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AVC Video Constraints for Cable Television
Part 2- Transport

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Editorial Note: Table numbers in this Part of SCTE 128 are not consecutive and retain the table numbers that appeared before SCTE 128 was split into two Parts.

1. Introduction

1.1. Executive Summary

This document assists in transport of an AVC coded video elementary stream constrained per SCTE 128 Part 1 and is intended for broadcast purposes. There are other applications: time-shifting (e.g., PVR/DVR service), Video-on-Demand service, unicast, multicast, splicing (e.g., Ad-insertion) that could employ the specifications in this document. However, constraints specific to those applications are outside of the scope of this document.

1.2. Scope

This document defines the transport constraints on ITU-T Rec. H.264 | ISO/IEC 14496-10 [5] video compression (hereafter called "AVC") for Cable Television. In particular, this document describes the transmission of AVC coded video elementary streams constrained per SCTE 128 Part 1 in an MPEG-2 service multiplex (single or multi-program Transport Stream).

Note: The carriage of MPEG-2 video in the MPEG-2 service multiplex is described in SCTE 54 [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] ANSI/SCTE 54 2015, Digital Video Service Multiplex and Transport System Standard for Cable Television.

[2] SCTE 128 Part 1 2018, AVC Video Systems Constraints for Cable Television

2.2. Standards from Other Organizations

[3] ATSC A/65:2013 Program and System Information Protocol for Terrestrial Broadcast and Cable; Section 6.9.2.

[4] ISO/IEC 13818-1, (2018), “Information Technology – Generic coding of moving pictures and associated audio – Part 1: Systems.”

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

[6] ETSI TS 101 154 V2.4.1 Digital Video Broadcasting (DVB): Specification for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream, 2014.

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

[7] ANSI/SCTE 43 2015 Digital Video Systems Characteristics Standard for Cable Television.

[8] ANSI/SCTE 21 2017 Standard for Carriage of NTSC VBI Data in Cable Digital Transport Streams.

[9] ANSI/SCTE 07 2013 Digital Transmission Standard for Cable Television.

[10] ANSI/SCTE 172 2017 Constraints on AVC Video Coding for Digital Program Insertion.

3.2. Standards from Other Organizations

[11] SMPTE ST 170, Television – Composite Analog Video Signal – NTSC for Studio Applications.

[12] SMPTE ST 274 Standard for television, 1920 x 1080 Scanning and Interface.

[13] SMPTE ST 296, Standard for television, 1280 x 720 Scanning, Analog and Digital Representation, and Analog Interface.

[14] ITU-R BT.601-6 Encoding parameters of digital television for studios.

[15] ITU-R BT.709-6, Basic Parameter Values for the HDTV Standard for the Studio and for International Programme Exchange.

[16] ITU-T J.83, Digital Video Transmission Standard for Cable Television.

[17] CTA-CEB16: Active Format Description (AFD) & Bar Data Recommended Practice.

[18] SMPTE ST 125, Standard for television, Component Video Signal 4:2:2, Bit Parallel Digital Interface.

[19] SMPTE ST 293, Standard for television, 720x483 Active Line at 59.95 Hz Progressive Scan Production, Digital Representation.

[20] SMPTE ST 267, Standard for television, Bit Parallel Digital Interface- Component Video Signal 4:2:2 16x9 Aspect Ratio.

[21] ATSC A/53, Part 3, “Service Multiplex and Transport Subsystem Characteristics”

[22] CTA-861-G “A DTV Profile for Uncompressed High Speed Digital Interfaces”

[23] ISO/IEC 13818-2 (2013), Information Technology – Generic coding of moving pictures and associated audio - Part 2: Video

3.3. Published Materials

- No informative references are applicable.

4. Compliance Notation

shall	This word or the adjective "***required***" means that the item is an absolute requirement of this document.
shall not	This phrase means that the item is an absolute prohibition of this document.
forbidden	This word means the value specified shall never be used.
should	This word or the adjective "*recommended*" 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.
should not	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
may	This word or the adjective "*optional*" means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.
deprecated	Use is permissible for legacy purposes only. Deprecated features may be removed from future versions of this document. Implementations should avoid use of deprecated features.

5. Abbreviations and Definitions

5.1. Abbreviations

ATSC	Advanced Television Systems Committee
AU	access unit
DPI	digital program insertion
DTS	decoding time stamp
DTV	digital television
DVB	digital video broadcasting
DVS	Digital Video Subcommittee
ESPI	elementary_stream_priority_indicator
HDTV	high definition television
IDR	instantaneous decoding refresh
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
MPEG	moving picture experts group
NAL	network abstraction layer
nPVR	network based personal video recorder
PPS	picture parameter set
PTS	presentation time stamp
PVR	personal video recorder
QAM	quadrature amplitude modulation
RAI	random_access_indicator
SDTV	standard definition television
SEI	supplemental enhancement information
SPS	sequence parameter set

SRAP	SCTE random access point
T-STD	transport stream system target decoder
TS	transport stream
VUI	video usability information

5.2. Definitions

AVC ITU-T Rec. H. 264 | ISO/IEC 14496-10 Advanced Video Coding standard

AVC Receiver The term "AVC Receiver" in this standard means a receiver having at least the attributes listed below:

1. Able to parse and decode the normative elements from AVC [5] that are specified with constraints in this standard;
2. Not adversely affected by the presence or absence of optional and informative elements from AVC [5];
3. Not adversely affected by the presence or absence of optional and informative elements in this standard;
4. Able to parse and process all elements from AVC [5] Annex D (SEI messages) and Annex E (VUI syntax elements) that are specified as normative in this standard and conveyed in-band; Note: These are optional elements in the AVC specification;
5. Able to parse and decode all the normative elements from ISO/IEC 13818-1 [4] that are normatively included and/or constrained by this standard;
6. Not adversely affected by the presence or absence of optional elements from ISO/IEC 13818-1 [4] (such as data in adaptation fields) that are specified with constraints in this standard;
7. Supports the processing of end_of_stream_rbsp() syntax element required by applications where another bitstream follows the end_of_stream NAL unit. The bitstream that follows will start with an IDR picture and may be accompanied by a time base discontinuity.
8. Supports the processing of elementary streams in Low Delay Mode and Still Pictures.

Note: The additional information from items 6 and 7 is optionally provided for the benefit of AVC receivers that include support for applications such as PVR, DPI and VOD.

Program An ISO-IEC 13818-1 MPEG-2 Program

SGOP A SCTE Group Of Pictures (SGOP) is the group of pictures spanning two consecutive SRAPs including the prior SRAP AU but not including the subsequent SRAP AU.

SRAP Picture An I- or IDR-picture that is part of an SRAP Access Unit.

Numerical formats are defined in the following table:

Table 1 - Numerical Format Definitions

Example Values	Description
12345	Example of a decimal value format
0x2A	Example of a hexadecimal value format
'10010100'	Example of a string of binary digits

6. MPEG-2 Multiplex And Transport Constraints For AVC

This section and its subsections describe MPEG-2 System details pertaining to AVC that extends the specifications of SCTE 54 [1].

6.1. Services and Features

This section describes additional services and features details pertaining to AVC.

Note: As described in SCTE 54 [1] and other SCTE standards, the MPEG-2 Transport provides services and features enabled by information carried at the MPEG-2 Transport multiplex level and not at the video elementary stream component level. Some of these services are System Information and Program Guide, Emergency Alerts, and Specification of Private Data Services.

Note: The bitrate value for the AVC Bitstream is application dependent and limited by the contiguous bandwidth of the transmission channel. In the application of AVC transmission over a 64-QAM channel, bitrate value in combination with other bitstreams in the MPEG-2 Transport multiplex, conforms to a channel bitrate of less than or equal to 27.0 Mbps; in transmissions over 256-QAM channels to less than or equal to 38.8 Mbps.

6.2. MPEG-2 Systems Standard

6.2.1. Video T-STD

Video T-STD for AVC shall be based on Section 2.14.3.1 of ISO/IEC 13818-1 [4] and shall follow the constraints for the profile and level encoded in the video elementary stream in Appendix A of AVC [5].

6.3. Assignment of identifiers

This section describes additional identifiers relevant to AVC video elementary stream components.

6.3.1. AVC Stream Type Codes

The AVC stream type value is 0x1B.

6.3.2. Descriptors

6.3.2.1. Video descriptor

AVC video is signaled by the AVC_video_descriptor() when required by ISO/IEC 13818-1[4] or as otherwise appropriate. This descriptor, when carried, shall be placed in the descriptor loop for the video program element of the PMT with a descriptor tag value of 0x28.

Certain services may include video elementary streams that contain one or more AVC still pictures that conform to the still picture model of ISO/IEC 13818-1 [4]. Any elementary stream containing still pictures shall include a AVC_video_descriptor() with AVC_still_present_flag set to "1" in accordance with section 2.6.64 of 13818-1[4]. Constraints for transmitting AVC still pictures are defined in section 9.0 of this document.

6.3.2.2. Caption service descriptor

When caption services are delivered within the AVC video elementary stream (as specified in Section 8.0 of SCTE 128 Part 1), the caption_service_descriptor(), as defined in Sec. 6.9.2 of ATSC A/65 [3], shall be present as described in SCTE 54 [1] section 5.8.3.6.

6.3.2.3. SCTE Adaptation field data descriptor

When private data bytes of the adaptation field of the TS packets are in use, with tag, length, and data structures as defined in Section 6.4.3, the SCTE_adaptation_field_data_descriptor shall be placed in the descriptor loop for the video program element of the PMT. In the absence of such adaptation field private data, the descriptor shall not be included in the corresponding ES_info_loop of the PMT. The presence of the SCTE_adaptation_field_descriptor() shall mean that private_data_byte(s) carried in adaptation field data in this stream are in tag-length-data format, where the tag values are as defined in SCTE standards. The absence of this descriptor does not preclude private data in the adaptation header that could conform to MPEG or other standards. The SCTE adaptation field data descriptor shall be formatted per Table 2.

Table 2 - SCTE adaptation field data descriptor

Syntax	Number of bits	Identifier
SCTE_adaptation_field_data_descriptor(){		
descriptor_tag	8	uimsbf
descriptor_length	8	uimsbf
}		

Where:

descriptor_tag: This value shall be set to 0x97

descriptor_length: This value is 0x00

Note: This descriptor varies from the signaling mechanism used by DVB [6] to indicate the presence of AU_Information. The descriptor establishes announcement for general and consistent syntax and semantics for the private data of the TS packet's adaptation field.

6.4. AVC Program Constraints

MPEG-2 Programs shall be constrained to carry at most one AVC video elementary stream component with a stream_type value of 0x1B.

6.4.1. SCTE Random Access Point (SRAP) Access Unit Composition

An SCTE random access point (SRAP) access unit, or SRAP, demarcates a location within an AVC Bitstream where an AVC Receiver is able to begin decoding video. The spacing of successive random access points is an important contributor to channel change time, but is not the only factor contributing to

channel change time. Other factors that contribute to channel change time include physical device tuning constraints, RF tuning, or conditional access operations.

An SRAP access unit is an AVC access unit shown pictorially in Figure 1. An SRAP access unit shall include exactly one sequence parameter set (SPS) (that is active) with VUI and the Picture Parameter Set (PPS) that is required for decoding the associated picture. The SPS shall precede any SEI NAL units that may be present in an SRAP access unit.

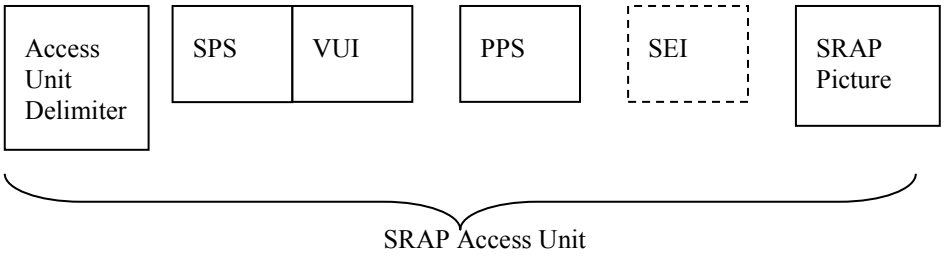

Figure 1 - NAL Unit Order for a Typical SRAP Access Unit

The picture encoded within the SRAP access unit, the SRAP Picture, shall be either an I- or IDR-picture. In broadcast applications, this picture is typically a reference picture.

6.4.2. SRAP Transport Constraints

An SRAP shall meet the following transport constraints.

6.4.2.1. TS Packet Header and Adaptation Field Constraints

A TS packet containing the PES packet header of an SRAP shall have an adaptation field. The payload_unit_start_indicator bit shall be set to '1' in the TS packet header and the adaptation_field_control bits shall be set to '11'(as per ISO/IEC 13818-1 [4]). In addition, the random_access_indicator bit in the Adaptation field of the TS packet that contains the PES packet header of the SRAP shall be set to '1' and follow the constraints as specified in ISO/IEC 13818-1 [4] in Subclause 2.4.3.5.

Per ISO/IEC 13818-1 [4], the elementary_stream_priority_indicator bit shall be set to '1' in the adaptation field of a TS packet containing the first slice start code of the SRAP Picture (which is an I or IDR picture with slice_type = 2 or slice_type = 7).

Both the random_access_indicator and elementary_stream_priority_indicator bits shall be set to '1' in the adaptation field of a TS packet containing the PES packet header of an SRAP if this TS packet also contains the first slice start code of the SRAP Picture. Otherwise, a TS packet with the elementary_stream_priority_indicator bit set to '1' shall immediately follow the TS packet with the random_access_indicator bit set to '1'.

Note 1: Setting of both a random_access_indicator and elementary_stream_priority_indicator bits for the access unit signifies an SRAP access unit.

Note 2: Multiple PPSs may be present in an SRAP access unit. The number of PPSs that may be present in an SRAP access unit is constrained by TS packet restrictions above (requiring both RAI and ESPI bits

set in either the same TS packet or of successive TS packets). According to AVC [4], this requires all the bytes between the access unit delimiter NAL Unit and the start of the first slice of the SRAP Picture to be part of the payload of either the same TS packet or two successive TS packets.

6.4.2.2. SRAP Picture Decoding Time Stamp and SRAP Picture Presentation Time Stamp Constraints

The AVC Bitstream shall contain necessary elements such that all pictures with PTS greater than or equal to DTSSRAP + 0.5 seconds (where DTSSRAP represents the decoding time stamp of an SRAP Picture) are fully reconstructable and displayable when decoding starts at the SRAP picture.

Note 1: This implies that any picture that has a PTS >= [DTSSRAP + 0.5 seconds] cannot be predicted directly or indirectly from reference pictures that were transmitted prior to the SRAP (i.e., with a lower value of DTS than DTSSRAP). This also implies that any picture that was transmitted prior to the SRAP as well as any partially reconstructed pictures in the time interval [DTSSRAP, DTSSRAP + 0.5 seconds], cannot have a PTS that is greater than or equal to [DTSSRAP + 0.5 seconds].

The time difference between the receipt of an SRAP (actual value of PCR if present in the transport packet or computed value of PCR for the transport packet containing SRAP) and the DTS/PTS of its SRAP Picture is another key component in determining channel change time. The time difference between the receipt of an SRAP and the DTS of its SRAP Picture is also known as the initial video buffering delay of the AVC Bitstream in the CPB. Like in MPEG-2 video, the maximum possible initial video buffering delay is determined by the size of the CPB divided by the AVC Bitstream's actual bitrate. The initial video buffering delay shall be limited to 3 seconds or less. For applications requiring fast channel change or small initial delay after random access, the initial video buffering delay should be limited to one second or less.

Note 2: The maximum delay of data through the T-STD is 10 seconds for AVC while it was 1 second for MPEG-2 video, and the ratio of CPB buffer size to maximum bitrate is also higher for AVC. In order to improve the channel change time or reduce the initial delay after random access for AVC, transmission systems should use a reasonable data delay without compromising the coding efficiency.

For broadcast applications where fast channel change is important, the PTSSRAP (where PTSSRAP represents the presentation time stamp of an SRAP Picture) should be less than or equal to DTSSRAP +0.5 seconds. This constraint bounds the time between decoding and presentation of an SRAP picture

6.4.2.3. Constraints on Decoding Time Stamps

For applications where fast channel change or random access is important, the maximum time interval between the decoding time stamp of successive SRAP Pictures shall be less than or equal to 1 second for integer frame rates, with appropriate adjustment (less than two pictures) for (1) non-integer frame rates and (2) small variabilities associated with scene change detection during encoding.

Note: The frequency at which SRAP access units are inserted into an AVC Bitstream is one of the key components in determining the channel change time and may simplify splicing and trick mode operations. If the interval between the Decoding Time Stamps of two successive SRAP Pictures is too small, such as 0.2 seconds, compression efficiency might be lowered significantly. On the other hand, if the interval between the Decoding Time Stamps of two successive SRAP Pictures is too large (such as 5 seconds), the time to effect a channel change or the initial delay after random access may be longer.

6.4.3. Adaptation Field Private Data

ISO/IEC 13818-1 [4] requires that the presence of an adaptation field be indicated by means of the adaptation_field_control, i.e. a 2-bit field in the header of the TS packet. The presence of private data bytes is signaled by means of the transport_private_data_flag coded at the beginning of the adaptation field.

When an adaptation field contains private data, the private_data_byte field shall contain the construct tag, length, data per Table 3.

Table 3 - private_data_byte

Syntax	No. of Bits	Format
private_data_byte {		
for i=0 to n {		
tag	8	bslbf
length	8	bslbf
If (tag==0xDF)		
format identifier	32	bslbf
data()	var	
}		
}		

tag: tag shall take a value from Table 4: Tag Values

Table 4 - Tag Values

Tag Values	Description
0x00	Forbidden
0x01	Used by DVB
0x02	AU_Information (deprecated; see Section 6.4.3.1
0x03	PVR assist information (see Section 6.4.3.1)
0x04-0xDE	Reserved for future standardized use. See ATSC Code Points Registry in addition to this standard.
0xDF	Registered Private Data
0xE0-0xFE	User Private (unmanaged, therefore collisions between different users or applications may occur, except perhaps in totally closed systems)
0xFF	Reserved for future extensions

Note: The syntax and semantics for the tag value associated with AU_Information (tag value 0x02) and PVR assist information (tag value 0x03) can be found in Appendix A. This standard places no constraint on the definition of new tag values that conform to the structure defined herein. The syntax and semantics for other tag values, when defined, may be found in other SCTE or other standards.

Tag value 0xDF is registered private data, managed by the format_identifier field.

length: this field is the number of bytes following this length field

format_identifier: this field shall be as defined by ISO/IEC 13818-1, Section 2.6.9, Section 2.10, and Annex O. Only registered values are permitted.

data: one or more bytes corresponding to the tag value

Even though multiple collections of tag, length, data may be contained in consecutive TS packets, each collection of tag, length, data shall be contained within one TS packet only

The total number of private data bytes is specified by means of the transport_private_data_length, an 8-bit field that is directly followed by the private data bytes. The private data bytes may be composed of one or more data fields. This syntax does not allow gaps between two data fields.

6.4.3.1. Optional Transport Adaptation Layer Information

Tag value 0x02 or 0x03 may be used to support applications where additional information is placed in the adaptation field of TS packets as described in Appendix A. PVR applications should use tag value 0x03. Use of tag value 0x02 is deprecated. Tag values 0x02 and 0x03 shall not both be carried in the same program. This information is optional; however when it is present, it shall follow the constraints specified in Appendix A.

6.5. PES constraints

Each PES packet shall contain only one AVC access unit start, as defined in Sections 2.1.3 and 2.14.1 of 13818-1[4]. The AVC access unit start shall occur in the same TS packet as the PES packet header, unless to do so would require bit stuffing. In this case the AVC access unit start shall occur in the next TS packet of the bitstream with the same PID. Each PES packet header shall contain a PTS and DTS if DTS differs from the PTS. PES packetization shall comply to ISO/IEC 13818-1 even under system time base or continuity counter discontinuities signaled by setting discontinuity_indicator to '1' in the adaptation header.

Note: Per 13818-1, the payload_unit_start_indicator bit is set to '1' in the TS packet header of a TS packet containing a PES packet header. The payload of this TS packet will commence with the first byte of the PES packet.

7. AVC Video Constraints

7.1. Possible video inputs

This topic is specified in SCTE 128 Part 1.

7.2. Source coding specification

This topic is specified in SCTE 128 Part 1.

7.2.1. Constraints with respect to AVC

This topic is specified in SCTE 128 Part 1.

7.2.1.1. Sequence Parameter Set (SPS) constraints

This topic is specified in SCTE 128 Part 1.

7.2.1.2. Video Usability Information (VUI) Constraints

This topic is specified in SCTE 128 Part 1.

7.2.1.3. Picture Parameter Constraints and Level Limits

This topic is specified in SCTE 128 Part 1.

7.2.1.4. Supplemental Enhancement Information (SEI) Constraints

This topic is specified in SCTE 128 Part 1.

7.2.1.5. Compression format constraints

This topic is specified in SCTE 128 Part 1.

7.2.1.6. Low Delay Mode

This topic is specified in SCTE 128 Part 1.

7.2.1.7. Program Splicing Constraint

This topic is specified in SCTE 128 Part 1.

8. Carriage Of Captioning, AFD, And Bar Data

This topic is specified in SCTE 128 Part 1.

8.1. Encoding and transport of caption, active format description (AFD) and bar data

This topic is specified in SCTE 128 Part 1.

8.1.1. Caption, AFD and Bar Data Syntax

This topic is specified in SCTE 128 Part1

8.1.2. Caption, AFD and Bar Data Semantics

This topic is specified in SCTE 128 Part .

8.2. ATSC1_data() Syntax

This topic is specified in SCTE 128 Part 1.

8.2.1. ATSC1_data() Semantics

This topic is specified in SCTE 128 Part 1.

8.2.2. Encoding and Transport of Caption Data

This topic is specified in SCTE 128 Part 1.

8.2.3. Encoding and transport of bar data

This topic is specified in SCTE 128 Part 1.

8.2.3.1. Recommended Receiver Response to Bar Data

This topic is specified in SCTE 128 Part 1.

8.2.4. Encoding and transport of active format description data

This topic is specified in SCTE 128 Part 1.

8.2.5. AFD Syntax

This topic is specified in SCTE 128 Part 1.

8.2.6. AFD Semantics

This topic is specified in SCTE 128 Part 1.

8.2.7. Recommended Receiver Response to AFD

This topic is specified in SCTE 128 Part 1.

8.2.8. Relationship Between Bar Data and AFD (Informative)

This topic is specified in SCTE 128 Part 1.

9. Support For AVC Still Pictures

AVC still pictures may be used in the transport multiplex and when used shall comply with the following transport constraints. Picture coding constraints for AVC still pictures are found in SCTE 128 Part 1 Section 9.0.

- A PES packet shall contain one and only one complete access unit with a still picture, which shall be aligned to the PES packet header. The PES packet header shall contain a coded PTS value.
- The PMT for this program element shall include the AVC_video_descriptor with the AVC_still_present_flag set to ‘1’.

APPENDIX A Use of Adaptation Field Private Data (Deprecated)

1. Introduction

This Appendix describes optional information based on ETSI TS 101 154 Annex D[6], which information, if present, shall meet the constraints herein.

The optional information may be used by applications such as PVR and nPVR and if present shall be carried in the private data section within the adaptation field of a TS packet. A descriptor format is used to allow future extensions and additions to the information carried, and to allow other information to be carried in the adaptation field's private data. The descriptor and constraints for carriage of this data are defined in section 6.4.3 of this specification.

This information when present, shall be in the TS packet that contains the start of each access unit of an AVC [5] video stream.

2. PVR assist information in Adaptation Field Private Data

2.1. Introduction

PVR assist information may be carried in the adaptation private data field to aid applications that perform trick play operations. Examples of such applications include local storage based Personal Video Recorders (dPVR), network PVR (nPVR) and Video On Demand (VOD). These applications are collectively referred to in this document as PVR applications. The PVR assist information signals picture dependencies that cannot easily be determined without otherwise making assumptions about those dependencies or deep inspection of the video elementary stream.

PVR applications typically fall into two categories, each with different requirements for generating trick play streams

- "Pull model", typically local storage based, where the bitrate of the trick play stream is constrained only by signaled level of the normal play stream. In addition the interface between the application and decoder may be such that the trick play stream is not required to meet normal play stream constraints. The details of such an interface are not described in this appendix.
- "Push model", typically network based where the storage and PVR application are discrete, and the trick play stream generated by the application is required to meet the requirements specified in the main body of this document. In addition network based PVRs may be operating in a managed network where the bitrate of the trick play stream may not exceed the maximum bitrate of the normal play stream.

The PVR assist information may be used in addition to the AU_information described in Appendix A of the present document. The PVR assist information is based on the definitions in Annex D3.4 of ETSI TS 101 154 [6].

PVR assist information consists of two features

1. Constraints on SGOP length to ensure acceptable interactive response.
2. A Tier Framework that signals picture interdependencies enabling a PVR to quickly determine which pictures can be safely extracted or removed/replaced when performing trick play operations.

ETSI TS 101 154 [6] also defines a Substream Framework that identifies subsets of pictures that can be used to build trick mode streams at designated speeds, e.g. 2x or 4x. Since these streams are allowed to exceed the play bit rate up to the limits imposed by the AVC level, they may not be directly applicable to push model applications such as network PVR.

It is recommended that the PVR assist information associated with cumulative frames and MMCO use is recommended to be carried only on SRAP pictures.

The tier framework assigns each picture to a dependency tier in the range 1 to 7, such that any picture with a particular tier number does not depend directly or indirectly on any picture with a higher tier number. If tier ‘n’ pictures are extracted to generate a trick mode stream, then all pictures with a tier number less than ‘n’ would also be extracted. Conversely if tier ‘n’ pictures are being removed or replaced, then all pictures with a tier number greater than ‘n’ would also be removed or replaced. Tier 6 and 7 pictures may be removed independently of other pictures in the same tier.

Examples of tier framework usage may be found in Annex D.3.3.3 of [6]

In addition, PVR assist information that applies to the entire SGOP may be carried, typically associated with SRAP pictures.

2.2. Requirements

The PVR assist information, if present, shall be carried in the private data section within the adaptation field of a TS packet. Section 6.4.3 of this document describes how PVR assist information and, optionally, other information may be carried in the adaptation field’s private data.

All the information provided in the PVR assist information should be considered "helper" information rather than definitive information. Thus, if there are any conflicts between the PVR assist information and the actual stream, then the information in the stream shall take precedence over the information in this descriptor. However, such a conflict should be considered an error condition and as such should not occur.

PVR assist information, when present, shall be carried with each access unit of an AVC [4] video stream and shall include a correct value for ‘PVR_assist_tier_pic_num’ (tier number). PVR assist information is required by Section A.1 to be in the TS packet that contains the start of the associated access unit.

The tier numbers shall be assigned according to the following rules:

- Tier 1 is assigned to the SRAP pictures. All tier 1 pictures are SRAPs and all SRAPs are assigned to tier 1. This represents the lowest level of extractability.
- Tiers 2 through 5 are pictures that may be used as reference pictures and are intended to be extracted for trick mode operations
- Tiers 6 and 7 are assigned to pictures that are may be discarded during trick mode operations, and which do not depend on other tier 6 or 7 pictures
- Tier 7 pictures shall have nal_ref_idc = 0
- Tier 6 pictures may have any legal value of nal_ref_idc
- Pictures in tiers 1 through 5 shall not have nal_ref_idc = 0
- Field pictures that belong to the same frame shall have the same tier number
- A picture that depends upon an MMCO issued by another picture shall not have a tier number less than that of the issuing picture

When the PVR assist information is present, the maximum time interval between the decoding time stamps of successive SRAP Pictures shall meet the requirements specified in 6.4.2.3 for random access applications.

2.3. Syntax

When present, the PVR assist information shall be carried using the syntax defined in Annex D.3.6 of [6].

2.4. Semantics

When present, the PVR assist information semantics shall be as defined in Annex D.3.6 of [6] except as constrained herein.

data_field_tag - this field shall have the value 0x03 as described in Annex D.3.6 of [6]

data_field_length - this field indicates the length of this descriptor excluding the "data_field_tag" and "data_field_length" fields. This field shall have a value greater than or equal to “0x01”. A value of “0x01” for this field indicates that the stream meets the SRAP interval requirements specified in A3.2 of this document, includes a correct value for ‘PVR_assist_tier_pic_num’ (tier number), conveys the ‘PVR_assist_tier_pic_num’ syntax element for each picture and sets all the following syntax elements to ‘0’:

- pvr_assist_block_trick_mode_present_flag
- pvr_assist_pic_struct_present_flag
- pvr_assist_tier_next_pic_in_tier_present_flag
- pvr_assist_substream_info_present_flag
- pvr_assist_extension_present_flag

The tier level values carried in ‘PVR_assist_tier_pic_num’ shall be assigned as described in Annex D3.3.3 of [6].

Note that Annex D3.2 of [6] specifies constraints on PES data alignment that are already required by the current specification (refer to section 6.5)

A value of "data_field_length" greater than “0x01” indicates that optional PVR assist information fields defined in Annex D3 of [6] are present. Use of these fields is not recommended, but if present values shall be assigned as described in Annexes D3.4.2, D3.4.3 and D3.4.4 of [6]. In addition network equipment may optionally remove this additional PVR assist information if present. If network equipment removes this optional information and changes the data_field_length to 0x01, the resulting adaptation field shall conform to ISO/IEC 13818-1 [4].

3. AU Information

Use of AU_information is deprecated. Use of the PVR assist information (Section A.2) is preferred.

AU_information is signified by the tag value 0x02.

The purpose of the AU_information() is to convey information about that access unit that is of use to applications. All the information provided in AU_information() should be considered "helper" information rather than definitive information. Thus, if there are any conflicts between AU_information() and the actual stream, then the information in the stream shall take precedence over the information in this descriptor. However, such a conflict should be considered an error condition and as such should not occur. The AU_information() when present, shall be in the TS packet that contains the start of each access unit of an AVC [5] video stream, except for the SRAP access unit, where it may be present either in the same TS packet or in the previous TS packet.

This specification applies only to the use of AU_information in conjunction with AVC [5] video streams. Any values or semantics defined in Annex D of [6]that are specific to other video coding types are out of scope of this specification.

3.1. Syntax

The format of AU_information() shall be as shown in Table 21.

Table 21 - AU_information data field

Syntax	No. of Bits	Mnemonic
AU_information () {		
data_field_tag	8	uimsbf
data_field_length	8	uimsbf
if (data_field_length >= 1) {		
AU_coding_format	4	uimsbf
AU_coding_type_information	4	bslbf
}		
if (data_field_length >= 2) {		
AU_ref_pic_idc	2	uimsbf
AU_pic_struct	2	bsblf
AU_PTS_present_flag	1	bslbf
AU_profile_info_present_flag	1	bslbf
AU_stream_info_present_flag	1	bslbf
AU_trick_mode_info_present_flag	1	bslbf
}		
if (AU_PTS_present_flag == '1') {		
AU_PTS_32	32	uimsbf
}		
if (AU_stream_info_present_flag == '1') {		

Syntax	No. of Bits	Mnemonic
reserved_zero	4	'0000'
AU_frame_rate_code	4	uismbf
}		
if (AU_profile_info_present_flag == '1') {		
AU_profile	8	uismbf
AU_constraint_set0_flag	1	bslbf
AU_constraint_set1_flag	1	bslbf
AU_constraint_set2_flag	1	bslbf
AU_AVC_compatible_flags	5	bslbf
AU_level	8	uismbf
}		
if (AU_trick_mode_info_present_flag == '1') {		
AU_max_I_picture_size	12	uismbf
AU_nominal_I_period	8	uismbf
AU_max_I_period	8	uismbf
Reserved_zero	4	'0000'
}		
if (*data parsed* < data_field_length) {		
AU_Pulldown_info_present_flag	1	bslbf
reserved_zero	6	'00'
AU_flags_extension_1	1	bslbf
}		
if (AU_Pulldown_info_present_flag == '1') {		
reserved	4	'000'
AU_Pulldown_info	4	bslbf
}		
for(i=0; i<n; i++) {		
AU_reserved_byte	8	bslbf
}		
}		

3.2. Semantics

data_field_tag - this field shall have the value 0x02.

data_field_length - this field is the number of descriptor bytes following this length field. The values 0 and 1 may be used to signal short versions of the descriptor. The value 0 means that no fields after the data_field_length are sent. The value 1 means that only the fields AU_coding_format and AU_coding_type_information are present.

AU_coding_format - This field shall signal the coding format used by the elementary stream carried by this TS packet. The values are as show in Table 22. The value "Undefined" means that the coding type is not specified. If this field is not transmitted then the value "undefined" shall be inferred.

Table 22 - AU_coding_format values

Value	Stream Type
0	Undefined
1	Forbidden
2	AVC video stream as defined in AVC[5]
3	Used by DVB
4-0xF	reserved

AU_coding_type_information - indicates the elementary stream slice types that are present in the immediately following access unit. For AVC video [5], this field shall be interpreted as a four bit field with the syntax shown in Table 23. If this field is not transmitted, then no information about the coding type may be inferred (i.e., any slice type may be present).

The value ‘0’ in this field means “undefined”. This shall only be used where the value is to be supplied by a subsequent stage in delivery or processing.

Table 23 - AU_coding_type_information for AVC video

Syntax	No. of Bits	Mnemonic
AU_IDR_slice_present_flag	1	bslbf
AU_I_slice_present_flag	1	bslbf
AU_P_slice_present_flag	1	bslbf
AU_B_slice_present_flag	1	bslbf

AU_ref_pic_idc - This field indicates if any part of the access unit is required in the reconstruction of other access units. The value '00' means that it is not used by other access units. In the case of AVC [5], the value shall be the nal_ref_idc field in the NAL header used for the access unit. If this field is absent, then inferences shall not be made about whether or not the AU is used as a reference to other AUs.

AU_pic_struct - This field shall be set to '01' if the access unit is a top field picture, '10' if it is a bottom field. Otherwise, it shall be set to '00'. '11' value is reserved. If this field is absent, inferences shall not may be made about the picture structure (i.e., it may be any format).

Note: AU_Pulldown_info may provide additional information in this area.

AU_PTS_present_flag - This field shall be set to '1' when the AU_PTS_32 value is present in the descriptor, otherwise it shall be set to the value '0'. If this field is not present, the value ‘0’ shall be inferred.

AU_profile_info_present_flag - This field shall be set to '1' when the AU_profile_idc and AU_level_idc values are present in the descriptor, otherwise it shall be set to the value '0'. If this field is not present, the value ‘0’ shall be inferred.

AU_stream_info_present_flag - This field shall be set to '1' when the AU_frame_rate_code value is present in the descriptor, otherwise it shall be set to the value '0'. If this field is not present, the value ‘0’ shall be inferred.

AU_trick_mode_info_present_flag - This field shall be set to '1' when the AU_max_I_picture_size and AU_max_I_period are present in the descriptor, otherwise it shall be set to the value '0'. If this field is not present, the value ‘0’ shall be inferred.

AU_PTS_32 - the 32 most significant bits of the 33-bit PTS that applies to the access unit to which this descriptor applies.

AU_frame_rate_code - this field indicates the video frame rate in the stream carried by packets with the current PID. In the case of video, this shall be encoded as in Table 6-4, Section 6.3.3 of ISO/IEC 13818-2[23]. The values in this table are informatively replicated on Table 24 below. If the field is absent inferences shall not be made at this layer about the frame rate.

Table 24 - Informative Frame Rate values taken from table 6-4 of 13818-2[23]

AU_frame_rate_code	Corresponding Frame Rate (Hz)
0	Forbidden
1	24/1.001
2	24
3	25
4	30/1.001
5	30
6	50
7	60/1.001
8	60
9 to 0xF	Reserved

AU_profile - this field conveys the profile to which the access unit conforms. For AVC video [5] this carries the profile_idc value as defined in AVC [5].

The value ‘0’ in this field means “undefined”. This shall only be used where the value is to be supplied by a subsequent stage in delivery or processing.

Constraint_set0_flag, constraint_set1_flag, constraints_set2_flag, AVC compatible flags - These fields carry the same semantics as the fields of the same name in the AVC_video_descriptor() in Section 2.6.65 of 13818-1[4], which in turn have semantics defined in AVC[5], section 7.4.2.1. Note that with High profile, the first bit in AVC_compatible_flags carries constraint_set3_flag.

AU_level - this field conveys the level to which the access unit conforms. For AVC video [5] this carries the level_idc value as defined AVC, Annex A [5].

The value ‘0’ in this field means “undefined”. This shall only be used where the value is to be supplied by a subsequent stage in delivery or processing.

AU_max_I_picture_size - this field conveys the maximum intra picture size, in units of 16x1024 bits, which may be found in the current bitstream. This value, according to profile and level, shall comply with AVC [5] limits. The value 0 shall be forbidden.

AU_nominal_I_period - this field conveys the nominal distance between two consecutive I or IDR pictures, counted in frame pictures. The value 0 shall be forbidden.

AU_max_I_period - this field conveys the maximum distance that may be found in the stream between two consecutive I/IDR pictures, counted in frame pictures. The value 0 shall be forbidden.

AU_Pulldown_info_present_flag - This flag indicates if information about 3:2 pulldown for this AU is present

If this field is not present, then the value ‘0’ should be inferred.

AU_Pulldown_info - This field contains the five bits carried in the AVC structure signalling the AU’s display characteristics, specifically the pic_struct field of the SEI message pic_timing. The default value for this field shall be as shown in Table 25 below.

Table 25 - AU_Pulldown_info default values

AU_pic_struct	AU_Pulldown_info default value
00	0 (progressive-scan formats)
00	3 (interlaced-scan formats)
01	1
10	2
11	reserved

APPENDIX B Encoding Guidelines to Enable Trick Play Support of AVC Streams (Deprecated)

This topic is specified in SCTE 128 Part 1.