

CTA Bulletin

Active Format Description (AFD) & Bar Data Recommended Practice

CTA-CEB16-B

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Active Format Description (AFD) & Bar Data Recommended Practice

1 Scope

This bulletin, CTA-CEB16-B, provides guidance for the development and implementation of consumer devices that process information related to aspect ratio signaling, Active Format Description (AFD) and bar data. Such devices may respond to this signaling by creating an optimum (or more desirable) display, by passing this signaling through to an analog or digital output, or in preparation of a digital recording. CTA-CEB16-B reviews the standardized methods for representing AFD, aspect ratio information, and bar data on various analog and digital Standard Definition (SD) and High Definition (HD) interfaces. For each of various transmitted display formats, CTA-CEB16-B provides recommendations for output signaling and display appearance, taking into account possible decoder capabilities, scaling options and user preferences regarding display format.

2 Informative References

The following references contain provisions, which, through reference in this text, constitute informative provisions of this standard. At the time of publication, the editions indicated below were valid. All documents 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.

2.1 Informative Reference List

1. ATSC Digital Television Standard (A/53), Part 4 – MPEG-2 Video System Characteristics, Advanced Television Systems Committee, 7 August 2009
2. ATSC Standard: Video – HEVC (A/341), Advanced Television Systems Committee, 2 March 2017.
3. ANSI/CTA-608-E R-2014, Line 21 Data Services, April 2008
4. CTA-770.2-D, Standard Definition TV Analog Component Video Interface, April, 2007
5. CTA-770.3-E, High Definition TV Analog Component Video Interface, June, 2013
6. CTA-805-E Data Services on the Component Video Interfaces, August 2013
7. ANSI/CTA-861-G A DTV Profile for Uncompressed High Speed Digital Interfaces, August, 2013
8. High-Definition Multimedia Interface (HDMI) Specification, HDMI Licensing Administrator, Inc.; <http://www.hdmi.org/>
9. JEITA CPR-1204 Transfer Method of Video Identification Information (525 line system), March 1997
10. ETSI TS 101 154 v2.2.1 Digital Video Broadcasting (DVB); Specification for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream, March 2015
11. IEC 61880 Video Systems (525/60) – video and accompanied data using the vertical blanking interval—Analogue interface, 1998
12. SMPTE ST 2016-1:2009, Format for Active Format Description and Bar Data, December 2009.
13. SMPTE ST 2036-1:2014, Ultra High Definition Television — Image Parameter Values for Program Production, October 2014
14. SMPTE RP 202:2008, Video Alignment for MPEG-2 Coding, April 2008

2.2 Informative Reference Acquisition

ATSC Standards:

- Advanced Television Systems Committee, 1776 K Street N.W., Washington, DC 20006; Phone 202-872-9160; Internet <http://www.atsc.org/>

CTA Standards and Bulletins:

- Global Engineering Documents, World Headquarters, 15 Inverness Way East, Englewood, CO 80112-5776; Phone 800-854-7179; Internet <http://global.ihs.com>; Email global@ihs.com

HDMI

- HDMI Licensing, LLC, 1060 E. Arques Avenue, Suite 100, Sunnyvale, CA 94085; URL <http://www.hdmi.org>

EIAJ Standards:

- Available from Japan Electronics and Information Technology Industries Association (JEITA). Internet <http://www.jeita.or.jp/eiaj/english/>

IEC Standards:

- International Electrotechnical Commission. E-mail: inmail@iec.ch. Internet <http://www.iec.ch/>

DVB Standards:

- Available from European Telecommunications Standards Institute. Internet: <http://www.etsi.org/>

SMPTE Standards, Recommended Practices and Engineering Guidelines:

- Society of Motion Picture and Television Engineers. Internet: <http://www.smpte.org/>

3 Acronyms

AFD	Active Format Description
ATSC	Advanced Television Systems Committee
CCO	center cut-out
CTA	Consumer Technology Association
CGMS-A	Copy Generation Management System-Analog
CVI	Component Video Interface
DTV	Digital Television
DVB	Digital Video Broadcasting
ETSI	European Telecommunications Standards Institute
HD	High Definition
HDMI	High Definition Multimedia Interface
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
JEITA	Japan Electronics and Information Technology Industries Association
MPEG	Motion Picture Experts Group
NTSC	National Television Systems Committee II
RP	Recommended Practice
SMPTE	Society of Motion Picture and Television Engineers
SD	Standard Definition
STB	Set-top Box
TS	Transport Stream
VBI	Vertical Blanking Interval
WSS	wide-screen signaling

4 Definition of Terms

Active Format Description — A 4-bit data field that conveys how the image should be displayed in order to best maintain the artistic intent of its creators.

Active Image — The useful portion of the image. The Active Image excludes letterbox bars and pillarbox bars.

bar data — Data that enable computation of regions of the image that are outside of the Active Image, for example areas of zero or uniform luminance.

Total Image — The entire image area including both Active Image and letterbox bars or pillarbox bars.

Coded Frame — As used in CTA-CEB16-B, a compressed signal representing a rectangular array of pixels containing an image that may, in whole or part, be eventually rendered onto a display.

Display Aspect Ratio — The physical width-to-height ratio of the light-emitting area of the display device.

Picture — As used in CTA-CEB16-B, an uncompressed signal representing an rectangular array of pixels containing an image that may, in whole or part, be rendered onto a display.

letterbox — A Total Image having horizontal bars, usually black, present at the top and bottom.

pillarbox — A Total Image having vertical bars, usually black, present at the left and right.

postage stamp image — A Total Image where both letterbox bars and pillarbox bars are present.

scale — To change the Picture size along both axes by multiplying the same constant. In CTA-CEB16-B, the term scaling does not include non-linear or anamorphic conversions.

5 Background and Overview

Broadcast standards in current use for television offer two aspect ratios for the Coded Frame: 4:3 and 16:9. But when source material is placed into the Coded Frame, exact matching of the aspect ratios is not always possible. For example, a 16:9 Active Image may be placed within a 4:3 Coded Frame, or a 4:3 Active Image within a 16:9 Coded Frame, resulting in “letterbox” or “pillarbox” display presentations, respectively. These effects also occur when the aspect ratios of the Pictures do not match the aspect ratios of the physical displays.

Content creators have employed framing techniques to optimize the presentation of their content on various displays. A producer may for example, shoot scenes using a 16:9 Total Image while “protecting” a 4:3 Active Image containing all “essential or useful” information. The result may then be presented on both 16:9 and 4:3 displays with minimal loss of content.

In many display products, user-selectable viewport modifiers such as zoom and stretch are offered since a single fixed-display format may not be optimal for all viewers or all content.

These variables in the production, coding, and display of content may lead to sub-optimal presentations. This document provides recommendations in an attempt to mitigate certain undesirable display effects. AFD and bar data as described below may be used by display devices to optimize automatically the presentation of visual content.

Aspect ratio and AFD signaling within the ATSC transport multiplex can indicate to the receiving device that certain portions of the Total Image do not carry essential information and thus may be cropped.

The syntax and semantics of the AFD were originally described in Annex B of the DVB document “Specification for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream” [10]. The coding of the 4-bit **active_format** field from this specification is reprinted here in Annex A. ATSC Digital Television Standard A/53 Part 4 [1], reiterates this information and defines the carriage of AFD in the ATSC video elementary stream, while introducing the related bar data as a refinement. In the ATSC 3.0 broadcast standard, ATSC A/341 Video – HEVC [2], specifies the carriage of AFD and bar data in HEVC video streams. SMPTE ST 2016-1, “Format for Active Description and Bar Data,” [12] specifies how AFD and bar data are originated for conveyance through the production and distribution processes.

Bar data signals the extents of the letterbox bars or pillarbox bars, specified in numbers of video lines or pixels respectively, and provides a finer resolution mechanism for the signaling of non-essential areas in the Total Image, especially in cases where the Active Image’s aspect ratio is other than 4:3, 14:9 or 16:9. Subtracting the bar areas from the Total Image yields an Active Image or “area of interest” that represents essential content.

Although this document provides guidance for content involving Active Images having 14:9 aspect ratios, such content is not likely to be encountered.

AFD and bar data are not mutually exclusive alternatives, but should be applied in concert to allow receiving and display devices to determine the proper framing of the image and the exact extent of its Active Image boundaries. The relationship between AFD and bar data is discussed in ATSC A/53 Part 4 [1] Section 6.2.5 and their use is explained in this document.

5.1 Aspect Ratios

In the consumer electronics (CE) industry, aspect ratios are typically expressed using HORIZONTAL:VERTICAL notation and include the ratios 4:3, 14:9, 16:9 and wider than 16:9.

The aspect ratio of the various components of a Total Image delivery system may vary. For example, the aspect ratio of

- the Coded Frame on the compressed interface,
- the Picture on an uncompressed interface,
- the Active Image (i.e. useful area) within a Coded Frame or Picture,
- the physical screen of the display device

may not all be the same. Therefore, a Total Image may encounter different aspect ratios as it flows from a creator to a viewer, perhaps as it is transferred via Coded Frame through a packaged-media, satellite, cable, terrestrial broadcast, or Internet-based delivery system to a set-top-box or player – then over an uncompressed analog or digital interface connecting local components within the home (see Section 5.2 below).

Where aspect ratio transitions occur, Total Images may need to be cropped, padded and/or scaled in order to adapt to the aspect ratio at each particular processing point. Active Format Description and bar metadata signaling can be used to help optimize this mapping process, by indicating incoming aspect ratio and which portions of an incoming Coded Frame or Picture is intended to be displayed. Improper interpretation of (or even ignoring) such metadata signals may lead to sub-optimal presentations. This document provides recommendations in an attempt to mitigate certain undesirable effects.

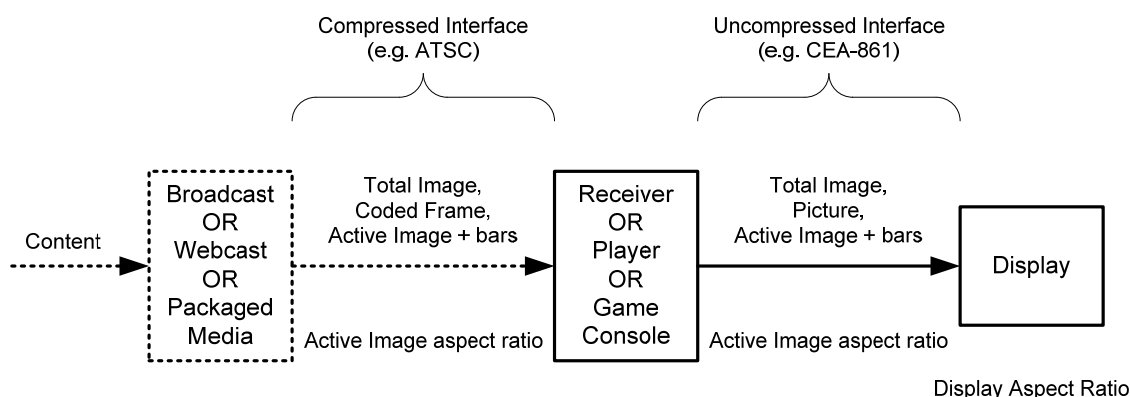


Figure 1 System Block Diagram & Terms

5.2 Examples of Interfaces

Figure 2 - Figure 5 show four examples of cable/terrestrial broadcast receivers connected by analog or digital interfaces to 4:3 or 16:9 monitor/displays. These setups illustrate various characteristics of aspect ratio and AFD signaling, as well as options possible within the video decoder and the processing elements within the display device. While CEB16-B recommends AFD and bar data signaling on the interfaces shown, the display formatting recommendations in CEB16-B apply equally to integrated receiver-display products.

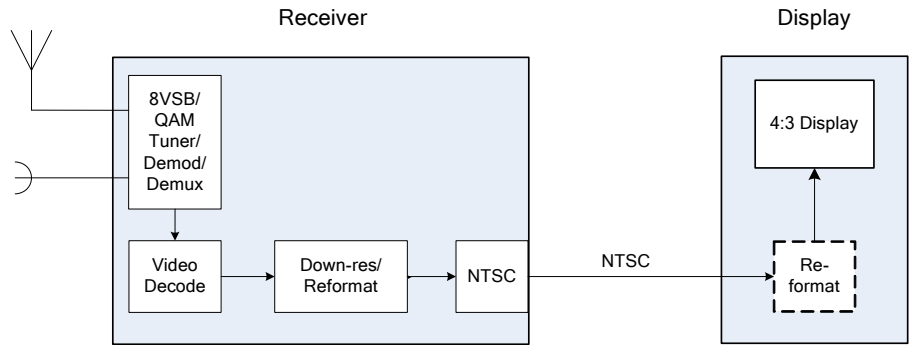


Figure 2 NTSC Interface to 4:3 Display

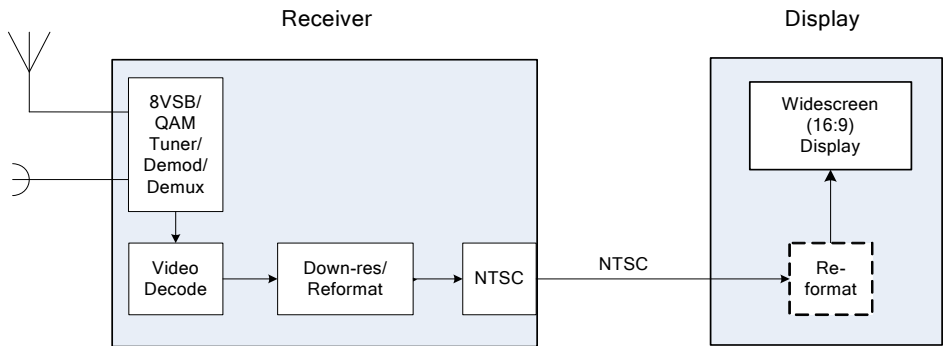


Figure 3 NTSC Interface to 16:9 Display

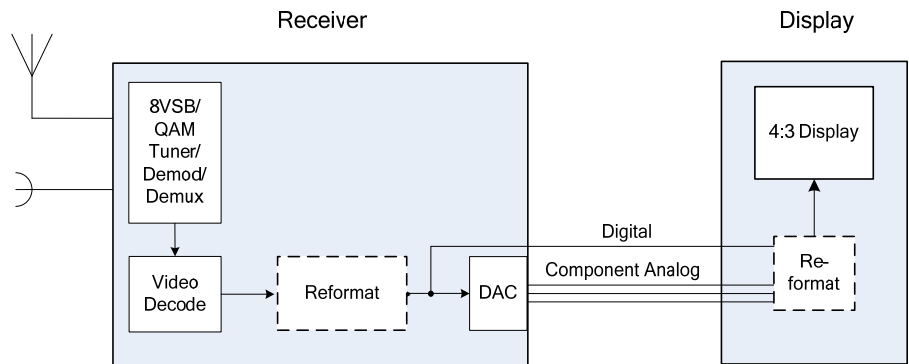


Figure 4 Digital or Component Analog Interface to 4:3 Display

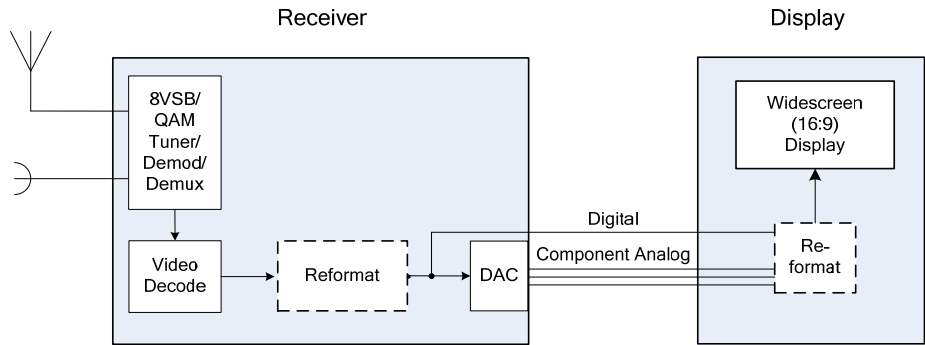


Figure 5 Digital or Component Analog Interface to 16:9 Display

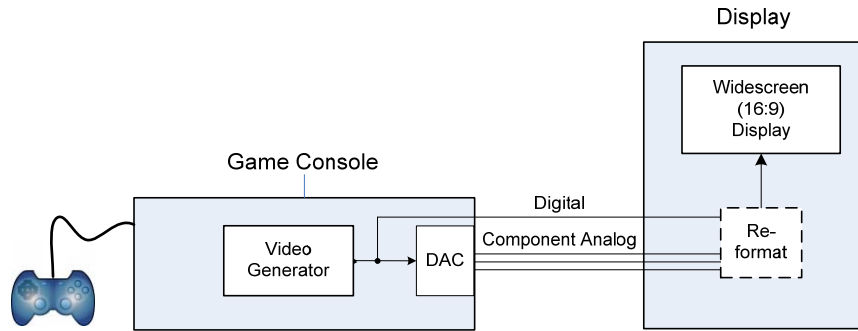


Figure 6 Game Console Interface to 16:9 Display

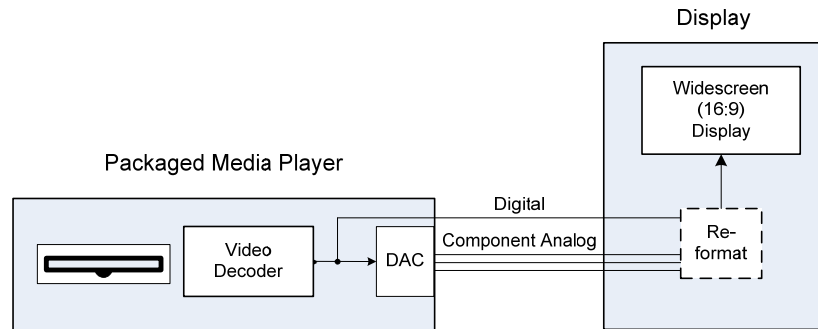


Figure 7 DVD/Blu-Ray Disc™ Player Interface to 16:9 Display

In Figure 2 - Figure 7, the dotted lines in the blocks labeled “reformat” indicate the function may or may not be present in any given implementation. In some instances, CTA-CEB16-B recommends the presence of certain reformatting functions. The video decoder in the receiver may be capable of more than simply decoding compressed video. It may, for example, be able to perform operations such as extraction of a 16:9 Active Image from within a 4:3 Coded Frame, or extraction of a 4:3 Active Image from the center of a 16:9 Coded Frame. Likewise, the display may be able to perform operations on the incoming Total Image prior to display. Examples of display-side image processing include scaling the image to crop areas at the top and bottom or left and right (eliminating letterbox or pillarbox bars) to optimize the image to better fit the physical display.

In Figure 2 and Figure 3, the receiver includes the capability to down-convert HD video formats to standard definition 480i for output on an NTSC analog interface. The resulting NTSC signal may be intended for displays having either 4:3 or 16:9 Display Aspect Ratios. If intended for a display having 4:3 Display Aspect Ratio, the image may or may not have a 16:9 Active Image letterboxed within the 4:3 Total Image. Standard signaling within the Vertical Blanking Interval (VBI) of the NTSC waveform signals which of the three cases applies. In Figure 2, the Display Aspect Ratio is 4:3, while in Figure 3 it is 16:9.

Figure 4 and Figure 5 include analog and digital interfaces capable of supporting high-definition resolutions. The digital interfaces are per CTA-861 [7] and HDMI [8]. The analog interface conforms to CTA-805 [6], which specifies data carriage on analog Component Video Interfaces (CVI) as described in CTA-770.2 [4] (for 2H 480p signals) and CTA-770.3 [5].

Video signals containing AFD signaling may originate from non-broadcast sources as well. In the example shown in Figure 6, video originates from a game console. Figure 7 depicts video originating from a packaged media player such as a DVD or Blu-Ray Disc™ player. Non-broadcast sources may output the same types of video signals to the display as broadcast video sources.

6 Standard Interface Signaling Methods

As mentioned, transport and definition of AFD is defined in ATSC A/53 Part 4 [1] Section 6.2.4 and ATSC A/341 [2] Sections 6.4.1 and 6.4.2. The following sections review standards for signaling defined within the interfaces shown in Figure 2 - Figure 7.

6.1 NTSC and 480i Component Analog

NTSC composite and S-video outputs, as well as 480i formats on component analog outputs, use the timing and VBI data format of the standard NTSC waveform. IEC 61880 [11] and JEITA CPR-1204 [9] define a 20-bit identification signal inserted into VBI lines 20 and 283 of an NTSC signal (or the luminance channel of a CVI when the format is 480i). The first two bits are relevant (the others are for Copy Generation Management System-Analog (CGMS-A)), and the meanings are as shown in Table 1. CTA-608 [3] defines CGMS-A.

Code Value	Aspect Ratio	Picture Display Format
00	4:3	Normal
01	16:9	Anamorphic
10	4:3	Letterbox
11	Not defined	

Table 1 IEC-61880 Aspect Ratio Coding

6.1.1 Uncompressed Digital and Other Component Analog

CTA-861 [7] describes an interface for uncompressed digital video while CTA-805 [6] describes a method for carrying data within component analog interfaces (analogous to VBI in an NTSC waveform). Both CTA-861 and CTA-805 define signaling for and transport encapsulations of AFD and aspect ratio data. In both cases, AFD is carried as a four-bit field encoded the same as the **active_format** field in the AFD of [10]. CTA-805 specifies how data is carried on 480i component video interfaces.

For these video interfaces, the Coded Frame of the compressed video case becomes the Picture carrying the Total Image being transmitted. AFD signaling across the component analog interface, for example, can indicate that the Active Image has a 4:3 aspect ratio and is carried within the 16:9 Total Image (or Picture). The display device may respond to this information by reformatting the displayed image and may substitute another light level outside the Active Image for those areas known to be outside the Active Image.

6.2 AFD Data

AFD values are most often used to indicate that a 16:9 or 14:9 Active Image is present letterboxed within a 4:3 Total Image, or that a 4:3 Active Image is present in pillarbox format within a 16:9 Total Image. (These combinations are illustrated in Tables 2 through 22 and Figure 9).

When the aspect ratio of the Active Image is not one of these standard values (for example, origination from a widescreen theatrical film), none of the AFD values is correct. In these cases, the AFD codes '0000' or '0100' should be used, accompanied by bar data that defines the exact vertical extent of the Active Image to be displayed. See Table 2 and Table 13.

In addition, three AFD values are available ('1101', '1110', and '1111') to signal that a content artist has purposely identified a specific area of the image that is essential for conveying intent. The image area outside of this "protected" area may be cropped or scaled from the final presentation.

In an MPEG-2 video stream, AFD is transmitted within the picture **user_data()** as indicated in ATSC A/53 Part 4, Section 6.2.4 [1]¹. CTA-861 [7] and CTA-805 [6] describe transport encapsulation of this data for carriage over uncompressed digital and component analog interfaces. For HEVC video compliant with ATSC 3.0, AFD is transported as defined in ATSC A/341 [2] Sections 6.4.1 and 6.4.2.

¹ In an AVC video stream, AFD is carried in supplemental enhancement information (SEI) syntactic elements.

6.2.1 Bar Data

If the aspect ratio of the Active Image does not exactly match the values 16:9, 14:9, or 4:3, the content or service provider should use the AFD codes '0000' or '0100' accompanied by bar data to provide a pixel-accurate indication of the Active Image. AFD '0100' signals that the Active Image has an aspect ratio wider than 16:9, as would be the case with a widescreen feature. AFD '0000', when accompanied by bar data, signals that the Active Image is narrower than 16:9, but not 4:3 or 14:9. This case is expected to be rarely encountered.

If AFD '0000' is present, but not accompanied by bar data, its meaning is the same as if no AFD were present.

For letterboxed images, bar data indicates the number of black video lines at the top and bottom of the frame, while for pillarboxed images, it indicates the width in pixels of the bars on the left and right of the frame.

NOTE—Individual bars are not required to be of equal width. A zero dimension bar is permitted.

Subtracting the bar areas from the Total Image yields an Active Image or “area of interest” that contains the essential information. Bar data is the only method for signaling aspect ratios other than 16:9, 14:9 or 4:3. Since it can signal almost any Active Image aspect ratio, it is more accurate than AFD data. Bar data is transmitted within the MPEG-2 video stream in the picture **user_data()** field as indicated in ATSC A/53 Part 4 Sections 6.2 & 6.2.3.2 [1]. For HEVC video compliant with ATSC 3.0, bar data is transported in accordance with ATSC A/341 [2] Sections 6.4.1 and 6.4.2. CTA-861 [7] and CTA-805 [6] describe transport encapsulation of this data for carriage over uncompressed digital and component analog interfaces. Additional information on bar data may be found in CTA-CEB16-B Section 8.

7 AFD Processing

Display devices should use the aspect ratio and AFD signaling to produce an optimal image presentation, especially when such response minimizes or eliminates user intervention. Various display conditions are illustrated in the tables included in CTA-CEB16-B, including recommendations for optimal display.

The preferred or Recommended DEFAULT presentation is provided to indicate the optimal display condition, which should involve no geometric distortion of the displayed image. Other display modes may be offered, including manual user-selections. For displays with integrated decoders, the response to aspect ratio and AFD signaling should be equivalent to that of a separate decoder and display.

AFD '0100' signals that the Active Image has an aspect ratio wider than 16:9. As the exact aspect ratio cannot be conveyed by AFD alone, video signals coded with AFD '0100' should be accompanied by bar data, and displays should use this bar data to determine the exact vertical extent of the Active Image.

AFD '0000', when accompanied by bar data, signals that the Active Image has an aspect ratio narrower than 16:9, but not 14:9 or 4:3. As the exact aspect ratio cannot be conveyed by AFD alone, video signals coded with AFD '0000' should be accompanied by bar data, and displays should use this bar data to determine the exact vertical or horizontal extent of the Active Image. If bar data is not present, AFD '0000' should be treated as if no AFD were present. See Table 11, Table 12, Table 21 and Table 22.

Receivers with video outputs should offer a user setup mode allowing the selection of support for either 4:3 or 16:9 Display Aspect Ratios.

7.1 480i Formats

Analog outputs in 480i format intended for display in 16:9 format should include line 20 signaling per IEC 61880 [11] (CPR 1204 [9]) to indicate 16:9 format, when (by user setup option) the output is being fed to a WSS-capable widescreen display or compatible recorder.

7.2 Illustrated AFD Recommendations

Recommended receiver response to active format and aspect ratio signaling are illustrated in this section. Section 7.2.1 describes the situation where a 4:3 aspect ratio is signaled in the compressed video;

Section 7.2.2 covers the 16:9 aspect ratio case. The tables show, in the leftmost column, the format of the incoming Coded Frame. These tables also show, for each incoming signal format, the aspect ratio and AFD setting, the recommended decoder response, and the recommended signaling across uncompressed analog or digital interfaces on the decoder output. Recommended receiver behavior is documented for eight of the 16 possible AFD states. These are expected to be the only ones likely to be encountered in practice. For all other states, AFD should be treated as if not present. The information contained in the tables may be the same for some AFD values because any of the values in this range may be encountered. There is no illustration for '0000', as its shape is determined by bar data, if present, and either letterbox or pillarbox bars may be used depending on the aspect ratio of the incoming image. See Sections 5.1.3 and 5.1.4. Except for '0100,' defined AFD values in the range '0001' to '0111' should be rarely encountered; these values are not addressed in CTA-CEB16-B.

In some cases, the recommendation involves display processing in response to aspect ratio and AFD signaling to create the optimum display. In other cases, processing on the source side can be done to output the optimum signal for direct display (to address the case that the display is unable to perform reformatting). CTA-CEB16-B recommends the resulting images illustrated. Other display options are shown, but not recommended.

In the tables in Sections 7.2.1 and 7.2.2, the rows relating to NTSC interfaces (as diagrammed in Figures 2 and 3) are highlighted with gray shading. The rows displayed with white background relate to interfaces capable of re-encapsulating complete AFD and barcode data. The "n.a." ("not applicable") notation indicates the signaling does not apply to that type of interface.

In the image format illustrations in the tables in Sections 7.2.1 and 7.2.2, the meaning of the shaded areas is:

-  Indicates the portion of the Active Image which may be cropped for optimum display as appropriate to the aspect ratio of the display screen
-  Indicates a matte, often black, which is transmitted as part of the video Coded Frame to fill the area outside the Active Image
-  Video/static level, typically black, generated by the receiver (either in the decoder or display)

Closed circles are provided as an aid to visualization. See also Annex B.

In the tables in Sections 7.2.1 and 7.2.2, the use of the word Default in the Comments columns means it is a receiver recommended initial default condition, i.e., after first receiving the aspect ratio signal and before any user aspect ratio control selections are made at the receiver. Numerical values for the geometrical relationships of the aspect ratios are shown in Annex B.

7.2.1 Transmissions with MPEG = 4:3

Table 2 through Table 12 provides recommendations for images transmitted in a 4:3 Coded Frame.

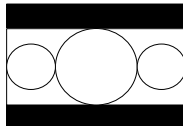
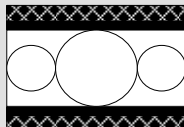
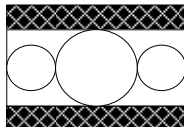
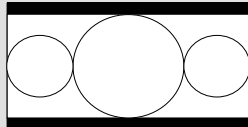
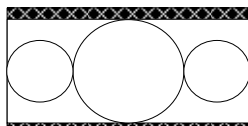
Transmission		Receiver							
Transmitted Signaling		Display Aspect Ratio	Receiver Format Conversion	Output Signaling			Display Action	Display Appearance	Comments
MPEG 4:3	AFD '0100' (Note 1)			WSS Line 20 Bit 1,2	CTA 861 R3..R0	CTA 805 R3..R0			
Greater than 16:9 Letterbox Image 		4:3	None	'01' 4:3 Letterbox	n.a.	n.a.	Substitute black or gray in area outside 16:9 if desired		
			None	n.a.	'0100' + bar data (Note 2)	'0100' + bar data (Note 2)	Substitute black or gray in bar areas if desired		
		16:9	None	'01' 16:9 Letterbox	n.a.	n.a.	Scale image to match horizontal display width		
			None	n.a.	'0100' + bar data (Note 2)	'0100' + bar data (Note 2)	Scale image to match horizontal display width. Substitute black or gray in bar areas if desired		
Note 1—This AFD value is expected to be used only when the aspect ratio of the content is greater than 16:9 (1.77:1). One example is content originally created for the cinema, such as a 'scope' feature with an aspect ratio of 2.40:1.									
Note 2—When bar data is available.									

Table 2 MPEG 4:3 AFD Value '0100'