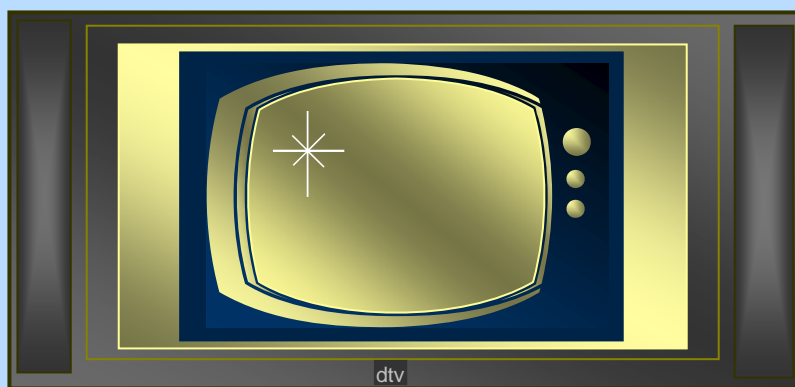


ASPECT RATIO ISSUES and GUIDELINES



FINAL

MARCH 30, 2005

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1. INTRODUCTION

CANADIAN DIGITAL TELEVISION (CDTV) has prepared this reference document on Aspect Ratio in television systems to help the broadcast, consumer electronics and production industries understand and deal with this issue during the transition to widescreen digital high definition television in Canada.

The transition to wide screen high definition television is occurring in North America from production, broadcast and delivery to the consumer television display. A widescreen high definition (HD) television picture uses an aspect ratio (the ratio of picture width to picture height) of 16:9 which is wider than the 4:3¹ ratio used by conventional standard definition (SD) television. The problem in Canada is that both HD and SD are going to be around for some time and this will mean working with two aspect ratios for many years to come. The challenge during this transition will be to ease the difficulties related to handling the two aspect ratios while ensuring that objects in the picture retain their original shape, regardless of the aspect ratio and display being used, with minimal impact on quality and on what content is viewable.

To minimize the difficulties during this period of transition, and ensure Canadian product will have adequate shelf life and appeal to the international market, the industry is urged to produce programs in HD format, which is inherently wide screen. Opinions among programmers differ as to how best to present wide screen content on 4:3 based services and 4:3 content on 16:9 services, largely because decisions depend on the type of programming content and service. However, there is agreement on one critical item:

To best prepare our industry, the more Canadian programming product that can be produced in HD, the better.

The following section in this Document provides an overview of core widescreen issues from a Broadcast, Service and Target Display perspective. Separate modules are provided in Sections 4.0 and 5.0 addressing specific issues for Producers and Broadcasters. Section 6.0 illustrates a possible transition for the industry, from today's mainly 4:3 environment, to one where 16:9 is the norm. Section 7.0 provides guidelines for Broadcaster consideration in the development of internal policies to ease the transition in Canada

A glossary of terms is included in Annex 1.

¹ 16:9 ratio is verbally referred to as "16 by 9" and 4:3 as "4 by 3."

2. WIDESCREEN AND THE CORE ISSUES EXPLAINED

The issues can be seen under two major conditions:

- 1) Broadcasting 16:9, either SD or HD programs on a 4:3 SD service
- 2) Broadcasting 4:3 SD programs on a 16:9 HD or SD service

These conditions create issues for production and displays as well.

2.1. Broadcasting 16:9 on a 4:3 SD service

Prior to transmission to the viewer, broadcasters may receive programs delivered in 16:9 in the following formats:

- A. 16:9 HD
- B. 16:9 SD Letterboxed within a 4:3 window
- C. 16:9 SD "Full Height Anamorphic" format

To integrate the 16:9 originated program within a 4:3 service, different treatments are available.

A. 16:9 HD

16:9 HD programs best position the broadcaster for HD broadcast, but for a 4:3 service must be down-converted to SD. Several choices exist in terms of presentation on the Standard definition 4:3 channel:

- If desired, the 16:9 image can be delivered in "letterbox" form. In this case, the resulting 4:3 image will have black bars (unused lines) at the top and bottom (letterbox). This approach is often desired for movie-based content where the viewer is expecting the original widescreen to be retained.
- Alternatively, a centre-cut approach (also referred to as "side-cut") may be desired. In this case, a converter will cut out a 4:3 image which will fill the entire 4:3 screen. Note that the centre-cut approach is easily accomplished if the original 16:9 content has been shot with the 4:3 window protected (i.e. "Shoot and Protect").

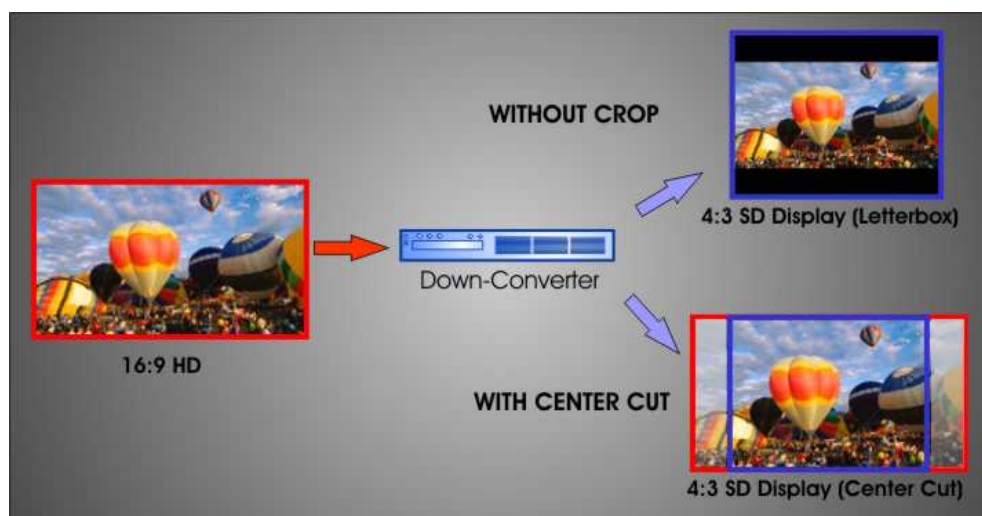


Figure A: 16:9 HD ON A 4:3 SERVICE

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B. 16:9 SD Letterboxed within 4:3 window

In this case an original image width has been used but the 4:3 image has black bars (unused lines) at the top and bottom. This format is ready for broadcast as letterbox. A center cut approach can also be taken. A 14:9 “compromise” is also possible that minimizes the loss of image content and shows less apparent black lines at the top and bottom of the picture. Either the original image width will be used but the 4:3 image will have black bars (unused lines) at the top and bottom (letterbox), or a 4:3 “center cut” portion of the 16:9 image will be used (original image height will be retained with portions of left and right discarded).

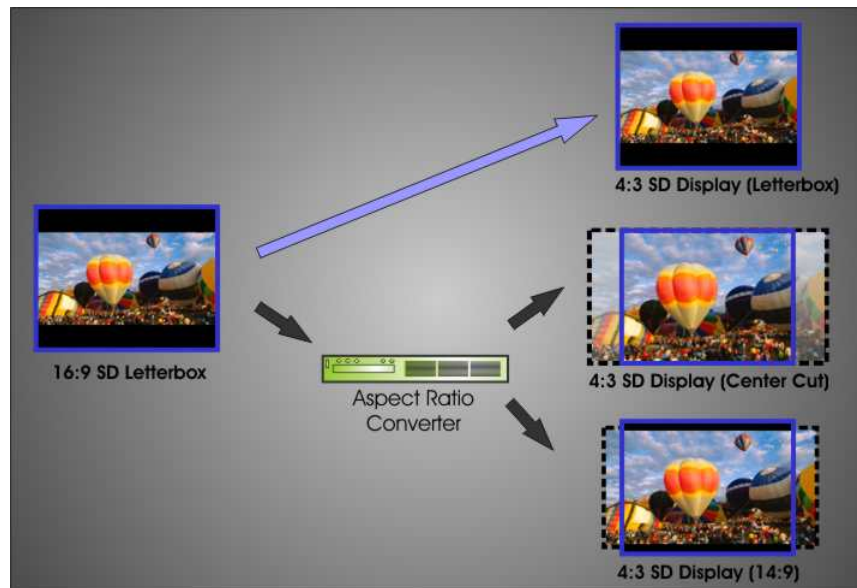


Figure B: 16:9 (Letterbox) SD ON A 4:3 SERVICE

C. 16:9 SD Widescreen (Full Height Anamorphic format)

While the 16:9 full height Anamorphic format is not currently common place, occasionally SD content is being produced using this approach, and broadcasters need to be aware of it. 16:9 full height Anamorphic format is also some times referred to as 16:9 SD Widescreen by some broadcasters. When a program is delivered to the broadcaster in standard definition full height Anamorphic format, all of the original 16:9 image information is retained for a full height widescreen display. This format provides the ability to easily handle 16:9 within a traditional 4:3 broadcast plant without the need for special equipment.

When viewed directly on a 4:3 screen in the broadcast plant, the images will appear elongated vertically as they will be squeezed horizontally to fit within the 4:3 raster. Due to past use in the industry of anamorphic camera lenses, the term “Anamorphic” can cause some confusion. Today, it is important to understand that all SD cameras with a 16:9 capture option will provide an anamorphic picture when displayed on a 4:3 screen. When displayed on 16:9 screen all of the 16:9 picture information is retained and will completely fill the full height and width of a 16:9 display. Once again choices are available in terms of program display on a 4:3 service.

For letterbox display, prior to broadcast, the top and bottom of the image will have to be reduced to reconstitute the 16:9 ratio but the resulting 4:3 image will have black bars (unused lines) at the top and bottom (letterbox). Alternatively, a 4:3 “center cut” portion of the 16:9 image can be used (original image height will be retained with portions of left and right discarded). Or, conversion for 14:9 display can be applied.

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Anamorphic format is of particular interest to broadcasters for Standard Definition content because it is easily handled within the 4:3 broadcast plant, and if the SD content is destined for High Definition, when up-converted the content will fill the complete 16:9 display. Note that the picture quality will not compare favourably to that of programs produced in true HD.

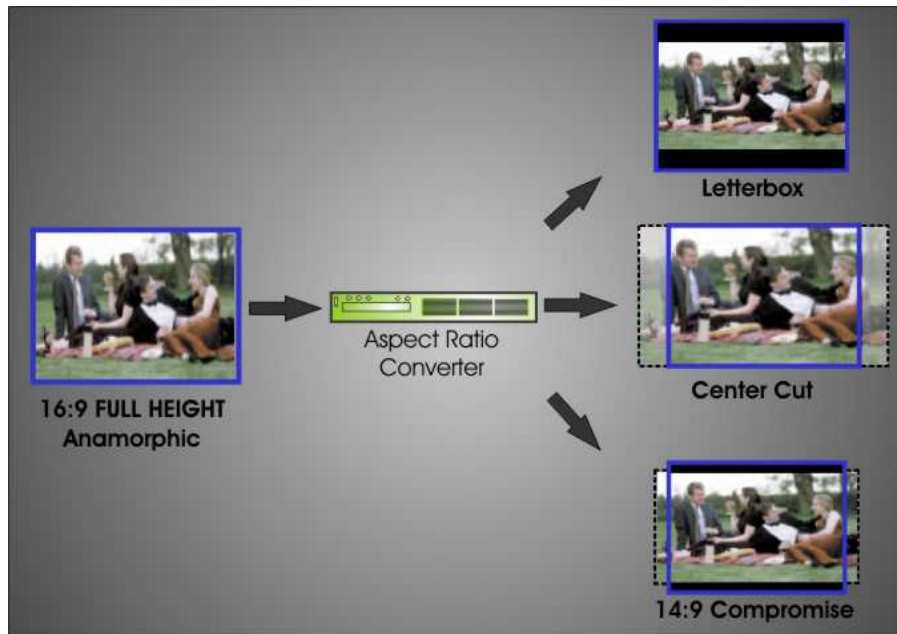


Figure C: 16:9 FULL HEIGHT ANAMORPHIC CONTENT ON A 4:3 SERVICE

2.2. Broadcasting 4:3 on a 16:9 HD service

Programming shot in 4:3 (either complete TV shows or program segments) will have to be up converted to the HD standard as follows:

- A. Using The Whole Picture
- B. Partial Expansion
- C. Full Expansion

A. Using the whole picture



This approach leaves black side panels on either side of the 4:3 image, also known as "pillarbox".

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B. Partial expansion



A compromise approach is 14:9 expansion. Much 4:3 picture programming will survive this partial expansion, but beware: graphics such as captions close to the bottom of frame could be cropped.

C. Full expansion



This mode is commonly used when 4:3 segments have to be included in a 16:9 production. Essentially, it involves zooming in to create a 16:9 picture from the desired portion of the 4:3 image.

This process may have to be done shot by shot, and while most shots can be made to work, frames carrying graphics may prove difficult. If using this option, picture quality may deteriorate, particularly if the original material is less than optimal.

To eliminate the need to compromise the picture for HD display, it is highly desired to increase the amount of content available in HD widescreen. When this is not possible, SD full height anamorphic format may provide the next best option. Decisions for broadcasters are discussed more fully in "Broadcaster Issues". First, it is important to understand the underlying concept of "Service" and "Target".

3. DEFINING THE “SERVICE” AND THE “TARGET”

When assessing how to deal with widescreen television, one must consider, the “Service” and the “Target.”

“Service” refers to the television delivery channel and the underlying capabilities of the technology used to deliver the signal to the viewer. *Is it 4:3 or 16:9?*

The “Target” refers to the television display device that the viewer will be using to view the material. *Is it analog, digital, 4:3 or 16:9? What are the capabilities of the set-top box connected to the display?*

3.1. The “Service”

Program services in Canada are available as over-the-air or through cable, satellite and MMDS (Multichannel Multipoint Distribution Service). Cable, satellite and MMDS also deliver the pay and specialty services. It is important to note that in Canada, analog and digital Standard Definition services are all 4:3, while HD services are 16:9.

Satellite and MMDS use digital technology for all services delivered but it is important to note that most of these are configured as 4:3 channels and only the HD channels are configured as 16:9.

Cable carries a mixture of analog and digital services. The analog channels, whether they are over-the-air or specialty services, are 4:3. The digital services are predominantly configured as 4:3. Cable does offer some 16:9 services but these are digital and are the HD capable channels.

Currently in Canada digital (Tier 1 & 2) cable channels as well as those delivered over satellite, are all native 4:3 services and have no short-term plans to convert their delivery platforms to widescreen.

Over the air broadcasters are only just starting to convert to digital transmission. They will maintain their analog 4:3 services for some time to come as there is no mandated shutdown of analog in Canada. These broadcasters are faced with simulcasting to their analog SD 4:3 channel and digital HD 16:9 channel for the foreseeable future. The 16:9 HD services are also fed to cable and satellite directly from the over the air broadcasters' operation centers.

3.2. The “Target”

The type of display or “Target” that a “Service” is delivering to must be considered.

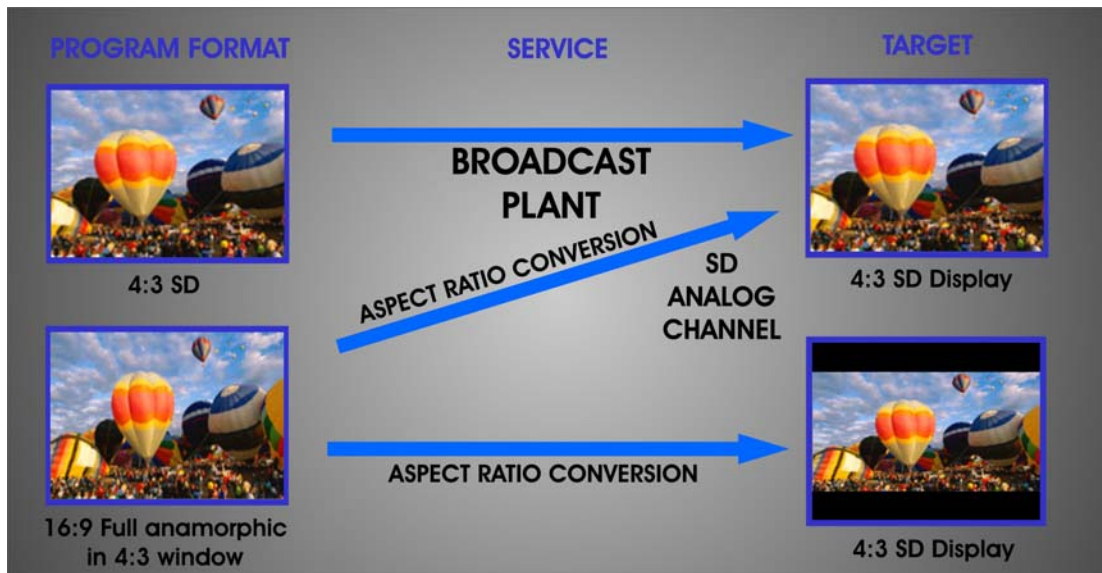
Today's display technologies fall into three main categories.

1. The 4:3 Analog “Target” (today's analog displays)
2. The 4:3 Digital HD “Target” (very few in the marketplace)
3. The 16:9 Digital HD “Target” (the future of all television displays)

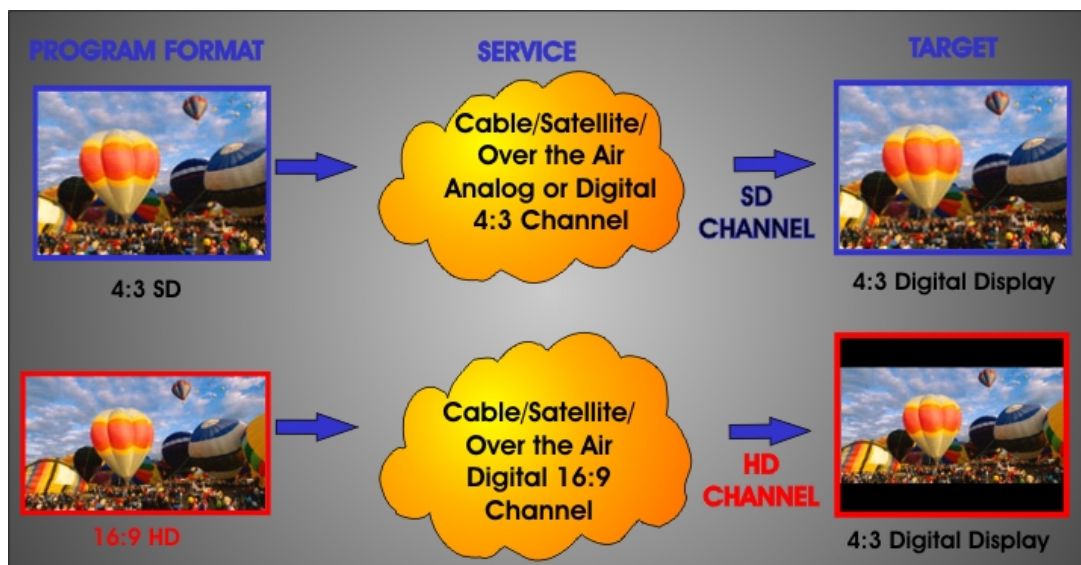
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The 4:3 Analog "Target" (today's analog displays)

Traditional "analog" services and standard definition "digital services" must consider this large existing base of 4:3 displays. These traditional displays directly reproduce the aspect ratio of the image received, with no capability to manipulate the picture. Hence, content delivered in "widescreen" will appear as "letterboxed" within the 4:3 screen (black bars top and bottom) assuming this conversion has been done at the broadcast plant.



The 4:3 Digital HD Target

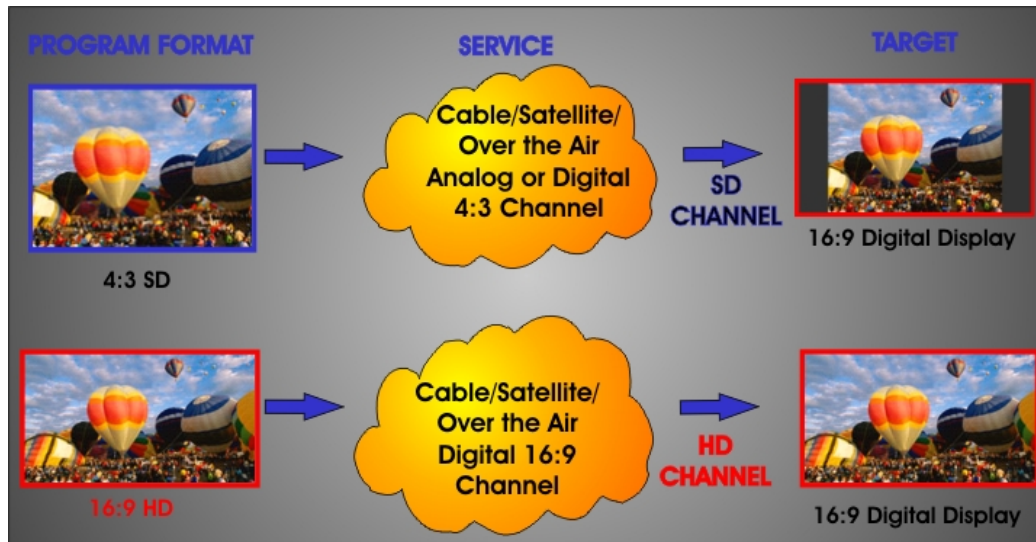


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This target, a 4:3 *digital* display, is seen to serve those viewers still predominantly watching 4:3 content but want the ability to see the occasional HDTV program. The HDTV content will always be in letterbox form on these sets. **With the consumer electronics industry committed to 16:9, these displays are not likely to become common in Canada, and hence not a major consideration for Canadian service providers.**

These HD displays can accept feeds from analog cable (RF), HD digital cable and HD DTH (direct-to-home) set-top boxes, DVD and DTV off-air.

The 16:9 Digital HD “Target”



These 16:9 HD displays can accept feeds from analog cable (RF), HD digital cable and satellite HD STB boxes, DVD and DTV off-air.

They have different types of inputs that can accept either Standard Definition (SD) only or High Definition (HD) capable signals. They are also equipped with considerable picture manipulation features which require in depth instruction. To further complicate matters the set-top boxes that are feeding these displays can process and alter the signal aspect ratio as well.

A more detailed explanation of interconnection and set-up issues is provided in Annex 2: “Receivers, Displays and Set Top Boxes.”

Uneven Screen Aging

It should be noted that when content which does not fill the full screen is displayed for a long period of time on some types of 16:9 displays, uneven screen aging can result. For example, when 4:3 content is displayed within a 4:3 window in the center of a 16:9 display, over time, the side panel portions of the screen will appear brighter than the 4:3 window in the center of the display. This is highly disconcerting to the consumer who has invested in a high end product. There is little a broadcaster can do to alleviate this problem with 4:3 services, and display manufacturers are now starting to include features such as “pixel shuffling” to mitigate this problem.

To ensure that 4:3 content shown within an HD (16:9) service does not contribute to this problem, the broadcaster can change the colour of the side panels to grey or a colour (other than black). Many broadcast up-converter products now contain this feature allowing change of side panel colour.

4. PRODUCTION ISSUES

The utilization of programs across 4:3 and 16:9 services creates challenges for the production community. As well, with expanding world markets and their increased segmentation, program producers and distributors seek more ways of benefiting from their new productions as such most new productions are being shot in a widescreen format. All new product expected to have an afterlife should be shot in HD format. When the budget is not available, productions can be shot in widescreen SD.

4.1. *Creating Widescreen SD Content for 4:3 and 16:9 Services*

A producer has two choices for delivery of widescreen content to a broadcaster if HD is not feasible. These are 16:9 SD Letterbox or 16:9 SD Widescreen (Full Height Anamorphic) and both approaches are compromises.

SD 16:9 letterbox allows a 16:9 image to fill the width of a 4:3 screen but only uses about 362 of the 483 lines that are available in SD. (NTSC has 525 total lines but only 483 are available for picture.) When this image is then up-converted to be shown on a 16:9 HD display, the image will appear as a small 16:9 image within the actual 16:9 display screen (postage stamp: see central screen shot, right hand column, Fig. C, p. 21). Even if the width were to be expanded to fill the display, the resolution will be poor with only 362 lines in HD systems designed for 720 to 1080 lines of resolution.

SD 16:9 Full Height Anamorphic fares slightly better as all available 483 SD lines are used and this format can be readily up-converted to fill the screen on a 16:9 HD display. As well the SD image can either be displayed as centre cut or letterbox.

4.2. *Shooting in Widescreen (SD or HD)*

While there is usually some angst when production staff anticipate transition from traditional 4:3 shooting to widescreen, experience is showing that once staff have a widescreen camera in hand, typically the rest falls into place surprisingly quickly. There are however, a few things that are different. For example there is generally less inclination to shoot close with 16:9 especially in HD. The widescreen frame allows the eye to select detail, rather than have it pointed out by, say, a cut to a close-up. For this reason, many directors find they are using fewer shots and cutting less frequently. Some care is required in the event that a protected 4:3 window is to preserve a possible centre-cut option.



16:9 without 4:3 protected window



16:9 with 4:3 protected window

Studio sets and blocking become an issue when shooting for 16:9 and 4:3 at the same time, especially when you have a group of people at a desk or table, for example in a newscast or panel discussion. The challenge is to spread them out just enough so that the 16:9 shot does not include a portion of the person next to the person being shot but retaining the intimacy of the discussion.

Widescreen shooting with an eye to protect the 4:3 window is a skill many directors are rapidly acquiring.

4.3. Technical Considerations

4.3.1. Acquisition: Video Cameras

When shooting for Digital Television, the best picture quality will be achieved when the path remains digital from acquisition to delivery. Producers should favour digital origination and select cameras that have widescreen capabilities in SD. (Note, once again, that the quality of image is notably less favourable than if shot in 16:9 HD.) When originating in HD, 16:9 is the default aspect ratio. In SD, there are three ways of achieving a 16:9 widescreen image:

1. Using a camera with a native 16:9 CCD or imaging sensor. This generates a full height anamorphic image "encapsulated" within the 4:3 SD aspect ratio. It results in a "squeezed"-looking image when viewed on a normal 4:3 monitor. This anamorphic image should be maintained throughout the postproduction phases.
2. Using a camera with a native 4:3 CCD or imaging sensor that outputs a 16:9 (Letterboxed) image. This is achieved by only using a 16:9 area of the CCD, resulting in a lesser defined image as it does not take full advantage of the CCD's area. This is the case for many Mini-DV camcorders.
3. Using a camera with a native 4:3 CCD or imaging sensor in combination with an anamorphic lens that is added to the optical path. This has the advantage of using a greater area of the CCD, but requires the use of cumbersome and sometimes limiting optical accessories. It also creates some hardships in the monitoring of the image for the DP.

4.3.2. Acquisition: Film (Telecine) Transfers

Today's film industry has developed numerous ways of capturing images on film when producing programs destined primarily for television release.² The most frequently used aspect ratios are 2.35:1 (Scope) and 1.85:1 (Academy). Whether it is by using smaller gauge film (Super16) or more traditional 35mm film (in either 3 or 4 perforation configurations), the resulting negative gets transferred to a video (HD or SD) support and generally remains in this electronic format throughout the postproduction stages.

When transferred to HD, most movies are now respecting the OAR (original aspect ratio) of either 2.35:1 or 1.85:1. In both cases these movies are letterboxed into the 16:9 frame. (At 1.85:1, the letterboxing is quite minimal.) Studios do also make some masters available in pan and scan to fill the 16:9 screen, but increasingly, it seems consumers want to see everything that was available in the theatre and ask for OAR. Hence, it is expected that some letterboxing to accommodate these formats will remain in the 16:9 world, at least for movies.

4.3.3. Monitoring

Control rooms in post production and broadcast should be equipped with monitoring to replicate the possible display scenarios in the home.

Production facilities need to be aware that new consumer displays such as LCD and Plasma monitors do not crop the edges of the image like traditional CRT displays. It is critical to view production monitors in "underscan" and ensure there are no undesirable elements near the edges of the picture that were previously not seen on analog 4:3 displays.

² Film originated content destined for an ultimate film release (as in Digital Intermediate processes) may scan the film at different resolutions and aspect ratios.

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Broadcasters still transmitting in 4:3 need to be conscious that viewers with widescreen sets will notice previously masked problems at the edges of the image. An example would be one source not being completely covered by a second source which is keyed over the original image in preparation for a DVE reveal.

16:9 Letterbox option

If the approach is to deliver a 16:9 image for both HD and 4:3 analog services with the analog portion converted to a letterbox format, there is no immediate need to modify existing monitoring facilities. For single-camcorder field productions, most available monitors are 4:3/16:9 switchable. As the full image will be unaltered in either broadcast, no special measures need to be implemented.

Centre cut and 14:9 Letterbox options

To ensure that the modified analog 4:3 output is working properly (camera framing, cutting points, graphics, etc) it is recommended that one 4:3 preview monitor situated close to the main transmission monitor is permanently arranged to show either the Center Cut or the 14:9 letterbox for comparison.

Judgements about the composition of shots may be helped if preview monitors and camera viewfinders are marked up with the appropriate (4:3 or 14:9) picture safe area limits. Some cameras have the built-in graticules. If all else fails, a chinagraph pencil can be used to mark the 4:3 window on the viewing monitor!

For single camera shooting, a small 16 inch widescreen TV set can be used if required, again marked up either electronically or by chinagraph lines.

It is recommended that similar dual monitoring - of widescreen picture and either center cut 4:3 or 14:9 letterbox - takes place at every stage during post-production. At the very least try to ensure that one true widescreen monitor is available.

Finally, remember that widescreen pictures look better on a widescreen TV set than when displayed in letterbox on a 4:3 set.

4.3.4. Editing

If delivery of the program will be to HD services or 16:9 SD letterbox,, there is no need for any special intervention during editing. However, special attention must be given to programs relying on either the center cut or the 14:9 letterbox approach.

Edits which depend on action at the edge of frame may cause difficulties, as the program will be seen by viewers in two versions - digital widescreen viewers seeing the whole frame, analog 4:3 viewers seeing either the center cut or the 14:9 letterbox with picture loss at the edges of frame.

For fast action, the mismatch is less noticeable, but with slow movement - the slow dramatic appearance of a character at edge of frame, for example - finding a compromise edit point could be a problem.

For simulcasting from one origination, there is no easy answer. The result will be a compromise. For which viewer should you edit? The widescreen viewer, who will be in a minority for the next few years? Or the 4:3 analog viewing majority - watching a Center Cut image or in 14:9 letterbox? This balance of course will shift as more and more widescreen displays make their way into Canadian households.

The judgement can be made only on a case-by-case basis but in the short term, and pragmatically, cutting for the majority audience makes sense, provided the widescreen audience sees something

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in as high a quality as possible. Fast cutting works less well in widescreen. The frame usually contains so much more detail that the eye needs a little more time to take it all in.

4.3.4.1. Using 4:3 picture material in 16:9 programs

Making use of 4:3 materials, either from the archive or from new material where widescreen facilities are not available, is a challenge that will occur frequently. Stretching or squeezing pictures to fit the 'other' format is generally not acceptable since the shape of objects will be altered. Conversion requires the use of a high quality aspect ratio converter. This is necessary in order to 'stick' the selected 4:3 picture on to a 16:9 widescreen black frame, or 'raster', while keeping objects in the picture the true shape. This is best done during the edit, and the resulting anamorphic material can be cut, mixed or wiped with widescreen original material. Here are some examples.

Using the whole picture



This method inevitably leaves black 'side panels' (another term in use is 'pillarboxing'). This method may not matter if the material in use is clearly differentiated. For example, an archive based program may use news interview shots in widescreen intercut with black and white archive material shown in 'pillarbox'. In this situation, the viewer may accept the change between formats as natural. Complete programs, either from the archive or for new programs where widescreen facilities are not available, are transmitted in this form.

Partial expansion



A surprising number of 4:3 picture compositions will survive this partial expansion to 14:9, but beware of graphics - bottom third captions will be perilously close to the bottom of frame. Using this option, transitions between full 16:9 and 14:9 pillarbox is much less noticeable.

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Full expansion



Full expansion usually requires more attention during conversion, using the aspect ratio converter to select an appropriate part of the original frame, perhaps by offsetting the converter to select the upper or lower part of the frame, or some compromise position in between. This process may have to be done shot by shot, and while most shots can be made to work, frames carrying graphics may prove difficult.

If using this option, keep an eye on picture quality which may become poor particularly if the original material is less than perfect. Also, remember that the 4:3 viewer, watching the analog transmission in 14:9 Letterbox, will lose even more of the original picture if anything more than the 14:9 expansion is used.

Framing 4:3 archival image within background

Producers and editors also have the option of framing 4:3 archival footage within a background image, a technique commonly used in sports and news programming.



4.3.4.2. Versioning or Pan & Scan

In the case of 16:9 content that needs to be included within a 4:3 image where a center cut is not appropriate due to the nature of the content (i.e.: where the action takes place at the outer edges of the 16:9 original frame), or a Letterbox or a 14:9 “compromise” is not acceptable because of continuity or uniformity requirements, you need to either re-edit the segment to be inserted (versioning) or you must perform a Pan & Scan operation.

In the case of versioning, the shot is segmented to maintain continuity in the action by re-framing the picture according to the action. Particular care is taken to ensure that the picture

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tracks the dialogue & effects. In the case where two actors are having a dialogue (where each one only occupies the areas of the 16:9 original picture that would be eliminated if a straight centre cut was performed to fit a 4:3 area) the shot would be re-framed for each actor whenever they speak and would be re-cut to follow the action. The drawback to this is that the shot may look unnatural, versioning between one actor and the other.

In the case of Pan & Scan, the entire shot would be re-framed to advantage either one of the actors. This can be further refined by re-framing dynamically as the action progresses (i.e.: the 4:3 re-framed area pans across the 16:9 frame to always keep the action within the 4:3 area).

Double conversion of 4:3 original material

If you are using 4:3 material in a widescreen program, remember to take account of the effect in any subsequent 4:3 version.



Original 4:3 picture



Selected area expanded to fill the 16:9 frame



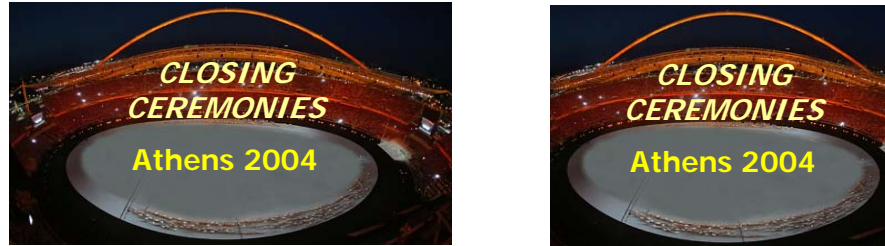
4:3 centre cut-out from the resulting 16:9 frame; pan-scanning might improve the framing

If 4:3 is first converted for inclusion into the 16:9 program and then the whole 16:9 program is converted back to 4:3, a double conversion has occurred. The results of this are both loss of quality and a reduced area of the original 4:3 frame being seen. The integration of 4:3 into 16:9 is often done at the final edit. At this stage also the 4:3 version can be made from the 16:9 master edit.

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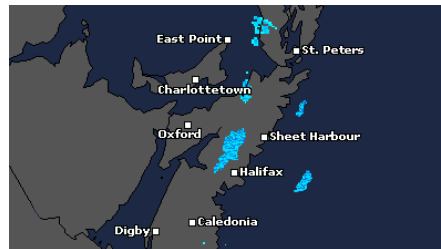
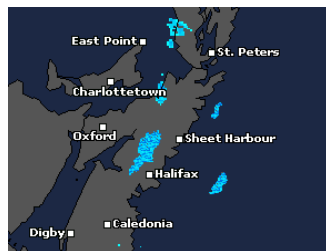
4.3.5. Graphics

Graphic design for widescreen programs must also follow the same 4:3 'shoot & protect' rules outlined earlier. These rules will generally mean designing for the centre 4:3 area within the widescreen frame.



A centred graphic as it appears in 16:9 (left) and 4:3 (right)

This effectively requires the design to be carried out for the 4:3 frame only, and then extending some design elements to the sides of the 16:9 frame: these examples were originally made for 4:3 programs, and modified for 16:9 to illustrate this point.



In this example of a news graphic, the additional areas left and right of frame in the widescreen version are featureless, and the result is poor



Carrying some design features to the edge of the widescreen frame helps

5. BROADCASTER ISSUES:

5.1. Service, Program and Target Considerations

Broadcasters need to make decisions on how to present and distribute the different aspect ratio formats within the context of the two main service conditions:

- 1) Broadcasting 16:9, either SD or HD programs on a 4:3 SD service
- 2) Broadcasting 4:3 SD programs on a 16:9 HD or SD service

The approach selected for any given service or program depends on a number of factors and the choices will be different depending on the specific context of the individual service. It is recognized that choices made will differ by broadcaster, type of service and the particular program. Consideration must be given to the following questions:

- Is the distribution channel 4:3 or 16:9?
- Is the signal format, SD or HD?
- What is the original format of the program as provided by the producer?
- What is the display “target” in use by the viewer?

In addition, some of the issues that the Broadcaster must take into account from a target display perspective are:

- (a) Display of received SD and HD DTV pictures on 16:9 HDTV displays.
- (b) Display of received SD and HD DTV pictures on 4:3 HDTV displays.
- (c) Display of received SD and HD DTV pictures on 4:3 NTSC displays connected to DTV set-top boxes.
- (d) Considerations of burn-in on 16:9 and 4:3 displays.

Assumptions made by the broadcaster related to the audience and the distribution channel in use, impacts the decision made for the presentation of the program content. Along with the impact on the display and the presentation to the viewer, the broadcaster faces challenges related to receiving and distributing the content through a broadcast facility. The factors to be considered will be discussed here.

5.1.1. Is the Service distribution channel native 4:3 or 16:9?

If the distribution channel is native 4:3, the content will be carried to the display as a 4:3 raster. However, if the signal is fed to a digital 16:9 display, the display will offer options to stretch or zoom the image to fill the 16:9 display. This option is in the control of the viewer.

This picture manipulation occurs with some loss of resolution and picture quality but the broadcaster has no control of this. If however that 4:3 service is received through an early generation HD set-top box and fed through the component output of the set-top box to the digital 16:9 display, the ability to alter the signal is not available on some set-top box / display configurations. Newer set-top boxes are eliminating this problem.

Broadcasters that are feeding a 4:3 native channel are often faced with program content delivered to them in 16:9 letterbox within the 4:3 raster. This technique is typically seen in commercials and used for artistic reasons. The broadcaster has learned to accept this and does not typically crop the 16:9 image and expand it to fill the 4:3 screen. The viewer with the 16:9 display could expand the image using the displays controls but would not do this for commercials. The viewer may however alter the display if this technique were used on a program which was being watched on a 16:9 HD display through its analog input.

The above scenario is the same regardless of whether the channel to the home is analog or digital.

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If the channel is 16:9, it is inherently a digital channel but is also capable of HD. (So far in Canada there are no implementations of 16:9 native channels that are SD only.)

For these 16:9 channels, the issue becomes how to present legacy 4:3 material, especially if it is being simulcast on the 4:3 native channel as well. If there is no simulcasting required, any 4:3 material could be up-converted in a way that might otherwise not be used for a simulcast application.

The 16:9 channels are all fed to the display through some sort of set-top box through component or "DVI" connections and as mentioned before the viewer is not always able to alter the image presentation in this case.

5.1.2. Is the signal format SD or HD ?

The signal format will dictate whether any up-conversion or down-conversion is required to feed the distribution channel in question. An SD service will require any HD programming to be down-converted and vice versa any SD programming will need to be up-converted for presentation on the HD channel. During these conversion processes choices can be made with the features provided in the converter hardware. The choice made will be subjective and would be made by the broadcaster. Some of the typical choices are illustrated in the Section 5.2.

5.1.3. What is the original format of the program as provided by the producer?

Obviously it all begins with the format of the content. How a program is delivered to the broadcaster conveys the producer's original intent and should guide the broadcaster on what should be done. Content producers need to make themselves aware of the challenges faced by and choices available to broadcasters.

5.1.4. What is the display "target" in use by the viewer?

The broadcaster should understand how these receiver /display devices can affect and present the image and they must determine which viewer will get priority, the 16:9 viewer or the 4:3 viewer, especially in a simulcast scenario. (The more common display scenarios are covered in Annex 2, Receiver and Display Issues.)

5.2. Simulcasting For 4:3 And 16:9: Typical Scenarios

Broadcasters face a number of scenarios. Definitely the most challenging is a broadcaster that must simulcast to both an SD 4:3 native channel and an HD 16:9 native channel. Following are some illustrations of these scenarios:

5.2.1. 16:9 HD Origination

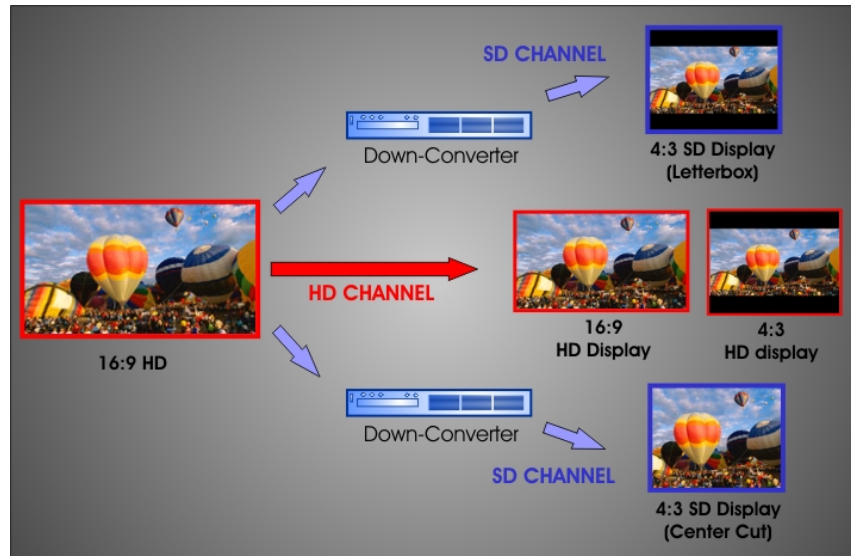


Figure A: 16:9 HD ORIGINATION

5.2.2. 4:3 SD Origination

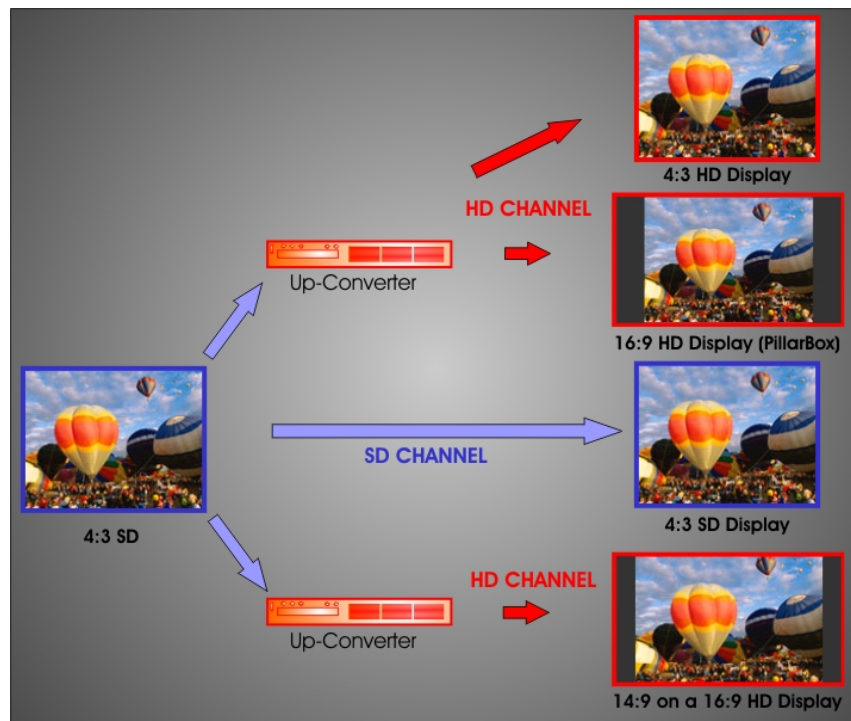


Figure B: 4:3 SD ORIGINATION

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Note that in this scenario, when 4:3 content is contained within a native 16:9 HD service, to eliminate uneven screen aging on 16:9 HD displays, the broadcaster can use grey or coloured side panels.

5.2.3. 4:3 SD Letterbox Origination

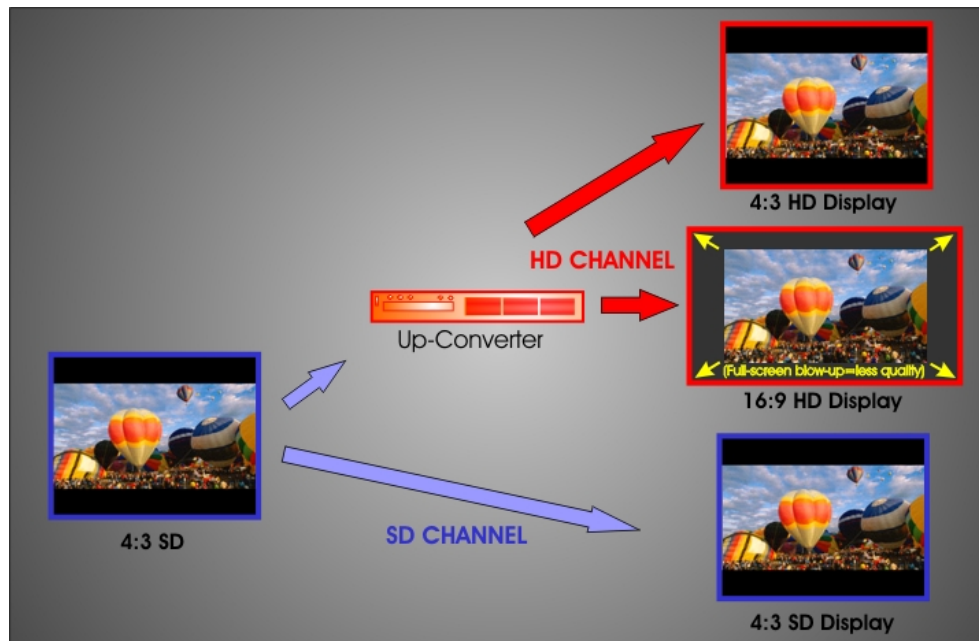


Figure C: 4:3 SD LETTERBOX ORIGINATION

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5.2.4. 16:9 SD Widescreen (Full Height Anamorphic Origination)

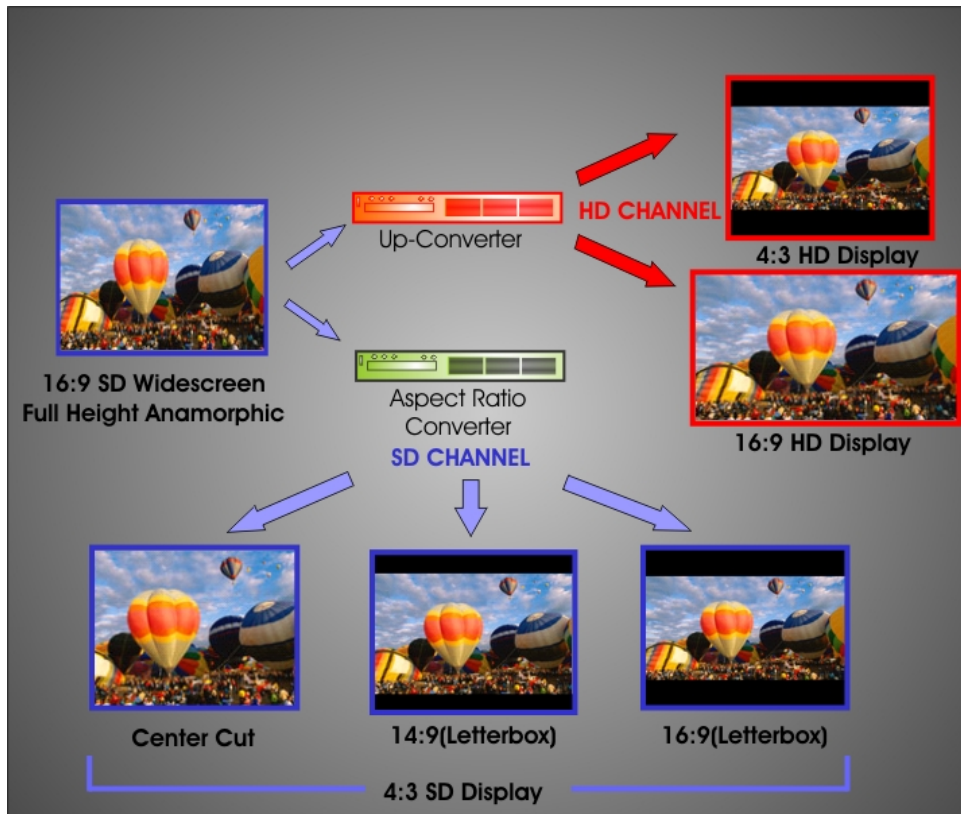


Figure D: 16:9 SD FULL HEIGHT ANAMORPHIC ORIGINATION

5.2.5. Treatment of 16:9 HD material in Analog or Digital services that are 4:3 native

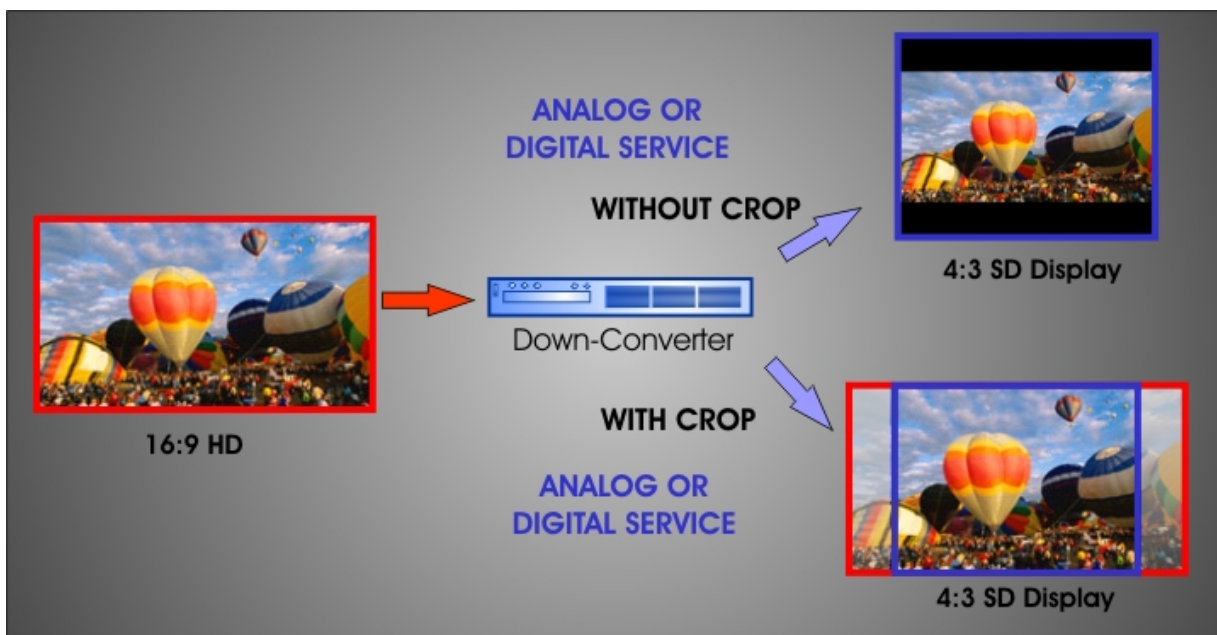


Figure E: 16:9 HD OVER 4:3 SERVICES

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Each broadcaster must review their situation and the scenario that they fall into. They should be prepared to test various alternatives and make their own determination of what best suits their objectives.

The choices also must address the planned distribution and preferred mode of operation and such things as integration of live event or studio programming and cross integration of these elements as well as the impact on staff, automation and master control switching. Also, are there elements that are unique to the SD and HD service such as logo inserters? All of the possible factors are beyond the scope of this document.

It is worth noting some of the decisions which have been made by major U.S. Broadcasters. PBS has a policy for the commissioning of programming which requires all producers of PBS programming to provide an increasing percentage of HD product over a three year period. All HD product simulcast on the PBS network is shown as letterbox on the 4:3 SD service. Most prime time product in the U.S. is now available in HD. While the majority of these programs are center-cut for the 4:3 service simulcast, an increasing amount of letterbox format is being shown, particularly for live sporting events.

The good news is that there will come a time that broadcasters and distributors will not have to deal with two formats, and eventually there will be only 16:9.

A possible transition plan is outlined in Section 6.

5.2.6. AFD - Active Format Descriptor

One development that might assist with aspect ratio issues on displays is the active format descriptor.

The ATSC (Advanced Television Systems Committee) decided to endorse the basic signalling structure developed by the DVB consortium in regards to aspect ratios. The benefits of common active format descriptor (AFD) signalling across many different markets are easily understood. The broadcaster would insert the AFD and bar_data in the appropriate field of the Program and System Information Protocol (PSIP). This data would instruct the receiver on how to deal with the aspect ratio of the content delivered. While this tool could resolve many of the issues associated with differing aspect ratio issues for programming content, to date no receiver manufacturer has included this feature.

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6. TRANSITION PLAN

Four major stages of the expected Transition Plan to the widescreen world are presented in this section to illustrate the changes required for:

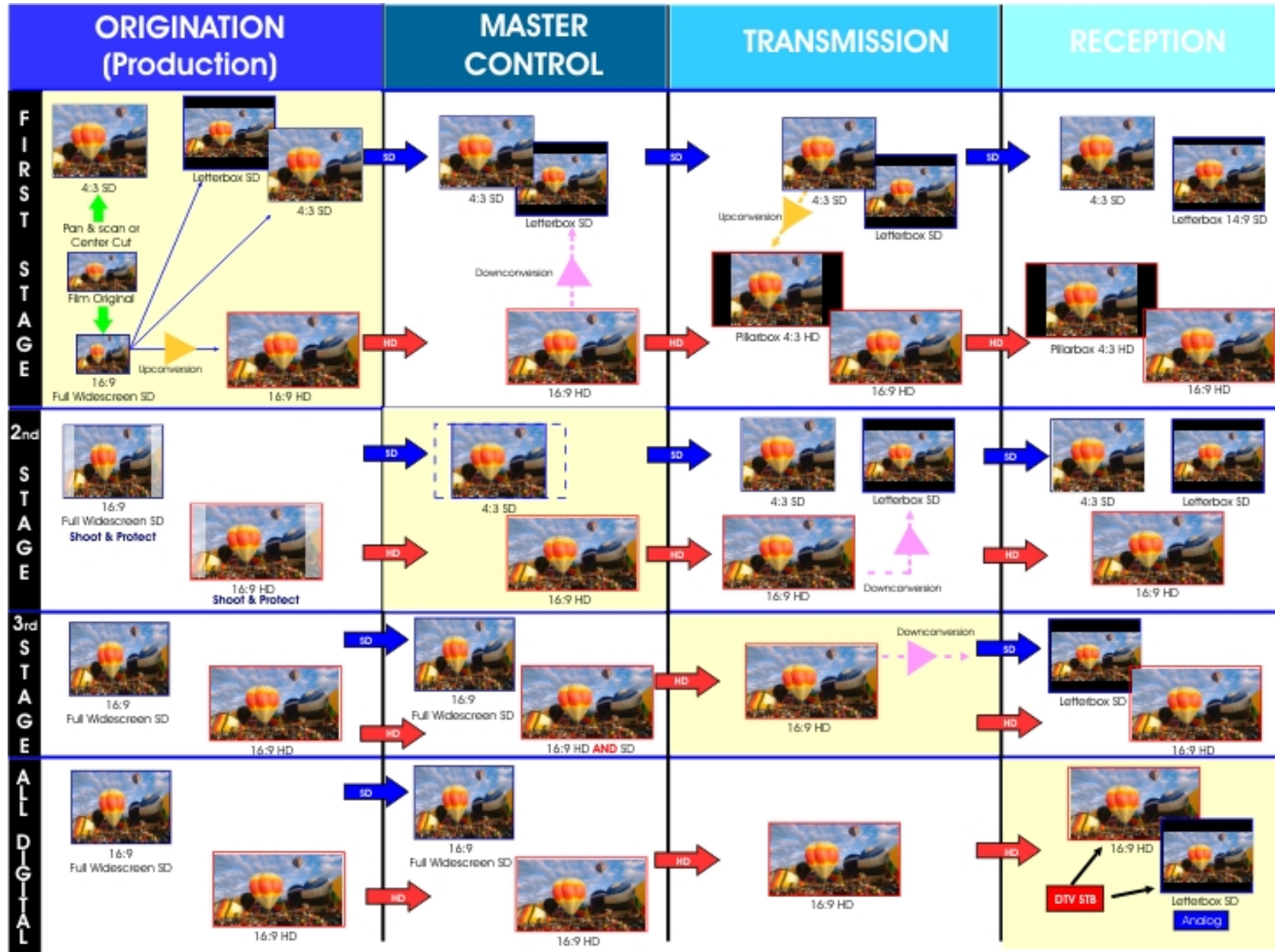
- Origination (Production)
- Broadcaster Master Control
- Transmission
- Reception

Currently, the Broadcaster has the difficult task of dealing with a mix of program aspect ratio formats for integration into both 4:3 and 16:9 services. However, ultimately, once the amount of HD programming product has increased, the penetration of HD televisions has grown, and new consumer set-top down conversion products have become common place, the conversion process will become simplified and move from the broadcast and distribution chain into the consumer household.

Once the penetration of 16:9 displays grows to the point when the majority of households have a 16:9 display, and analog over the air services are no longer broadcast, it is expected that viewers with old 4:3 analog displays will be able to acquire a set-top down-converter which will enable display of all programming in letterbox format. Viewers with 16:9 displays should be provided a cohesive widescreen service with all 16:9 programming.

The following diagram provides an overview of the transition stages presented, illustrating the complexity of this transition across the industry.

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7. GUIDELINES

CDTV presents the following guidelines to assist broadcasters in the development of internal strategies to deal with the transition to HD.

1. Broadcasters should stimulate and grow the amount of commissioned 16:9 HD programming.

Whenever possible, new Canadian Programming should originate in HD format (16:9), with the requirement for delivered HD product increasing on a yearly basis. If letterbox viewing on 4:3 services is not desired, the 4:3 window should be protected during widescreen production ("Shoot and Protect"). "Shoot and protect" should be clearly indicated. (e.g in program information data on tape cassette!).

2. As HD content increases, and the majority of households obtain widescreen displays, Broadcasters should consider presentation of all widescreen content in letterbox format on 4:3 services with grey top and bottom panels with a luminance level of 30 to 50% to protect viewers displays against uneven screen aging ("burn-in").

This would assist in accelerating consumer transition to widescreen display and enable elimination of separate SD service provisioning through Master Control. Down-conversion of an HD service to create the SD service could occur immediately before Distribution.

3. When transmitting 4:3 programs on 16:9 HD services, broadcasters should use grey side panels with a luminance level of 30 to 50% to protect viewers displays against uneven screen aging ("burn-in").

4. Broadcasters should phase out 4:3 program production and "Pillar box" display on 16:9 HD services (archived program material excepted).

5. Broadcasters should study the feasibility of insertion of adequate AFD (Active Format Descriptor) into their digital services to enable viewer's receivers and displays to automatically adjust to the optimum display mode.

ANNEX 1: DEFINITIONS

To ensure that Aspect ratios in television are well understood by all, here are some definitions of the terms and expressions used most frequently in the industry when addressing image formats. As the challenge of harmonizing those has been going on for some time in many parts of the world, the terminology used may have been interpreted differently across the many industry segments that have had to deal with it. Hopefully this will eliminate any confusion that may remain.

General definitions³

- **ASPECT RATIO:** The relationship of an image's width to its height.
- **WIDE SCREEN:** Any aspect ratio wider than 4:3 (1.33:1), width to height. Typically 16:9.
- **STANDARD SCREEN TELEVISION:** A television presentation whose aspect ratio matches the current 4:3 standard.
- **WIDESCREEN TELEVISION:** A television presentation whose aspect ratio is 16:9 irrespective of the method of acquisition, recording, and transmission method. (The technology can be analog or digital.)
- **PICTURE RESOLUTION:** The amount of image detail allowed for in any visual presentation. Each visual technology defines, or limits, the maximum amount of picture information possible. Television resolution is measured by the number of horizontal scanning lines, and spacing of the picture elements (pixels) within each horizontal line, that constitutes a complete television frame. As the number of scanning lines & picture elements increases, the detail, clarity and crispness of the picture improves.
- **INTERLACE SCAN:** Method of moving the electron beam in a camera or TV receiver that sends every other line to create a television field. The odd lines are sent as the first field, then the even lines are sent to create the second field. Odd and even fields are combined together in the human visual system to make up the complete television frame. Interlace scanning requires less information to be transmitted.
- **PROGRESSIVE SCAN:** Method of moving the electron beam in a camera or TV receiver that sends every scanning line in sequence to create the complete television frame. Progressive scanning has twice the information of interlace method and has fewer motion artefacts and is better for capturing fast action situations like sporting events.
- **NTSC – (ANALOG) TELEVISION:** The representation of television image and sound as an electrical signal that directly corresponds to, is analogous to, the original visual image and aural stimulus. The black & white, color and synchronizing signal elements of the captured image are combined into a single information stream according to standards set in the 1940's and early 1950's by the National Television Systems Committee (NTSC). Specs: Resolution of 525 scanning lines (483 active) with about 60 interlaced frames per second

³ Copyright Verdier Ventures, Inc. 1998

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- **ATSC:** The Advanced Television Systems Committee (ATSC) is a standards organization that was created in 1982 as part of the Advanced Television Committee (ATV) to promote the establishment of technical standards for all aspects of advanced television systems. The ATSC developed standards for digital television (DTV) that specify technologies for the transport, format, compression, and transmission of DTV in the U.S. ATSC DTV Standards developed, or in development currently, include digital high definition television (HDTV), standard definition television (SDTV), datacasting, multi-channel surround-sound audio, conditional access and interactive services.
- **DTV - DIGITAL TELEVISION:** The representation of television image and sound as a series of numerical values capable of being generated and manipulated by computer and computer like devices.
- **SDTV - STANDARD DEFINITION (Digital) TELEVISION:** A digital television system that provides picture resolution (number of active scanning lines) that is equivalent to current NTSC (analog) television standard. The aspect ratio is intended to be 16:9 but can also be 4:3. Specs: Resolution of 486 active scanning lines with 720 picture elements per line, either interlaced or progressive, are included in the ATSC standard.
- **HDTV - HIGH DEFINITION (Digital) TELEVISION:** A television system that provides picture detail, color purity, and aspect ratio greater than the standard NTSC television system. HDTV is always presented in a widescreen 16:9 aspect ratio. Specs: Resolution of either 720 active progressively scanned lines with 1280 picture elements per line OR 1080 interlaced active scanning lines with 1920 picture elements per line are defined by the ATSC standard.
- **RASTER:** The term refers to the region of a cathode ray tube (CRT) or liquid crystal display (LCD) monitor that is capable of rendering images. In a CRT, the raster is a sequence of horizontal lines that are scanned rapidly with an electron beam from left to right and top to bottom.

Aspect Ratio-related definitions

- **ANAMORPHIC:** A subsidiary format, or its associated lens, in which the horizontal dimension of a widescreen is squeezed by some factor with respect to the horizontal dimension of a base format having narrower aspect ratio. In film, the widescreen (anamorphic) image conventionally has 2.4:1 aspect ratio and the squeeze is by a factor of 2. In video, the widescreen (anamorphic) image has 16:9 aspect ratio and the squeeze is typically by a factor 4 to 3.⁴
- **CROPPED:** The process whereby portions of an original image are deleted to fit within a desired area or to fit a particular frame. In the case of trying to fit a 4:3 image within a 16:9 widescreen aspect ratio, this would require deleting an area at the top and/or bottom of the picture; when attempting to fit a widescreen image (16:9) into a 4:3 image area, this would require deleting an area on either side of the picture. To avoid truncating essential components within an image, the process of selecting the areas to crop is called Pan & Scan.
- **LETTERBOX:** A widescreen image (such as 16:9 aspect ratio) conveyed or presented in a format having a narrower aspect ratio (such as 4:3), using the full width of the narrower format but not using the full height.⁵

⁴ Charles Poynton, *Digital Video & HDTV, Algorithms and interfaces*

⁵ Charles Poynton, *Digital Video & HDTV, Algorithms and interfaces*

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- **PILLARBOX:** An image (such as 4:3 aspect ratio) conveyed or presented in a format having a wider aspect ratio (such as 16:9), using the full height of the widescreen format but not using the full width. The term echoes *Letterbox*; it derives from the name for a tall post box in the U.K.⁶

⁶ Charles Poynton, *Digital Video & HDTV, Algorithms and interfaces*

ANNEX 2: RECEIVERS AND DISPLAY ISSUES

The viewer has considerable control of aspect ratio. This section presents some of the aspect ratio control capabilities of today's home receivers, set-top boxes and displays.

Displays

To help with the understanding how aspect ratio can be altered by the home viewer. It is imperative to be clear on the display "target" in question. Three "targets" are defined here:

- i) 4:3 ANALOG "TARGET"
- ii) 4:3 DIGITAL TARGET
- iii) 16:9 DIGITAL "TARGET"

The 4:3 Analog "Target" (today's analog displays)

Providers of "analog" services and new standard definition "digital services" must consider the existing base of 4:3 displays. These analog displays directly reproduce the aspect ratio of the image received, with no capability to manipulate the picture. Hence, content delivered in widescreen will be letterboxed within the 4:3 screen (black bars top and bottom).

The 4:3 Digital "Target"

These displays were intended for those viewers who were planning to watch predominantly 4:3 SD content but want the ability to see the occasional 16:9 HD. The HD content will always be in letterbox form on these displays. Not many of these have been sold in Canada and are not actively promoted.

This display poses a challenge when 4:3 up-converted material is displayed in the 16:9 HD "window", as often occurs. This situation leads to the "postage stamp" effect, black bars top and bottom and black side panels. This condition is one reason that the ATSC has added a new feature to the ATSC DTV Standard, the "Active Format Descriptor" (AFD), as a means of eliminating this condition. The AFD would "identify" the picture format thus "signalling" the display which would enlarge the 4:3 images to fill the entire screen.

The 16:9 Digital "Target" (new "digital" displays)

These displays are becoming more the norm. They are HD capable and 16:9. Up until recently the only way to receive and decode HD was with an external receiver/set-top box. Soon any set over 35" will have built-in DTV over-the-air and cable tuners capable of decoding HD. As well, in the US there are some displays with built-in DTH receivers but these are not available in Canada. There is however, a large base of displays that do not have built-in digital tuners. Those displays can accept feeds from analog cable (RF), S-Video from DVDs, VCRs etc. and HD digital cable and HD DTH set-top boxes, through component video or DVI/HDMI.

With external set-top boxes, it is important to understand what happens to the signals under different interconnection scenarios. For example, for most 16:9 HD digital displays, the aspect ratio of signals fed to the analog inputs can be modified within the display whereas signals fed to the component input cannot.

The 16:9 displays will be focus of the next discussion pertaining to interconnection issues.

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HD Receivers/Set-top boxes (STB) and Aspect Ratio

Most 16:9 HD digital displays will be connected to some form of “HD” set-top box (STB)⁷. It is important to understand how these can manipulate the aspect ratio. The capabilities of these devices differ depending on whether the signal source is SD or HD.

SD SERVICES

SD services can be received by the display through an RF cable connection (many current HD displays come with a built-in “analog” tuner). However, given that the viewer has purchased an HD display it is assumed that a STB is connected to the display. If this is the case it decodes the signal and presents the SD video to the display via an RCA phono, or S-video connections from the STB.

SD sources are 4:3 and will be displayed with left and right side bars. Some displays allow the viewer to change the bars from black to grey. The displays also provide a variety of options to “stretch” the image to “fill” the 16:9 viewing area. ***This is all in the control of the viewer.*** Each manufacturer offers different techniques with different results.

It is also possible that SD signals are fed via the analog component or digital interconnection from the STB to the display. This would be the normal interconnection for HD signals discussed below.

Some STBs provide the option to “up-convert” the SD signals to this component output. If the STB is in this mode, display interprets the signal to be “HD” and hence does not allow any aspect ratio manipulation. Standard definition channels delivered in 4:3 will be seen only in a 4:3 window with black or grey side bars. Any 16:9 material within the 4:3 window will be seen as letterboxed within the 4:3 frame. Creating a “postage stamp” affect with black bars all around the image. This has led to some consumer frustration to.



Postage Stamp Effect

Consumers may find the inability to use the display features frustrating when viewing 4:3 based services and need to be guided to select an alternate input, video or S-video, to view SD services if aspect ratio manipulation is desired or ensure the STB does not up-convert.

If the signal is not up-converted then the displays aspect ratio adjustments are available to the viewer to “zoom” or “stretch”. Each display manufacturer has different terms for these options.

HD SERVICES

HD services are delivered to the display from either, component outputs of the STB (analog RGB or Y Pb Pr) or, digitally through DVI, HDMI and 1394.

Content within an HD program service will be viewed only as provided by the broadcaster. For example:

- if the source is 16:9 it will be displayed 16:9.
- if the DTV broadcaster, is sending a 4:3 up converted image it will be displayed as 4:3 with the side panels.

⁷ At the time of writing displays with built-in DTV tuners were not available in Canada.

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- if the 4:3 video window happens to include 16:9 content like some commercials, the viewer will see bars on the top and on the bottom as well as on the sides: "Postage stamp affect"

Broadcasters providing HD services may find this limitation preferable, as they will be assured that viewers are seeing the content as was intended. However, it should be noted that some set-top boxes allow manipulation of the HD output of the box and can be set to "stretch" or "zoom" the image. This is a good feature if you are watching primarily up-converted programming; however it is awkward to change back and forth between "stretch" and "normal".

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