Navigating the DTV Transition: How Broadcasters are using AFD to Maintain Formatting Control of their Programming

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INTRODUCTION

The 2009 Analog Shutdown is quickly approaching and television broadcasters have been preparing throughout this year. As programming content will continue to originate in both SD and HD for many years, broadcasters have been forced to find ways to maintain the presentation quality for each home viewer after the February 17, 2009 deadline.

In 2007, SMPTE standardized Active Format Description (AFD) with SMPTE 2016-1 and 2016-3. AFD has become the cornerstone of a number of broadcasters' strategies for management of aspect ratio throughout the delivery path to the home. With thousands of different touch points, end-to-end deployment of AFD has been a challenge, but significant progress has been made.

How do broadcasters plan to utilize AFD in the post DTV transition landscape? What steps have been taken to deploy AFD throughout the end-to-end delivery path to the home?

This paper will answer these questions and provide technical background on many of these issues.

DUAL ASPECT RATIO CHALLENGES

The amount of high definition programming available to home viewers has grown considerably over the past few years. In this environment, television broadcasters are faced with challenges on how to best format and deliver their content to both HD and SD audiences.

When HD programming was introduced by broadcasters, a parallel production and distribution process was most commonplace. For scripted programming, two unique versions of a show were normally provided by the content providers – i.e. an HD version and an SD version. For live programming, two separate control rooms and production groups were often utilized. One of the main benefits of this approach was being able to maintain full control on how programming was viewed by both HD and SD audiences. See examples below.

HD 16:9 Version

SD 4:3 Version

Figure 1: Example of 16:9 and 4:3 Shot Selection

With a changing distribution landscape and increasing cost pressures, broadcasters have been forced to move towards a more efficient single production / single delivery approach. In this model, a single version of content is produced and delivered in HD. The SD version is derived from the HD version through a down-conversion process.

The most common methods of down-conversion are referred to in this paper as “center-cut” and “letterbox” as illustrated below.

Original HD 16:9 Image *Letterbox Result* *Center-Cut Result*

Figure 2: Letterbox and Center-cut Down-conversion Illustrations

The use of down-conversion to generate SD from HD introduces certain restrictions on how each version can be presented to viewers. As the aspect ratio of HD (16:9) and SD (4:3) formats differ, certain decisions must be made on how to reformat the original HD signal into SD.

Producing HD content for center-cut SD delivery requires producing content that is “center-cut” safe. “Center-cut safe” refers to video content with no important details on the left and right sides of the screen. This content can be center-cut to generate a properly displayed full screen 4:3 image.

However, for HD content that takes full advantage of the entire 16:9 frame, a center-cut down-conversion can result 4:3 content with that is missing important details. The examples below illustrate how full frame HD content can be adversely affected when center-cut.

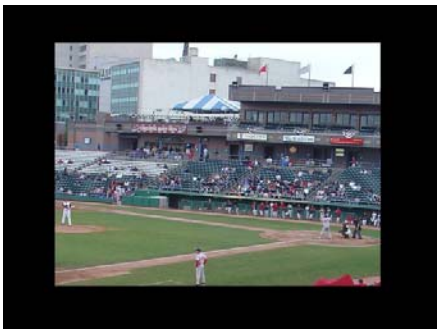
HD 16:9 Original *4:3 Center-Cut Version*

Figure 3: Example of Adversely Affected Center-Cut Down-conversion

The preferred down-conversion method by many HD content providers is letterbox. Letterbox down-conversion is the best way to insure that all image details from the original HD program is preserved for the 4:3 SD audience.

However, much of the content in HD distribution paths is up-converted from SD sources. When up-converting 4:3 SD signal to HD, the result is a “pillarbox” representation (with black bars on the right and left sides of the 16:9 frame. Letterbox down-conversion of this material will result in a “postage stamp” representation. See below.

HD 16:9 Original (Pillarbox)



Letterbox Version (Postage Stamp)

Figure 4: Example of Adversely Affected Center-Cut Down-conversion

Most HD broadcasters will continue to have a mixture of both HD and SD originated content for many years. Locking into a specific down-conversion format (center-cut or letterbox) will force broadcasters to make compromises on the presentation quality for HD and SD viewers.

DYNAMIC ASPECT RATIO CONTROL WITH AFD

AFD (Active Format Description) is a method of describing aspect ratio and picture characteristics of video signals. It has been used to control how television sets optimally display pictures transmitted with varying aspect ratios.

In 2007, SMPTE released SMPTE 2016-1 and 2016-3. With these new standards AFD codes were updated and a method of carrying AFD within base band SDI video signals was defined.

One of the first implementations of the new standard was dynamic of aspect ratio on base band video format converters. These AFD supported down-converter devices opened the door for new production and distribution methods optimized for dual format delivery.

The table below describes the most commonly used AFD codes along with their usage for HD to SD down-conversion.

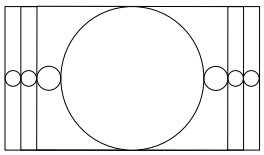
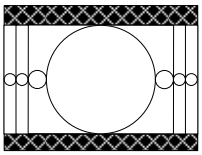
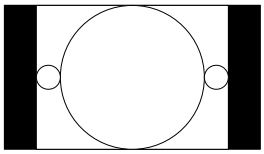
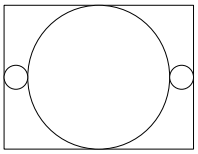
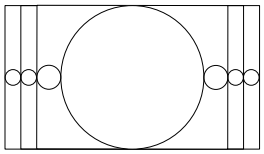
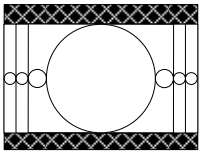
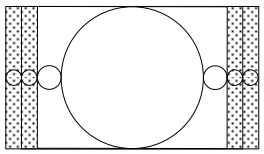
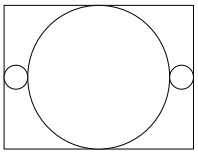
AFD Code	Aspect Ratio	Description of HD Signal	Original HD Image	Description of Down-converted SD Signal	Down-converted SD Image
'1000'	16:9	Full frame 16:9 image. Not Center-cut Protected		16:9 Letterbox in 4:3 Frame	
'1001'	16:9	Pillarbox 4:3 image. From 4:3 Originated material		Full frame 4:3 Image	
'1010'	16:9	Full frame 16:9 image. Not Center-Cut protected		16:9 Letterbox in 4:3 Frame	
'1111'	16:9	Full frame 16:9 image. Center-Cut Protected		Full frame 4:3 Image	

Figure 5: AFD Usage for HD to SD Down-conversion

The following sections of this paper focus on AFD based solutions that are in use today along with guidelines on how existing technology can be used to help navigate the DTV Transition.

While AFD can be used for a wide range of solutions, the following implementation pieces are covered in this paper.

1. AFD Authoring
2. AFD Data Preservation
3. AFD Controlled Down-conversion

PRODUCTION SCENARIOS

One of the main benefits of AFD is to provide the ability for program providers to maintain creative control of their content. With proper use of AFD, broadcasters are able to maintain this creative control by allowing the audience to view content as the content creator originally intended.

Within the production process, the most proven use of AFD is applied at the final stage of production – not on individual production elements. Within this model, the proper AFD code is recorded onto the final version of content as it will be aired – whether is be a live show, recorded program or commercial spot.

From an operational standpoint, a predefined down-conversion format should be assigned to HD programs or commercial spots through application of the proper AFD code.

For live programming produced from a control room, a device can be used to insert the proper SMPTE 2016-3 AFD code into the main program output. This will help to insure that the proper AFD code is attached to the final version for air and available to all down-stream distribution systems.

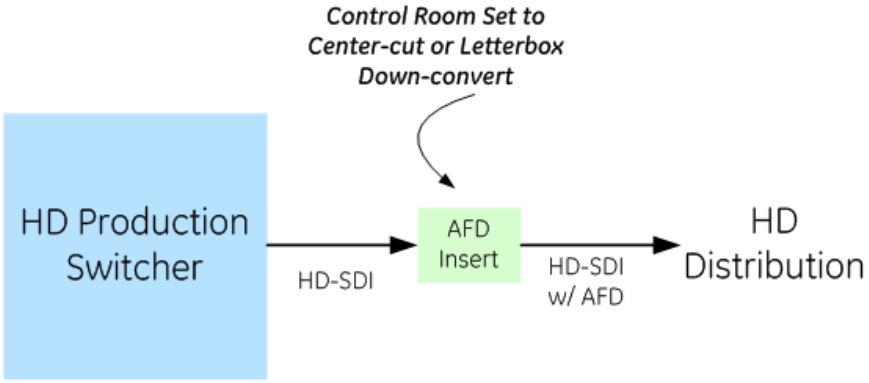


Figure 6: AFD Insertion in Live Control Room

For pre-produced programming, a number of options are available for AFD authoring. If the output of the production session is HD-SDI, the same SMPTE 2016-3 AFD insertion described above can be affectively utilized.

For finished content that is delivery via tape (e.g. commercial spots) or base-band video (e.g. from edit rooms), the appropriate AFD data can be authored during the ingest process as shown below. Using this model, a process should be established to allow the content providers to select how their HD content should be down-converted.

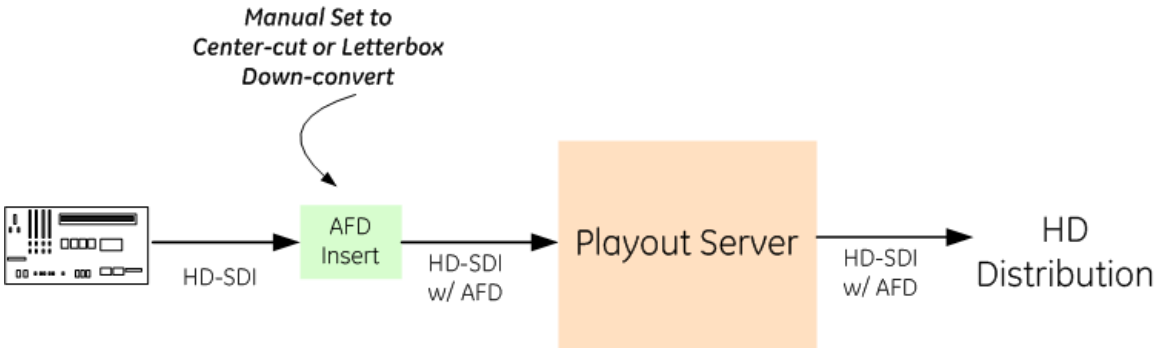


Figure 7: AFD Insertion during Ingest Operation

With file based transfers from NLEs (Non-linear editing systems) to play-out servers becoming more common, AFD insertion in this domain has also been successfully implemented. This production workflow allows for finished NLE projects to be automatically transcoded and transferred to play-out servers without the need for going back to baseband video. As illustrated below, a completed project can be transcoded and transferred directly to a playout server with the desired AFD code attached.

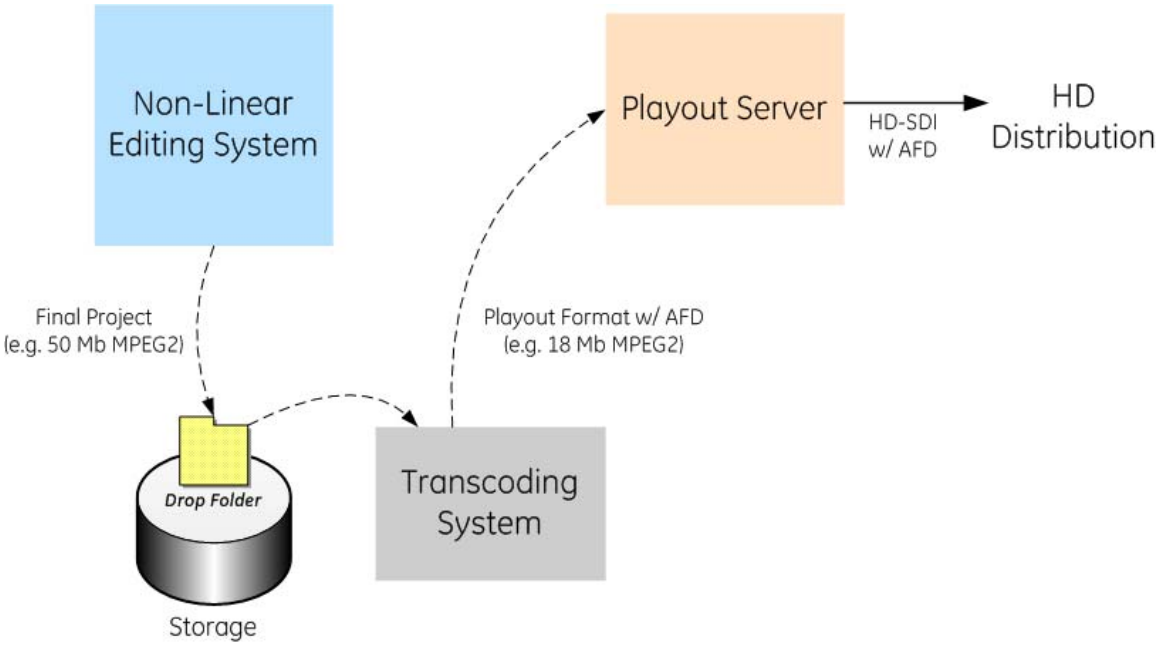


Figure 8: File based AFD Insertion

Note: Many HD servers preserve VANC on ingest and play-out. However, each manufacturer has a proprietary method of storing VANC information in their internal file formats. For this reason, simple file transfers in and out of play-out servers may result on the loss of AFD data. Limiting these types of file transfers between the same manufacturer models will help to protect against AFD data loss. File compatibility and VANC preservation must be tested and established.

DISTRIBUTION AND AFD PRESERVATION

As discussed in the previous section, ensuring that AFD data is encoded on final versions of content is the first important step in establishing a successful AFD driven process. Ensuring that the AFD data is preserved through downstream signal path within the broadcast facility is just as critical.

AFD data in accordance with SMPTE 2016 is carried in the VANC (Vertical Ancillary Data Space) of SDI video signals. Specific attention should be paid toward ensuring all downstream video processing systems (e.g. video routers, switchers, DAs, frame syncs, etc) will reliably pass VANC data uncorrupted. The following specific recommendations should also be considered.

1. **Focus on HD Signals**. System designs should be focused on carriage of AFD data in the HD-SDI signals for the purposes of down-conversion to SD. Most legacy SD devices have been found to strip out any VANC data present in the video signal, so systems designs should not rely on AFD data within SD signals.
2. **Select Video Line location**. Select a specific video line location to carry AFD data to be followed plant-wide. This will be essential for quality control and troubleshooting throughout the signal path.
3. **Avoid multiple AFD codes**. For any AFD inserting system that is implemented, specific care should be taken to avoid the introduction of multiple AFD codes in a single video stream. This can cause adverse affects in many AFD supported systems.
4. **Insert AFD on Up-conversion**. SD originated content must go through an up-conversion process before being inserted into a facility's HD distribution path. Where possible, the proper AFD code should be inserted at the point of up-conversion. Many up-conversion devices allow for this and will help to ensure that the AFD code will be available throughout the facility.

Despite best efforts to encode program specific AFD codes, mechanisms should be put into place to insure that a default AFD code is automatically inserted into video streams when authored AFD data is not present. This is best handled close the final distribution point out of the facility as shown below.

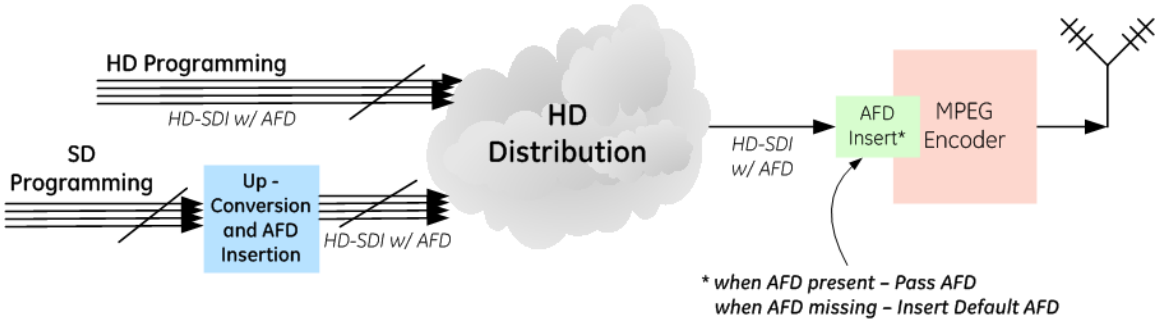


Figure 9: Down-stream AFD Paths

DISTRIBUTION TO THE HOME

After the DTV Transition, most cable and satellite providers will continue to provide broadcast network signals on their analog tier (or digital SD channels), but will no longer have off-air NTSC signals available to do so. Cable and satellite providers will down-convert HD signals from local stations to provide these SD services to their subscribers.

Leading up to the February 2009 Transition, cable and satellite providers will be installing new PIRD (Professional Integrated Receiver/Decoder) devices within their head-end / local collection facilities. These new devices will down-convert the DTV signals from local stations for delivery to their SD subscribers.

Most of these new PIRD devices include support for AFD controlled down-conversion. If AFD data is properly encoded into the local stations' DTV signals, cable and satellite providers will be able to automatically create properly formatted SD signals as shown below.

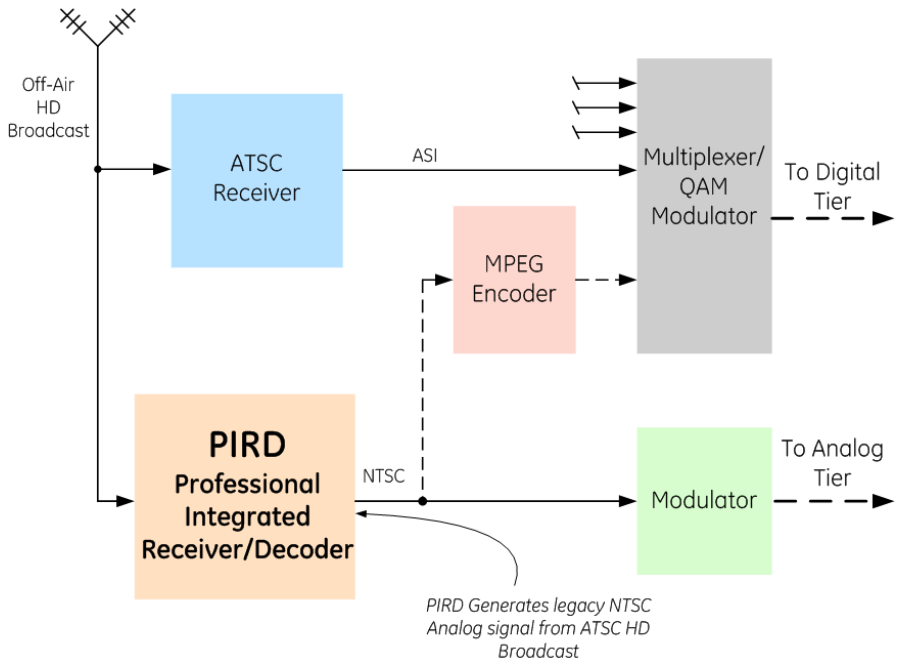


Figure 10: Head-end Signal Path with AFD

CONCLUSION

Proper aspect ratio management will be critical for preserving creative control of programming after the DTV Transition. The use of AFD technology can improve the capability for program providers to deliver content to their audience exactly as they intend.

AFD will not solve all of the aspect ratio challenges, but existing technical solutions have been proven to be successful at providing the flexibility needed by broadcasters. The paper has outlined some specific examples of successful end-to-end AFD implementations. As AFD usage expands and technology solutions mature, more advanced uses are sure to emerge.

BRIEF BIOGRAPHY OF THE AUTHOR

Clarence Hau is Director of Systems Engineering at NBC-Universal. During his 4 years with NBC-Universal, he has led key technology initiatives for the NBC Network, including local affiliate branding and mobile content distribution. Most recently, he has been leading the DTV Transition Technology efforts for NBCU including the AFD Ready Initiative.

Clarence holds an MS degree in Electrical Engineering from the University of Michigan and a BS degree in Electrical Engineering from Drexel University. Prior to joining NBC-Universal, Clarence held positions with Pinnacle Systems and Panasonic.