ATSC Digital Television Standard, Part 3 – Service Multiplex and Transport Subsystem Characteristics

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Advanced Television Systems Committee
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Revision History

Version	Date
A/53 Part 3:2007 Initial version of A/53 Part 3 approved. Previously Part 3 was Annex C of A/53.	3 January 2007
A/53 Part 3:2009 First revision of A/53 Part 3 approved.	7 August 2009
A/53 Part 3:2013 Second revision of A/53 Part 3 approved. Amendment No. 1 approved	7 August 2013 15 February 2023
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1. SCOPE

This part of the ATSC Digital Television Standard constitutes the normative specification for the transport subsystem of the Digital Television Standard. The syntax and semantics of this specification conform to ISO/IEC 13818-1 [3], with additional constraints and conditions specified in this standard. Within this context, other ATSC standards may further constrain and/or supplement the transport subsystem specification.

2. REFERENCES

All referenced documents are subject to revision. Users of this Standard are cautioned that newer editions might or might not be compatible.

2.1 Normative References

The following documents, in whole or in part, as referenced in this document, contain specific provisions that are to be followed strictly in order to implement a provision of this Standard.

[1] ATSC: "Digital Audio Compression (AC-3, E-AC-3) Standard," Doc. A/52:2012, Advanced Television Systems Committee, Washington, D.C., 17 December 2012.

[2] ANSI/SCTE 128 2010-a, "AVC Video Systems and Transport Constraints for Cable Television," Sections 6.3.2.3 and 6.4.3, Society of Cable Telecommunications Engineers.

[3] ISO: ISO/IEC IS 13818-1:2007 (E), "International Standard, Information technology – Generic coding of moving pictures and associated audio information: systems."

[4] ISO: ISO 639-2, "Code for the representation of Names of Languages - Part 2: Alpha-3 code," as maintained by the ISO 639/Joint Advisory Committee (ISO 639/JAC), http://www.loc.gov/standards/iso639-2/iso639jac.html; ISO 639-2 standard online: http://www.loc.gov/standards/iso639-2/langhome.html.

[5] ISO/IEC: ISO/IEC 8859-1:1998, "Information technology — 8-bit single-byte coded graphic character sets — Part 1: Latin alphabet No. 1."

[6] ATSC: "Video System Characteristics of AVC in the ATSC Digital Television System," Doc. A/72 Part 1:2015, Advanced Television Systems Committee, Washington, D.C., 19 May 2015.

[7] ITU-T Rec. H.264 | ISO/IEC 14496-10, (09/2014), "Information Technology – Coding of audio visual objects – Part 10: Advanced Video Coding."

[8] SCTE: "AVC Video Constraints for Cable Television, Part 1 – Coding," Doc. ANSI/SCTE 128-1 2020, Society of Cable Telecommunications Engineers, Exton, PA.

2.2 Informative References

The following documents contain information that may be helpful in applying this Standard.

[9] ATSC: "Digital Television Standard, Part 1 – Digital Television System," Doc. A/53 Part 1:2013, Advanced Television Systems Committee, Washington, D.C., 7 August 2013.

[10] ATSC: "ATSC Digital Television Standard, Part 2 – RF/Transmission System Characteristics," Doc. A/53 Part 2:2011, Advanced Television Systems Committee, Washington, D.C., 15 December 2011.

[11] ATSC: "ATSC Digital Television Standard, Part 4 – MPEG-2 Video System Characteristics," Doc. A/53 Part 4:2009, Advanced Television Systems Committee, Washington, D.C., 7 August 2009.

[12] ATSC: "ATSC Digital Television Standard, Part 5 – AC-3 Audio System Characteristics," Doc. A/53 Part 5:2010, Advanced Television Systems Committee, Washington, D.C., 6 July 2010.

[13] ATSC: "ATSC Digital Television Standard, Part 6 – E-AC-3 Audio System Characteristics," Doc. A/53 Part 6:2013, Advanced Television Systems Committee, Washington, D.C., 7 August 2013.

[14] ATSC: "Program and System Information Protocol for Terrestrial Broadcast and Cable," Doc. A/65:2013, Advanced Television Systems Committee, Washington, D.C., 7 August 2013.

[15] ATSC: "Parameterized Services Standard," Doc. A/71:2012, Advanced Television Systems Committee, Washington, D.C., 3 December 2012.

[16] ATSC: "Data Broadcast Standard, with Amendment 1 and Corrigendum 1 and 2," Doc. A/90, Advanced Television Systems Committee, Washington, D.C., 26 July 2000.

[17] ETSI: "Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems," ETSI EN 300 468, European Telecommunications Standards Institute, France.

3. DEFINITION OF TERMS

With respect to definition of terms, symbols, abbreviations, mathematical operators, and units, A/53 Part 1 [9] applies.

3.1 Compliance Notation

This section defines compliance terms for use by this document:

shall – This word indicates specific provisions that are to be followed strictly (no deviation is permitted).

shall not – This phrase indicates specific provisions that are absolutely prohibited.

should – This word indicates that a certain course of action is preferred but not necessarily required.

should not – This phrase means a certain possibility or course of action is undesirable but not prohibited.

3.2 Treatment of Syntactic Elements

This document contains symbolic references to syntactic elements used in the audio, video, and transport coding subsystems. These references are typographically distinguished by the use of a different font (e.g., restricted), may contain the underscore character (e.g., sequence_end_code) and may consist of character strings that are not English words (e.g., dynrng).

3.2.1 Reserved Elements

One or more reserved bits, symbols, fields, or ranges of values (elements) may be present in this document. These are primarily used to enable adding new values to a syntactical structure without altering the syntax or causing a backwards compatibility issue, but also are used for other reasons.

The ATSC default value for reserved bits is '1.' There is no default value for other reserved elements. Use of reserved elements except as defined in ATSC Standards or by an industry

standards setting body is not permitted. See individual element semantics for mandatory settings and any additional use constraints. As reserved elements may be changed in subsequent version(s) of the Standard, receiving devices are expected to disregard reserved elements independent of the defined value for that element.

3.3 Terms

The following terms are used within this document.

reserved – An element that is set aside for use by a future Standard.

Program – An MPEG-2 program that is constrained to be the collection of all elements that are referenced by a specific value of MPEG-2- defined program_number.

4. SYSTEM OVERVIEW

The transport format and protocol for the Digital Television Standard is based on the MPEG-2 Systems specification defined in ISO/IEC 13818-1 [3]. It is based on a fixed-length packet transport stream approach that has been defined and optimized for digital television delivery applications, including direct references and additional extensions, constraints and conditions.

As illustrated in Figure 4.1, the transport subsystem 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. It also is responsible for delivering packets intended for transmission using coding methods defined in A/53 Part 2 [10]. A receiver recovers 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 properly timing the packets to enable receiver synchronization.

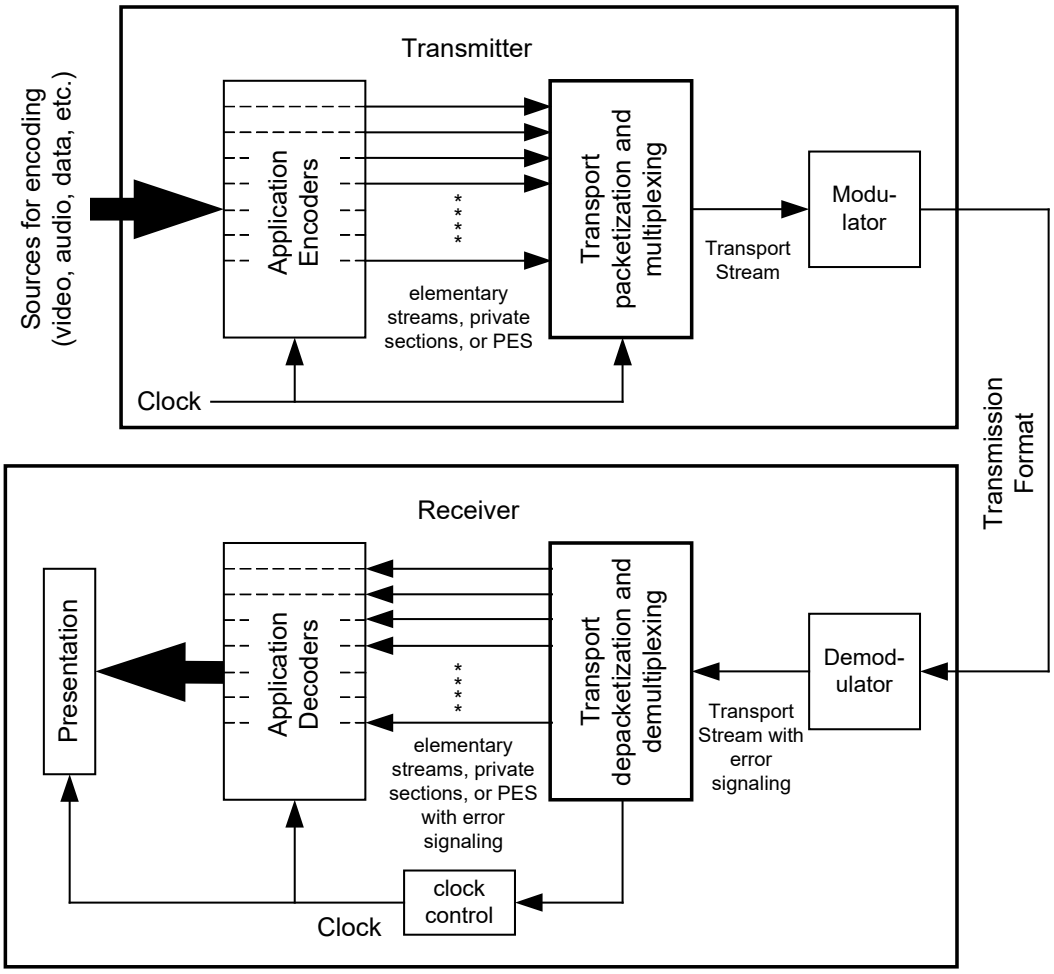

Figure 4.1 Sample organization of functionality in a transmitter-receiver pair for a single Program.

One approach to describing the system multiplexing approach is to consider it as 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 (ISO/IEC 13818-1 [3] Table 2-30) sources. In the second layer, one or more single Program transport streams are combined to form a service multiplex of Programs (also known as a multi-program transport stream in the MPEG-2 Systems standard, and a Digital Television Standard multiplexed bit stream in this ATSC standard). Program Specific Information (PSI), carried within Transport Stream packets, relates to the identification of Programs and the components of each Program.

5. SPECIFICATION

This section of the standard describes the coding constraints that apply to the use of the MPEG-2 Systems specification [3] in the digital television system.

5.1 MPEG-2 Systems Standard

The transport subsystem shall comply with the transport stream definition of the MPEG-2 Systems standard as specified in ISO/IEC 13818-1 [3] and shall be further constrained as specified herein.

ATSC has established a way to classify Programs (see Section 3.3) by type of service using a code sent in a field called service_type, whose syntax is defined in A/53 Part 1 [9]. The usage rules for each code value are defined by the standard establishing that usage.

Note that the MPEG-2 Transport Stream supports delivery of other transport protocols. This standard does not prohibit the Transport Stream from delivering such transport protocols.

5.1.1 Video T-STD

5.1.1.1 Video Streams of stream_type 0x02 (MPEG-2 Video)

For video streams of stream_type 0x02, the video shall conform to the T-STD as defined in Sections 2.4.2.2 and 2.4.2.3 of ISO/IEC 13818-1 [3] and shall follow the constraints for the level encoded in the video elementary stream. When there is a video stream of stream_type 0x02 in the TS, the T-STD buffer *Bn* defined in ISO/IEC 13818-1 [3], Section 2.4.2 shall apply for such a stream.

Any elementary stream containing Still Picture data shall include a video_stream_descriptor() in accordance with ISO/IEC 13818-1 [3] Section 2.6.2 and shall have the value of the field still_picture_flag set to '1' and the interval between I frames shall not be greater than 60 seconds.

5.1.1.2 Video Streams of stream_type 0x1B (AVC Video)

For video streams of stream_type 0x1B, the video shall conform to the T-STD for AVC as defined in Section 2.14.3.1 of ISO/IEC 13818-1 [3] and shall follow the constraints for the profile and level encoded in the video elementary stream in Appendix A of AVC [7].

5.1.2 Audio T-STD

The audio T-STD for AC-3 shall comply with Annex A, Section A4.4 of ATSC Standard A/52 [1]. The audio T-STD for E-AC-3 ("Enhanced AC-3") shall comply with Annex G, Section G3.6 of ATSC Standard A/52 [1].

5.1.3 Program Constraints

This section standardizes how to carry Programs in the ATSC system. Each Program contains certain elementary streams as specified for the service_type[1] associated with that Program. Programs may also contain private elementary streams.

5.1.3.1 Service Type 0x02 - ATSC Digital Television

This service type indicates video coded with the MPEG-2 or AVC video codec and audio coded with the AC-3 audio codec, with optional associated data.

This service type shall be identified by the value 0x02 in the field service_type in the Virtual Channel Table of A/65 [14]. Virtual channels (see A/65 [14]) associated with this service type carry television programming (audio, video and optional associated data) as constrained by ATSC Standards A/53 Part 4 [11] or A/72 Part 1 [6] for video, and A/53 Part 5 [12] for audio, and other ATSC standards for the optional data.

There shall be at most one video elementary stream associated with each service identified with service_type 0x02.

There shall be at least one audio elementary stream that is an AC-3 complete main audio service (CM)[2] associated with each service identified with service_type 0x02.

[1] This field is defined in A/53 Part 1 [6], Section 4.2.

[2] CM is defined in Section 6 of A/53 Part 5 [1].

5.1.3.2 Service Type 0x03 - ATSC Audio

This service type indicates audio coded with the AC-3 audio codec, with optional associated data. This service type shall be identified by the value 0x03 in the field service_type in the Virtual Channel Table of A/65 [14]. Virtual channels (see A/65 [14]) associated with this service carry audio programming (audio service and optional associated data) as constrained by ATSC Standard A/53 Part 5 [12] for audio and other ATSC standards for the optional data.

There shall be at least one audio elementary stream that is an AC-3 complete main audio service (CM) associated with each service identified with service_type 0x03.

5.1.3.3 Other service_type Values

Other values for the service type field may be present as defined in other ATSC standards. A/71 Parameterized Services Standard [15] establishes a general-purpose signaling mechanism using service_type 0x07.

5.2 Identification of MPEG-2 Private Ranges

ATSC defines code points in the MPEG-2 user private range and may define code points private to ATSC users within this range.

5.2.1 MPEG-2 Registration Descriptor

Under circumstances as defined below, this standard uses the MPEG-2 Registration Descriptor described in Sections 2.6.8 and 2.6.9 of ISO/IEC 13818-1 [3] to identify the contents of Programs and program elements to decoding equipment. No more than one MPEG-2 Registration Descriptor shall appear in any given descriptor loop.

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.

5.2.1.1 Program Identifier

Programs that conform to ATSC standards may be identified by use of an MPEG-2 Registration Descriptor (as defined in Sections 2.6.8 and 2.6.9 of ISO/IEC 13818-1 [3]). When present for this purpose, the MPEG-2 Registration Descriptor shall be placed in the descriptor loop that immediately follows the program_info_length field of the TS_program_map_section() describing this Program and the format_identifier field of this MPEG-2 Registration Descriptor shall have a value 0x4741 3934 (“GA94” in ASCII).

5.2.1.2 Audio Elementary Stream Identifier

The presence of audio elementary streams of stream_type 0x81 or 0x87 that conform to ATSC standards may be indicated by use of an MPEG-2 Registration Descriptor (as defined in Sections 2.6.8 and 2.6.9 of ISO/IEC 13818-1 [3]). When present for this purpose, the MPEG-2 Registration Descriptor instance as defined in A/52 Annex A [1] shall be placed in the descriptor loop that immediately follows the ES_info_length field in the TS_program_map_section() for each program element of stream_type 0x81 (AC-3 audio) or stream_type 0x87 (E-AC-3 audio).

5.2.1.3 Other Program Element Identifiers

Any program element carrying content not described by an approved ATSC standard shall be identified with an MPEG-2 Registration Descriptor (as defined in Sections 2.6.8 and 2.6.9 of ISO/IEC 13818-1 [3]). The format_identifier field of the MPEG-2 Registration Descriptor shall be

registered with the SMPTE Registration Authority, LLC[3]. The descriptor shall be placed in the descriptor loop that immediately follows the ES_info_length field in the TS_program_map_section() for each such non-standard program element.

5.3 Audio Constraints

Constraints for AC-3 audio streams are found in A/53 Part 5 [12]; constraints for E-AC-3 audio streams are found in A/53 Part 6 [13].

5.4 Constraints on PSI

All program elements in the Transport Stream shall be described in the PSI.

5.4.1 General Constraints

There are the following constraints on the PSI information in the Transport Stream:

- 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(). For terrestrial broadcast applications, these Transport Stream packets shall be further constrained to carry no other kind of PSI table.
- 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 are 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 specified in ISO/IEC 13818-1 [3] Section 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.
- When an elementary stream of stream_type 0x02 (MPEG-2 video) or stream_type 0x1B (AVC video) is present in the Transport Stream, the data_stream_alignment_descriptor() (described in Section 2.6.10 of ISO/IEC 13818-1 [3]) shall be included in the descriptor loop that immediately follows the ES_info_length field in the TS_program_map_section() describing that elementary stream. The descriptor_tag value is set to 0x06; the descriptor_length value shall be set to 0x01, and the alignment_type value shall be set to 0x02 (video access unit).
- Adaptation headers shall not occur in Transport Stream packets identified by a program_map_PID value for purposes other than for signaling with the discontinuity_indicator that the version_number (Section 2.4.4.9 of ISO/IEC 13818-1 [3]) may be discontinuous.

[3] The ISO/IEC-designated registration authority for the format_identifier is SMPTE Registration Authority, LLC. See (http://www.smpte-ra.org/).

- Adaptation headers shall not occur in Transport Stream 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 [3]) may be discontinuous.
- This standard does not define a Network Information Table (NIT) as specified in MPEG-2 Systems. The use of program_number 0x0000 should be avoided as MPEG-2 Systems reserves this value for the network_PID, which in turn is used to identify the TS packets of a NIT.

5.4.2 Constraints on Mixed AC-3 and E-AC-3 Audio Services

When a Program includes both AC-3 and E-AC-3 main audio services, the value of each mainid in the respective AC-3_audio_stream_descriptor() or E-AC-3_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 AC-3 main audio services shall be delivered in independent substream 0, which is specified in A/52 [1].

> 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 [1]. When an AC-3 CM stream has an associated service carried in an E-AC-3 stream, the associated service is required (by A/52 [1]) to be carried only in independent substream 0 of such E-AC-3 bitstream.

5.5 PES Constraints

Packetized Elementary Stream syntax and semantics shall be used to encapsulate the audio and video elementary stream information. The Packetized Elementary Stream syntax is used to convey the Presentation Time-Stamp (PTS) and Decoding Time-Stamp (DTS) information required for decoding audio and video information with synchronism. This section describes the coding constraints on this MPEG-2 Systems 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’.

5.5.1 MPEG-2 Video PES Constraints (for Streams of stream_type 0x02)

For video streams of stream_type 0x02, each PES packet shall begin with a video access unit, as defined in Section 2.1.1 of ISO/IEC 13818-1 [3], which shall be aligned with the PES packet header. The first byte of a PES packet payload shall be the first byte of a video access unit. Each

PES header shall contain a PTS. Additionally, it shall contain a DTS as appropriate. For terrestrial broadcast, the PES packet shall not contain more than one coded video frame, and shall be void of video picture data only when transmitted in conjunction with the discontinuity_indicator to signal that the continuity_counter may be discontinuous.

Within the PES packet header, the following restrictions apply:

- The PES_packet_length shall be coded as 0x0000
- data_alignment_indicator shall be coded as '1'

5.5.2 AC-3 (stream_type 0x81) and E-AC-3 (stream_type 0x87) Audio PES Constraints

The value of stream_id for both AC-3 and E-AC-3 streams shall be '1011 1101' (private_stream_1). Additional audio PES constraints for AC-3 and E-AC-3 are specified in ATSC Standard A/52 [1].

5.5.3 AVC Video PES Constraints (for Streams of stream_type 0x1B)

For video streams of stream_type 0x1B, the video shall conform to SCTE 128-1 Section 6.5 [8]

5.6 Services and Features

5.6.1 System Information and Program Guide

Transport Streams include system information and program guide data formatted according to the structure and syntax described in ATSC Standard A/65 "Program and System Information Protocol for Terrestrial Broadcast and Cable" [14]. All use of Transport Stream packets identified by PID value 0x1FFB shall be as defined by A/65 [14]. System information provides data necessary for navigation among digital service offerings. The program guide database allows a receiver to build an on-screen grid of program information for the various services that may be available.

5.6.1.1 System Information and Program Guide STD Model

The STD model for program guide and system information is specified in ATSC Standard A/65 [14].

5.6.2 Specification of ATSC Private Data

Within the ATSC set of standards, private data may be transported by various means:

1) **Data services** – Carriage of ATSC data services including system information shall be as documented in applicable ATSC standards. See for example the ATSC A/90 Data Broadcast Standard [16].
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 standards). Such privately-defined program elements are associated with an MPEG-2 Registration Descriptor (see Section 5.2.1.3).
3) **Adaptation fields** – Private data may be transmitted within the adaptation field of Transport Stream packets (Sections 2.4.3.4 and 2.4.3.5 of ISO/IEC 13818-1 [3]). Program elements that include private data in the adaptation fields of their Transport Stream packets shall be associated with an MPEG-2 Registration Descriptor (see Section 5.2.1.3). When private data is present in the adaptation field, the private data bytes shall use the tag, length, and data structures as defined in Section 6.4.3 of ANSI/SCTE 128 [2], and the descriptor loop that immediately follows ES_info_length in the TS_program_map_section() shall contain the SCTE_adaptation_field_data_descriptor() as defined in Section 6.3.2.3 of ANSI/SCTE 128 [2].

5.7 Assignment of Identifiers

In this section, those identifiers and codes that have fixed values are summarized. These include stream types and descriptor tags. Various identifiers are documented in the ATSC Code Points Registry for the convenience of the implementer.

5.7.1 AC-3 Audio Stream Type

The stream_type value for AC-3 audio program elements shall be as defined in A/52 [1] Annex A. This value is 0x81.

5.7.2 MPEG-2 Video Stream Type

The stream_type value for MPEG-2 video program elements shall be as defined in ISO/IEC 13818-1 [3]. This value is 0x02.

5.7.3 E-AC-3 Audio Stream Type

The stream_type value for the E-AC-3 audio program elements shall be as defined in A/52 [1] Annex G. This value is 0x87.

5.7.4 AVC Video Stream Type

The stream_type value for AVC video program elements shall be as defined in [6]. This value is 0x1B.

5.8 Descriptors

Unless explicitly stated to the contrary for a given descriptor, no more than one descriptor with a given value of descriptor_tag shall appear in any descriptor loop.

5.8.1 Audio Descriptors

The descriptors in this section are used with audio elementary stream components.

5.8.1.1 AC-3 Audio Descriptor

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

1) The 6-bit bit_rate_code field shall have a value in either the range ‘000000’ through ‘001111’ or ‘100000’ through ‘101111’; i.e., signaling a bit rate less than or equal to 448 kbps.
2) The num_channels field shall have a value in the range 1 to 13.
3) The langcod field is a reserved field. The langcod field shall have a value of 0xFF if present in the descriptor (this field is immediately after the first allowed termination point in the descriptor). Audio language is signaled in the language field (see 5).
4) The descriptor shall identify the type of the audio service in the bsmod field, which shall be the same as the bsmod field in the elementary stream associated with this descriptor.
5) The descriptor may optionally carry a 3-byte language code that is represented per ISO 639.2/B [4].

Audio language, when signaled, shall be indicated by including the ISO 639 Language bytes within the AC-3_audio_stream_descriptor(). Use of the ISO_639_language_descriptor() to indicate language is optional, but recommended to support legacy devices which may rely on it for language selection.

When multiple audio elementary streams of the same language and bsmod are present in the Program, there is an additional constraint on each AC-3_audio_stream_descriptor(): the language code(s) shall be included in the AC-3_audio_stream_descriptor().

The fields indicating language in the AC-3_audio_stream_descriptor() shall contain codes only for registered language values in the ISO 639.2 registry [4] and shall be the code marked "(B)" in that registry if two codes are present. Each character shall be coded into 8 bits according to ISO 8859-1 [5] (ISO Latin-1) and inserted in order into the 24-bit field.

> Note: Receiving devices are expected to use the bsmod (bit stream mode) field in the AC-3_audio_stream_descriptor() to determine the type of each AC-3 audio stream rather than the audio_type field in the ISO_639_language_descriptor().

5.8.1.2 ISO 639 Language Descriptor

While audio language for AC-3 audio, when indicated, is required in Section 5.8.1.1 above to be indicated by including the ISO 639 language bytes within the AC-3_audio_stream_descriptor(), use of the ISO 639 Language Descriptor, in addition, to indicate language is recommended to support legacy devices that rely upon the ISO 639 Language Descriptor for language selection.

The ISO 639 Language Descriptor is defined in ISO/IEC 13818-1 [3] Section 2.6.18 as ISO_639_language_descriptor(). When used, the ISO_639_language_descriptor() shall be included in the descriptor loop that immediately follows the ES_info_length field describing the AC-3 audio in the TS_program_map_section().

The fields indicating language in the ISO_639_language_descriptor() shall contain codes only for registered language values in the ISO 639.2 registry [4] and shall be the code marked "(B)" in that registry if two codes are present. Each character shall be coded into 8 bits according to ISO 8859-1 [5] (ISO Latin-1) and inserted into the 24-bit field in the order presented in ISO 639.2.

If the ISO_639_language_descriptor() is present for a given AC-3 audio elementary stream and, if the language code is present in the corresponding AC-3_audio_stream_descriptor(), the language code in the ISO_639_language_descriptor() shall be set to the language code value present in the AC-3_audio_stream_descriptor().

The audio_type field in any ISO_639_language_descriptor() used in this standard shall be set to 0x00 (meaning "undefined").

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.

5.8.1.3 E-AC-3 Audio Descriptor

When an elementary stream of stream_type 0x87 (E-AC-3 audio) is present in a Program, an E-AC-3 Audio Descriptor (E-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 and semantics of the E-AC-3 Audio Descriptor are defined in Annex G of ATSC Standard A/52 [1]. The value of this descriptor's descriptor_tag is 0xCC. The following constraints shall apply to the values in the E-AC-3 Audio Descriptor:

- The value of the audio_service_type field in the main body of the descriptor shall indicate the same audio service type as is identified in the bsmod field in independent substream 0 of the elementary stream corresponding to the descriptor.
- The value of the service type flags (bits 5 to 3 of the substream1, substream2, and substream3 fields) shall indicate the same audio service type as is identified in the bsmod field in

independent substream 1, independent substream 2 and independent substream 3, respectively, of the elementary stream corresponding to the descriptor.

- When multiple associated audio service substreams (see A/52 [1]) are present in an elementary stream, and convey the same type of audio service (as indicated by the value of the service type flags), the language of each such substream shall be identified in the descriptor.
- When multiple associated audio service substreams (see A/52 [1]) are present in an elementary stream, convey the same type of audio service (as indicated by the value of the service type flags), and have the same language code, the substream_priority field associated with exactly one such substream shall be set to '1', thereby designating that substream as "primary."

The descriptor is able to carry a 3-byte language code for the main audio service, and individual language codes for up to three associated audio services carried in the same bit stream as the main audio service.

5.8.1.4 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 consisting of audio delivered via elementary streams of stream_type 0x81 or 0x87, and with each carrying the same type of audio service (as indicated by bsmod for the AC-3 streams or audio_service_type for the E-AC-3 streams), then the 3-byte language code for each audio service shall be included in the corresponding audio descriptor.

At most one elementary stream of stream_type 0x81 or 0x87 in a given Program shall be labeled "Primary" in the relevant audio descriptor.

5.8.2 ATSC Private Information Descriptor

The ATSC_private_information_descriptor() provides a method to carry and unambiguously label private information. The ATSC Private Information Descriptor shall be the method to carry descriptor-based information associated with a private entity. More than one ATSC_private_information_descriptor() may appear within a single descriptor loop. Table 6.1 defines the bit-stream syntax of the ATSC_private_information_descriptor().

Table 6.1 ATSC Private Information Descriptor

Syntax	No. of 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 that immediately follows the descriptor_length field.

format_identifier – The format_identifier is a 32-bit field as defined in ISO/IEC 13818-1 [3], Section 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/)[4]. 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.

5.9 PID Value Assignments

In order to avoid collisions with fixed PID values and ranges already established in this and other international standards, transport_packet() PID field values are restricted as follows:

- TS packets identified with PID values in the range 0x1FF0 – 0x1FFE shall only be used to transport data compliant with ATSC-recognized standards specifying fixed-value PID assignments in that range. (Informative note: One such use is A/65, which requires the use of 0x1FFB to identify packets containing certain tables defined in that standard.)
- In order to avoid collisions with fixed PID values and ranges already established in this and other international standards, PID values used to identify Transport Stream packets carrying TS_program_map_section() or program elements shall not be set below 0x0030. (Informative note: One such use is in ETSI 300 468 [17], which requires the use of 0x0011 to identify packets containing certain tables defined in that standard.)

6. FEATURES OF 13818-1 NOT SUPPORTED BY THIS STANDARD

The transport definition is based on the MPEG-2 Systems standard, ISO/IEC 13818-1 [3] however, it does not implement all parts of the standard. This section describes those elements that are omitted from or constrained by this standard.

6.1 Program Streams

This part of the ATSC Digital Television Standard does not include those portions of ISO/IEC 13818-1 [3] and Annex A of ATSC Standard A/52 [1] that pertain exclusively to Program Stream specifications.

6.2 Still Pictures

A/53 Part 3 does not include those portions of ISO/IEC 13818-1 Transport Stream specification that pertain to the Still Picture model.

7. TRANSPORT SUBSYSTEM INTERFACES AND BIT RATES

7.1 Transport Subsystem Input Characteristics

The MPEG-2 Systems standard defines system coding at two hierarchical layers: The Packetized Elementary Stream (PES) and the systems stream, either in Transport Stream or Program Stream format (the ATSC only uses the Transport Stream format). Under this standard and by common industry usage, private_section encapsulated data is a parallel layer to PES. Physical implementations may include the PES packetizer within a video, audio, or other data encoder; and a private_section encapsulator within a data encoder; and not as part of the transport subsystem. Therefore, the inputs to the transport subsystem may be elementary streams, PES packets, or private_section encapsulated data.

[4] SMPTE Registration Authority, LLC, 3 Barker Ave., 5th Floor, White Plains, NY 10601 USA.

7.2 Transport Subsystem Output Characteristics

Conceptually, the output from the transport subsystem is a continuous MPEG-2 Transport Stream as defined in this document at a constant rate of T_r Mbps when transmitted in an 8 VSB system and $2T_r$ when transmitted in a 16 VSB system where

$$T_r = 2 \times \left(\frac{188}{208}\right)\left(\frac{312}{313}\right)\left(\frac{684}{286}\right) \times 4.5 = 19.39... \text{ Mbps}$$

The symbol rate S_r in Msymbols per second for the transmission subsystem (see Section 5 of ATSC A/53 Part 2 [10]) is

$$S_r = \left(\frac{684}{286}\right) \times 4.5 = 10.76... \text{Msymbols per second}$$

T_r and S_r shall be locked to each other in frequency.

> Note: The signals in the source coding subsystems (see A/53 Parts 4, 5, and 6) and the signals in the transport/transmission subsystems (A/53 Parts 2 and 3) are not required to be frequency-locked to each other, and in many implementations will operate asynchronously. In such systems, the frequency drift can necessitate the occasional insertion or deletion of a null packet so that the transport subsystem accommodates the frequency disparity and thereby meets the requirement to remain locked with respect to the transmission subsystem symbol rate.

All Transport Streams conforming to this standard shall conform to the ISO/IEC 13818-1 [3] T-STD (Transport System Target Decoder) model.

8. DESCRIPTOR AND TABLEPROCESSING CONSIDERATIONS FOR RECEIVERS

8.1 Descriptor Processing Considerations

MPEG-2 Systems defines syntax for descriptors, consisting of type (descriptor_tag), length (descriptor_length) and data. ATSC uses the descriptor structure in this and other ATSC standards.

Descriptors are placed in loops, each of which can contain zero or more descriptors. These "descriptor loops" indicate that zero, one or more descriptors are carried in that position in the data structure. In some descriptor loops, certain descriptors are required and others are optional. ATSC standards specify descriptors which are required to be, or optionally can be, carried in a particular descriptor loop.

8.1.1 Processing Descriptor Loops

Descriptor loops are collections of descriptors, and each descriptor must be at least partially processed (descriptor_tag and descriptor_length) in order to process the descriptor loop correctly. Receivers are expected to parse the descriptor_tag and descriptor_length, and subsequently either process the content of the descriptor or discard the number of bytes indicated in descriptor_length and proceed with the next entry in the descriptor loop (if any).

The collection of descriptors carried in a descriptor loop is an unordered set. *No information is provided* by the fact that a particular descriptor is before or after another within a descriptor loop.

8.1.2 Treatment of Descriptor Length

The length of each descriptor in a descriptor loop is *exclusively* described by the descriptor_length field. There are certain descriptors (e.g., the AC-3_audio_stream_descriptor()) that have varying lengths. There is at least one descriptor with descriptor_length of zero. Receivers are expected to be able to process and use recognized descriptors with:

- zero length;
- varying length;
- non-zero, but unexpected length, where length is larger than expected. (Note: many descriptors are extensible, in future updates of the standard, by the addition of bytes at the end).

Since a given descriptor_tag value is defined in any given descriptor loop to have only one meaning, the tag value and its context are used together to recognize and thereby determine how to parse the descriptor.

Receivers are expected to discard descriptors:

- with an un-supported or unrecognized tag value;
- with one or more invalid field values;
- determined to be inconsistent with defined/allowed syntax;

Receivers are expected, when skipping or discarding descriptors, to use the descriptor_length value.

8.1.3 Treatment of Unrecognized Descriptor Types

Descriptors have a common header (descriptor_type and descriptor_length) which devices use to identify descriptors and process them (if they are a known type). New descriptor types are added as standards evolve. Therefore, receivers can expect to encounter unknown descriptor types. Emission, processing and reception devices are expected to ignore descriptors that they do not process.

8.1.4 Treatment of Recognized Descriptor Types Appearing in Unexpected Contexts

Some descriptors are defined only within a limited scope (for example, defined for use only within one type of table). If a descriptor bearing that same value of descriptor_tag is found in a different table (out of its defined context), and the receiver does not recognize this type of descriptor in the context of the table being parsed, the receiver is expected to ignore it.

8.1.5 Multiple Instances of One Type of Descriptor in the Same Loop

Section 5.8 establishes that in the ATSC transport, unless explicitly stated to the contrary for a given descriptor, no more than one descriptor with a given value of descriptor_tag is allowed to appear in any descriptor loop.

In some cases it is useful and explicitly permitted for there to be more than one instance of a descriptor with a given descriptor_tag value (e.g. ATSC_private_information_descriptor()). Receivers are expected to process these instances individually.

8.2 Table Processing Considerations

MPEG-2 Systems [3] defines syntax for tables, which consist of a type (table_id), a number of fields in a standard table header including the length of each section of the table (section_length), followed a number of fields carrying data. ATSC builds on the MPEG-2 Systems-defined table structure in this and other ATSC standards. Certain tables are required to be present in every ATSC-compliant

Transport Stream. For example, every TS must include a Program Association Table (PAT) and one or more Program Map Table sections (PMTs).

8.2.1 Unrecognized Table Types

Certain ranges of table_id are reserved for use either when revising the standard, or when another standard is issued. Table parser algorithms are expected to gracefully disregard tables with unrecognized values of table_id.

8.2.2 Table Structure Versioning

Note that some ATSC tables adopt an extension to the MPEG-2 long-form table section syntax in order to manage protocol versioning, i.e. changes to the table syntax and semantics. Table parser algorithms are expected to process the protocol versioning field and discard any instance of a table corresponding to an unrecognized value.

8.2.3 Table Extensibility

Many tables are extensible by addition of new fields at the end, or by other means. Extensibility of tables is covered by the standard defining the table. Table parser algorithms should carefully accommodate the specifications in the defining standard with regard to extensibility. Table parser algorithms are expected to ignore unrecognized extensions.

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