrambled with “odd” key

Elementary Streams for which the transport_scrambling_control field does not exclusively have the value of ‘00’ for the duration of the program, shall carry a CA_descriptor in accordance with Section 2.6.16 of ISO/IEC 13818-1 [12].

9.2. Service Acquisition Considerations (Informative)

The ISO/IEC 13818-1 [12] (MPEG-2 Systems) and 13818-2 [13] (MPEG-2 Video) standards specify minimum rates for inclusion of PTS indicators in the bit stream (at least every 700 milliseconds). These standards also require inclusion of a video sequence_header just once per sequence, where a sequence could be several hours long. Service providers may (and often will) choose rates for delivery of data critical to fast acquisition of the service that exceed the minimum rates mandated by the MPEG-2 Systems [12] and Video [13] standards.

Care in creation of the multiplex can optimize service acquisition time within the same multiplex, acquisition time to a new multiplex, acquisition of scrambled services, changes between film and video modes (both directions) and change from video to still pictures mode. Service providers may choose to send PTS values more often, such as once per picture. They may repeat sequence_header information frequently, for example once every 0.5 seconds, and for scrambled services, repeat relevant ECMs at a similar rate. These provisions can result in improved acquisition performance at the expense incurring a small increase in bandwidth usage.

10. Features Of ISO/IEC 13818-1 Not Supported By This Standard

The transport definition is based on the MPEG-2 Systems standard, ISO/IEC 13818-1 [12]; however, it does not implement all parts of the standard. This Section describes those elements which are omitted from this Standard.

10.1. Program streams

This Standard does not include those portions of ISO/IEC 13818-1 [12] that pertain exclusively to Program Stream specifications.

11. Transport Encoder Output Bit Rates

Conceptually, the output from the transport subsystem is a continuous MPEG-2 Transport Stream as defined in this Standard at a constant rate of T_{64} Mbps when transmitted in an 64-QAM system and T_{256} when transmitted in a 256-QAM system where:

$$T_{64} = 26.97035 \text{ Mbps}$$

and

$$T_{256} = 38.81070 \text{ Mbps.}$$

The symbol rates in Msymbols per second for the transmission subsystem (see Table 3 of SCTE 07 [17]) are:

$$S_{64} = 5.056941 \text{ Msps}$$

and

$$S_{256} = 5.360537 \text{ Msps.}$$

T_{64} and S_{64} are locked to each other in frequency. Also T_{256} and S_{256} are locked to each other in frequency.