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Candidate Standard:
Part 1 of Proposed Doc. A/72,
"Video System Characteristics of AVC in the ATSC Digital Television System"

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The Advanced Television Systems Committee, Inc., is an international, non-profit organization developing voluntary standards for digital television. The ATSC member organizations represent the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.

Specifically, ATSC is working to coordinate television standards among different communications media focusing on digital television, interactive systems, and broadband multimedia communications. ATSC is also developing digital television implementation strategies and presenting educational seminars on the ATSC standards.

ATSC was formed in 1982 by the member organizations of the Joint Committee on InterSociety Coordination (JCIC): the Electronic Industries Association (EIA), the Institute of Electrical and Electronic Engineers (IEEE), the National Association of Broadcasters (NAB), the National Cable Television Association (NCTA), and the Society of Motion Picture and Television Engineers (SMPTE). Currently, there are approximately 140 members representing the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.

ATSC Digital TV Standards include digital high definition television (HDTV), standard definition television (SDTV), data broadcasting, multichannel surround-sound audio, and satellite direct-to-home broadcasting.

About the Candidate Standard

This specification is being put forth as a Candidate Standard by the TSG/S6 Specialist Group on Audio and Video Coding. ATSC members and non-members are encouraged to review and implement this specification and return comments to cs_amend_editor@atsc.org. ATSC Members can also send comments directly to the TSG/S6 Specialist Group. The ATSC believes this specification is stable. It is expected to progress to Proposed Standard within a period of time ending 31 December 2007.

Advisory Notice

In issuing this standard, the ATSC recognizes that it includes encoding and decoding techniques for digital television transmission which are not backwards compatible with existing MPEG-2-based ATSC DTV deployments. Transitional issues associated with continuing service to existing receivers, how and when to deploy advanced-capability receivers, allocation of channel bit capacity, and related issues should be considered. ATSC recognizes that this standard will be utilized more readily in countries that have not yet implemented digital terrestrial television broadcasting systems, or in countries that have achieved internal agreement on a transition plan.

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1. SCOPE

This Part describes the video coding constraints on ITU-T Rec. H.264 | ISO/IEC 14496-10 [5] ("AVC") video compression in the ATSC Digital Television System. The Transport Stream constraints for AVC are described in Part 2 of this standard.

2. REFERENCES

2.1 Normative References

The following documents contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

[1] ATSC: A/53 Part 1:2007, "ATSC Digital Television Standard, Part 1 – Digital Television System," Advanced Television Systems Committee, Washington, D.C., 3 January 2007.

[2] ATSC: A/53 Part 4:2007, "ATSC Digital Television Standard, Part 4 – MPEG-2 Video System Characteristics with Amendment No. 1," Advanced Television Systems Committee, Washington, D.C. (Amendment No. 1, CS/TSG-744r1, is currently at Candidate Standard).

[3] ISO/IEC 13818-1:2000 (E), International Standard, Information technology – Generic coding of moving pictures and associated audio information: Systems.

[4] ISO/IEC 13818-1/Amd. 3: 2003 Amendment 3: Transport of AVC video data over ITU-T Rec. H.222.0 |ISO/IEC 13818-1 streams.

[5] ISO/IEC 14496-10 (ITU-T H.264), International Standard (2005), Advanced video coding for generic audiovisual services.

[6] SMPTE: SMPTE 170M (1999), "Standard for Television—Composite Analog Video Signal, NTSC for Studio Applications," Society of Motion Picture and Television Engineers, White Plains, N.Y.

[7] SMPTE: SMPTE 274M (2003), "Standard for Television—1920 x 1080 Scanning and Analog and Parallel Digital Interfaces for Multiple Picture Rates," Society of Motion Picture and Television Engineers, White Plains, N.Y.

[8] SMPTE: SMPTE 293M (2003), "Standard for Television—720 x 483 Active Line at 59.94-Hz Progressive Scan Production, Digital Representation," Society of Motion Picture and Television Engineers, White Plains, N.Y.

[9] SMPTE: SMPTE 296M (2001), "Standard for Television—1280 x 720 Progressive Image Sample Structure, Analog and Digital Representation and Analog Interface," Society of Motion Picture and Television Engineers, White Plains, N.Y.

[10] ITU-R BT.601-5 (1995): Encoding Parameters of Digital Television for Studios.

[11] ITU-R BT.709-5 (2002): Parameter values for the HDTV Standards for Production and International Programme Exchange.

2.2 Informative References

[12] CEA: CEA-708-C, "Digital Television (DTV) Closed Captioning," Consumer Electronics Association, Arlington, VA, 30 July 2006.

[13] ETSI TS 101 154 V1.8.1, Digital Video Broadcasting (DVB): Implementation Guidelines for the use of MPEG-2 Systems, Video and Audio in Satellite, Cable and Terrestrial Broadcasting Applications, Annex B, June 2007.

[14] Digital Receiver Implementation Guidelines and Recommended Receiver Reaction to Aspect Ratio Signaling in Digital Video Broadcasting, Issue 1.2, August 2000, Digital TV Group.

[15] ITU-T T.35, International Standard (2000), Procedure for the allocation of ITU-T defined codes for non-standard facilities.

[16] ITU-T H.261 (1993): Video Codec for Audiovisual Services at *p* x 64 kbits

[17] CEA: CEA-805-C, "Data on the Component Video Interfaces," Consumer Electronics Association, Arlington, VA, 31 July 2006.

[18] ATSC: A/72 Part 2, "Use of AVC in the ATSC Digital Television System, Part 2 – Transport Subsystem Characteristics," Advanced Television Systems Committee, Washington, D.C. (in process).

[19] CEA: CEB16, "Active Format Description (AFD) & Bar Data Recommended Practice," Consumer Electronics Association, Arlington, VA, 31 July 2006.

[20] CEA: CEA-608-D, "Line 21 Data Services," Consumer Electronics Association, Arlington, VA, May 2007.

3. COMPLIANCE NOTATION

As used in this document, "shall" denotes a mandatory provision of the standard. "Should" denotes a provision that is recommended but not mandatory. "May" denotes a feature whose presence does not preclude compliance, that may or may not be present at the option of the implementor.

3.1 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 Symbols, Abbreviations, and Mathematical Operators

The symbols, abbreviations, and mathematical operators used herein are as found in Section 3.4 of ATSC A/53 Part 1 [1] and as herein specified.

one_bits – Each bit in fields marked, one_bits, shall be set to '1'.

4. SYSTEM OVERVIEW (INFORMATIVE)

Please see the A/53 Part 4 Section titled "System Overview" [2].

5. POSSIBLE VIDEO INPUTS

Please see the A/53 Part 4 Section titled "Possible Video Inputs" [2] for information regarding television production standards. Television production standards supported by this standard include 25 and 50 Hz inputs as well as 29.97 and 59.94 Hz inputs.

6. SOURCE CODING SPECIFICATION

With the exceptions stated in the following paragraph, the AVC video compression algorithm shall conform to either the Main or the High Profile syntax of AVC video (ISO/IEC 14496-10) [5]. The allowable parameters shall be bounded by the upper limits specified for the High Profile at Level 4.[1] AVC bit streams shall conform to either the Main or High Profile syntax for SD resolutions (input formats SMPTE 293M [8] and ITU-R BT.601-5 [10]) and to the High Profile syntax for HD resolutions (input formats SMPTE 274M [7] and SMPTE 296M [9]).

For standard-definition SIF (352x240) (sometimes referred to as "525 CIF") or QSIF (176 x 120) resolution services, the AVC video compression algorithm shall conform to either the Main or Baseline Profile syntax of AVC video (ISO/IEC 14496-10) [5] with additional constraints as specified in Section 6.2.2. Such operation is intended only for mobile or handheld applications.

Additionally, AVC bit streams shall meet the constraints and specifications specified in Table 6.3 and as further described in Sections 6.1, 6.2, 6.3, and 6.5 of this document.

AVC bit streams shall utilize the both the "Supplemental enhancement information (SEI)" and the "Video usability information (VUI)" syntactic elements defined in ISO/IEC 14496-10 Annexes D and E [5]. Decoder design should be made under the assumption that any legal structure as permitted by ISO/IEC 14496-10 [5] may occur in the broadcast stream even if presently reserved or unused.

6.1 Constraints with Respect to AVC (ISO/IEC 14496-10)

The tables in the following sections list the allowed values for each of the ISO/IEC 14496-10 [5] syntactic elements which are constrained.

6.1.1 Constraints with Respect to AVC Main and High Profiles

Picture coding shall not use the High Profile tools unless required by the picture format. See Table 6.3.

6.1.2 Constraints with Respect to AVC Baseline Profile

When used for image formats where Baseline profile is permitted, the picture coding shall use only the subset of Baseline tools that are also present in the Main profile. The constraint_set1_flag shall be set to '1' allowing decoders that support only 'Main' profile to decode streams from both the Main and Baseline profiles.

6.1.3 AVC Access Point

An Access Point is defined as an access unit in an AVC bit stream at which a decoder can begin decoding video successfully. The access unit must contain one Sequence Parameter Set NAL unit and one Picture Parameter Set NAL unit that are active or being activated when decoding the primary coded picture in this access unit. The access unit must contain an IDR picture or an I picture.

[1] See ISO/IEC 14496-10, Annex A [5] for more information regarding profiles and levels.

6.1.4 Sequence Parameter Set Constraints

For each Access Point, there shall be one Sequence Parameter Set present in the bit stream. Table 6.1 identifies parameters in the sequence parameter set of a bit stream that shall be constrained by the video subsystem and lists the allowed values for each.

Table 6.1 Sequence Parameter Set Constraints

Sequence Parameter Set Syntactic Element	Allowed Value
profile_idc	see Table 6.3
level_idc	see Table 6.3
constraint_set0_flag	0
constraint_set2_flag	0
constraint_set3_flag	0
PicWidth InMbs	see Table 6.3
PicHeight InMbs	see Table 6.3
aspect_ratio_idc	see Table 6.3
num_units_ in_tick	see Table 6.3
time_ scale	see Table 6.3

The constraint_set1_flag shall be set to 1 when profile_idc has the value 77 and to 0 when profile_idc has the value 100. The time interval between two changes in pairs of pic_width_in_mbs_minus1 and pic_height_in_map_units_minus1 shall be greater than or equal to one second.

6.1.5 Picture Parameter Set Constraints

More than one Picture Parameter Set can be present in the bitstream between two Access Points. Between two Access Points, the content of a Picture Parameter Set with a particular pic_parameter_set_id shall not change. (If more than one Picture Parameter Set is present in the bitstream and these Picture Parameter Sets are different from each other, then each picture parameter set shall have a different pic_parameter_set_id.).

6.1.6 Video Usability Information (VUI) Parameter Constraints

The following parameters in the Video Usability Information (VUI) part of a bit stream that shall be constrained. video_format shall only take the value of '000', low_delay_hrd_flag shall only take the value of '0'.

The decoder shall support the use of the VUI's following syntax elements: Aspect Ratio Information (aspect_ratio_idc), Color Parameter Information (colour_primaries, transfer_characteristics, and matrix_coefficients), Chrominance Information (chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field), and Timing information (time_scale, num_units_in_tick, low_delay_hrd_flag, timing_info_present_flag, and fixed_frame_rate_flag).

The values for time_scale, num_units_in_tick, and fixed_frame_rate_flag shall be explicitly indicated in the vui_parameters(). For each frame rate shown in Table 6.3, the values for num_units_in_tick and time_ scale shall be as shown in Table 6.2.

Table 6.2 Frame rate VUI Parameter Constraints

frame rate	num_units_in_tick	time_ scale
23.98 Hz	1,001	48,000
24 Hz	1	48
25 Hz	1	50
29.97 Hz	1,001	60,000
30 Hz	1	60
50 Hz	1	100
59.94 Hz	1,001	120,000
60 Hz	1	120

The values for color_primaries, transfer_characteristics, and matrix_coefficients shall be explicitly indicated in the vui_parameters(). While all values for color_primaries, transfer_characteristics, and matrix_coefficients defined in Tables E-3, E-4, and E-5 of ISO/IEC 14496-10, Annex E [5] are allowed in the transmitted bit stream, those of ITU-R BT.709 [11] and SMPTE 170M [6] are the most likely to be in common use.

6.2 Compression Format Constraints

Profiles and Levels shall be constrained as shown in Table 6.3 (indicated values for profile_idc and level_ idc). The Level shall be constrained to 3 or 3.1 for SD resolutions (formats SMPTE 293M [8] and ITU-R BT.601-5 [10]) and 3.2, 4, or 4.2 for HD resolutions (formats SMPTE 274M [7] and SMPTE 296M [9]). Note: It is expected that all fixed receivers will handle Level 4.0 and profile_idc 100. Mobile and handheld receivers are expected to handle Level 3.0 and profile_idc 77.

Table 6.3 lists the allowed compression formats.

Table 6.3 Compression Format Constraints

vertical size	horizontal size	PicWidth InMbs	PicHeight InMbs	aspect_ ratio_idc	profile_ idc [1]	level_ idc	display aspect ratio	allowed frame rates	Progressive interlaced
1080	1920	120	68	1	100	40	16:9	1,2,3,4	P
1080	1920	120	68	1	100	42 [2]	16:9	5,6	P
1080	1920	120	68	1	100	40	16:9	3,4	I
1080	1440	90	68	14	100	40	16:9	1,2,3,4	P
1080	1440	90	68	14	100	42	16:9	5,6	P
1080	1440	90	68	14	100	40	16:9	3,4	I
720	1280	80	45	1	100	32, 40	16:9	1,2,3,4,5,6	P
480	720	45	30	3	77 or 100	31, 40	4:3	1,2,3,4,5,6	P
480	720	45	30	5	77 or 100	31, 40	16:9	1,2,3,4,5,6	P
480	720	45	30	3	77 or 100	30	4:3	3,4	I
480	720	45	30	5	77 or 100	30	16:9	3,4	I
480	704	44	30	3	77 or 100	31, 40	4:3	1,2,3,4,5,6	P

480	704	44	30	5	77 or 100	31, 40	16:9	1,2,3,4,5,6	P
480	704	44	30	3	77 or 100	30	4:3	3,4	I
480	704	44	30	5	77 or 100	30	16:9	3,4	I
480	640	40	30	1	77 or 100	31, 40	4:3	1,2,3,4,5,6	P
480	640	40	30	1	77 or 100	31, 40	4:3	3,4	I
480	544	34	30	5	77 or 100	30	4:3	1	P
480	544	34	30	5	77 or 100	30	4:3	3	I
480	528	33	30	5	77 or 100	30	4:3	1	P
480	528	33	30	5	77 or 100	30	4:3	3	I
480	352	22	30	7	77 or 100	30	4:3	1	P
480	352	22	30	7	77 or 100	30	4:3	3	I
240	352	22	15	3	66 or 77	30	4:3	1	P
120	176	11	8	3	66 or 77	11	4:3	1	P

Legend:
frame rate: 1 = 23.976 Hz, 2 = 24 Hz, 3 = 29.97 Hz, 4 = 30 Hz, 5 = 59.94 Hz, 6 = 60 Hz
aspect_ratio_idc: 1 = 1:1 [square samples], 3 = 10:11, 5 = 40:33, 7 = 20:11, 11 = 15:11, 14 = 4:3

Footnotes:
[1] A compliant bitstream may have a profile_idc value of either 77 or 100.
[2] Use of this format may be constrained by service_type (see A/72 Part 2 [18]).

For vertical sizes of 1080 and 120, that 1088 and 128 lines (respectively) are actually coded in order to satisfy the AVC requirement that the coded vertical size be a multiple of 16 (progressive scan) or 32 (interlaced scan). The bottom 8 lines should be black and "frame cropping" shall be used. The value of frame_crop_top_offset shall be 0 and frame_crop_bottom_offset shall be 2*(1 + frame_mbs_only_flag).

6.3 Low Delay and Still Picture Modes

For all applications, low_delay_hrd_flag shall be 0. Note: This standard does not permit "big pictures."

6.3.1 Low Delay Mode

In AVC, "Low delay mode" may be provided without special timing or buffering, so no special signaling is required.

6.3.2 Still Picture Mode

Still Picture Mode is supported and is governed by the conventional MPEG-2 Systems principles designed to support this mechanism. In particular, still picture mode is characterized by:

- Still picture mode shall be indicated when the fixed_frame_rate_flag is set to 0 in the vui_parameters( ). Otherwise, the fixed_frame_rate_flag shall be set to 1.

- Still pictures shall comply with the "AVC still picture" definition in ISO/IEC 13818-1, Amendment 3 [4] Section 2.1.5. For Still pictures the frame rate specification for AVC decoders shall not apply.
- In the presence of Still pictures, a decoder shall maintain a fixed frame refresh rate according to the previous non-Still frame rate. When AVC Still picture mode is first sensed, the previously decoded picture shall be displayed until the presentation time of the next picture.

6.4 Bit Stream Specifications Beyond AVC (ISO/IEC 14496-10)

This section covers the specific data carried in the SEI RBSP and VUI sections of the video syntax. The syntax used for the insertion of closed captioning, AFD, and bar data in the SEI payload shall be as specified in the following sections.

6.4.1 Encoding and Transport of Caption, Active Format Description (AFD) and Bar Data

Advanced DTV closed captions (CEA-708 [12]), when present, shall be encoded in accordance with CEA-708 [12] and shall be transported as specified in Section 6.5.2. Line 21 caption data, encoded in accordance with CEA-608 [20], when present shall be transported as specified in CEA-708 [12] and Section 6.5.2.

> Note: CEA-708 [12] requires a fixed bandwidth of 9600 bits per second for the closed caption payload data. Bandwidth calculations should anticipate this requirement.

6.4.2 Caption, AFD and Bar Data Syntax

Caption, AFD and bar data shall be carried in the SEI RBSP (raw byte sequence payload) syntax of the video Elementary Stream. Table 6.4 describes the SEI syntax (see ISO/IEC 14496-10, Annex D.1.5 and D.2.5 [5]).

Table 6.4 SEI Syntax[2]

Syntax	No. of Bits	Format
user_data_registered_itu_t_t35 ( ) {		
itu_t_t35_country_code	8	bslbf
itu_t_t35_provider_code	16	bslbf
user_identifier	32	bslbf
user_structure()		
}		

Note that SEI payloads carrying a SEI payloadType of 4 and containing a 32-bit field following the itu_t_t35_provider_code which has a value other than user_identifier may be present in an ATSC-compliant AVC video bit stream. Receiving devices are expected to process this field and use it to determine the syntax and semantics of the user data construct to follow.

Receiving devices are expected to silently discard any unrecognized SEI payloads encountered in the video bit stream. For example, if an unrecognized 32-bit identifier is seen following the itu_t_t35_provider_code, data should be discarded until another SEI payload is seen or the RBSP terminates.

[2] Shaded cells in this table indicate syntactic and semantic additions to the ISO/IEC 14496-10 Standard [3].

Note: The values specified below for both itu_t_t35_country_code and itu_t_35_provider_code are the assigned values for the purposes of this standard. This does not imply that other uses of this SEI construct will not also be used for other applications. See ITU-T Recommendation T.35 [15] for additional information.

6.4.3 Caption, AFD and Bar Data Semantics

itu_t_t35_country_code – A fixed 8-bit field, the value of which shall be 0xB5.

itu_t_35_provider_code – A fixed 16-bit field, the value of which shall be 0x0031.

user_identifier – This is a 32 bit code that indicates the syntax and semantics of the user_structure() as indicated in Table 6.7 of ATSC A/53 Part 4 [2].

user_structure() – This is a variable length data structure defined by the value of user_identifier and Table 6.7 of ATSC A/53 Part 4 [2]. It is reproduced below in Table 6.5 for the convenience of the reader.

Table 6.5 user_identifier

user_identifier	user_structure()
0x47413934 (“GA94”)	ATSC_user_data()
0x44544731 (“DTG1”)	afd_data()
all other values	Not defined in this Standard.

6.4.4 ATSC_user_data() Syntax

ATSC_user_data() syntax and semantics shall be those given in A/53 Part 4 [2] Table 6.8 for the “ATSC_user_data()” structure. While those syntax and semantics are nominally MPEG-2 specific, they are fully applicable to AVC.

6.4.4.1 Captioning Data

When user_structure() contains captioning data it shall be encoded as specified in A/53 Part 4 [2] Table 6.10.

6.4.4.2 Bar Data

Bar data, when present, shall be encoded and transported using the ATSC_user_user_data( ) structure defined in A/53 Part 4 [2] Table 6.8. The syntax and semantics of bar data shall be as specified in A/53 Part 4 [2] Table 6.11 and the text following the table in Section 6.2.3.2 (“Bar Data”). Bar data should be included in an SEI message whenever the rectangular picture area containing useful information does not extend to the full height or width of the coded frame and AFD alone is insufficient to describe the extent of the image.

When bar_data() is present in the Video Elementary Stream, the SEI pan_scan_rect() parameters in the SEI RBSP syntax (ISO/IEC 14496-10, Annex D.1.3 and D.2.3 [5]) shall not be present. Bar data is to be preferred over the use of the SEI pan_scan_rect().

After each access_unit_delimiter NAL Unit, the bar data may be signalled by the bar_data() parameters carried by ATSC1_data(). After introduction, bar data shall remain in effect until the next sei_payload() or until new bar data is introduced. Within a sequence, bar data shall remain in effect until a picture contains new bar data or a picture contains AFD data without bar data.

At an access_unit_delimiter NAL Unit, the absence of bar data in a sei_payload(), unless accompanied by AFD data specifying otherwise, shall indicate that the rectangular picture area containing useful information extends to the full height and width of the coded frame.

At an Access Point, unless AFD data is present specifying otherwise, the absence of bar data shall indicate that the rectangular picture area containing useful information extends to the full height and width of the coded frame.

> Note: Bar data is constrained to be signaled in pairs, either top and bottom bars or left and right bars, but not both pairs at once. Bars may be unequal in size. One bar of a pair may be zero width or height.

6.4.4.3 Active Format Description Data

Active Format Description (AFD), when present, shall be encoded and transported in accordance with A/53 Part 4 [2] Section 6.2.4 ("Active Format Description Data"). Some of the text from A/53 Part 4 is reproduced in this section for the convenience of the reader. While those syntax and semantics are nominally MPEG-2 specific, they are fully applicable to AVC.

The AFD shall be carried within the SEI RBSP of the video Elementary Stream and, when present, shall be encoded and transported using the afd_data( ) structure specified in A/53 Part 4 [2] Table 6.7 and defined in A/53 Part 4 [2] Table 6.13. For each Access Point the default aspect ratio of the area of interest shall be that signalled by the Supplemental Enhancement Information parameters. After introduction, an AFD shall remain in effect until the next Access Point or until another AFD value is introduced. Receivers should interpret the absence of AFD in a sequence start to mean the active format is the same as the coded frame, corresponding to AFD value '1000' (see A/53 Part 4 [2] Table 6.14).

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