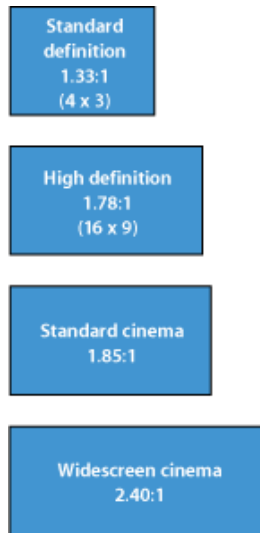


## Aspect Ratio of the Video Frame

The ratio of horizontal to vertical dimensions of a film or video frame is called the *aspect ratio*. Aspect ratio is independent of absolute image size or resolution.



Aspect ratios can be expressed as absolute dimensions (4 x 3), a ratio (4:3), a fraction (4/3), or as the decimal equivalent of a ratio (1.33:1, or simply 1.33). Aspect ratios are generally expressed according to the following conventions:

- Video aspect ratios are often written as ratios, such as 4:3 for SD video or 16:9 for HD video.
- Film aspect ratios are often written as decimal equivalents, such as 1.33, 1.85, and 2.40. The larger the decimal number, the wider the image. An aspect ratio of 2.40 is wider than 1.85, and 1.85 is wider than 1.33.
- Digital video resolutions are usually written as absolute pixel dimensions, such as 720 x 480, 1280 x 720, 1920 x 1080, and so on.

Below is a list of commonly used aspect ratios, mostly from the film and television industry, plus a few others for comparison.

Aspect ratio	Medium
1.33 (4:3)	Early 35 mm film and SD television
1.37	4-perforation 35 mm camera footage (prior to projection)—also known as “Academy” aspect ratio
1.66 (15:9)	Standard European film; masked in projector
1.78 (16:9)	HD television
1.85	Standard North American and UK film; masked in projector
2.40 (also referred to as 2.35 and 2.39)	Widescreen (anamorphic) film projection

Footage with different aspect ratios can be combined using a variety of techniques, as described in the following sections.

## Pixels per Line

In digital video formats, each line is sampled a number of times. In an attempt to create a single digital VTR that could digitize and record both NTSC and PAL signals, the ITU-R BT.601 specification uses 720 samples per line for both NTSC and PAL video. Therefore, a digital NTSC video frame is 720 pixels x 486 lines, and a PAL video frame is 720 pixels x 576 lines.

HD video with 1080 lines uses 1920 pixels per line (1920 x 1080). HD video with 720 lines uses 1280 pixels per line (1280 x 720). Both of these formats have an aspect ratio of 16:9.

Common video frame sizes are shown in the table below.

Width	Height	Pixel aspect ratio	Screen aspect ratio	Description
320	240	1:1	4:3	Used for web distribution or offline video editing.
640	480	1:1	4:3	An early standard for analog-to-digital video editing, and an ATSC video specification.
720 <sup>1</sup>	480	Height greater than width	4:3	NTSC DV and DVD image dimensions. Also part of the ATSC video specification.
720 <sup>1</sup>	486	Height greater than width	4:3	NTSC SD video dimensions used for professional digital formats such as Digital Betacam, D-1, and D-5.
720 <sup>1</sup>	576	Width greater than height	4:3	PAL SD video dimensions used for digital formats such as Digital Betacam, D-1, and D5, as well as DVD and DV.
1280	720	1:1	16:9	An HD video format, capable of higher frame rates in exchange for smaller image dimensions.
1920	1080	1:1	16:9	An HD video format with very high resolution.
960	720	4:3	16:9	Some 720p formats (such as DVCPRO HD and HDV) subsample 1280 pixels to 960 to minimize the data rate.
1440 1280	1080	4:3 3:2	16:9	Some 1080-line formats (such as HDV and DVCPRO HD) subsample 1920 pixels to 1440 or even 1280 to minimize the data rate.

<sup>1</sup> In most video devices, only 704 or 708 pixels are actually used for picture information.

**Note:** For information on pixels per line and aspect ratios in digital cinema formats such as REDCODE, see *Professional Formats and Workflows*, available in Final Cut Pro Help.

### 720 x 486 Versus 720 x 480

One issue that comes up during post-production is the subtle difference between NTSC SD formats that use 486 lines per frame (such as Digital Betacam, D-1, and D-5) and formats that use 480 lines per frame (such as DV, DVCPRO, and DVD). Why is there this subtle difference? The reason is simple: 480 is divisible by 16, and 486 isn't. Divisibility by 16 is convenient for certain block-based codecs because each frame is broken into 16 x 16 pixel blocks (known as *macroblocks*) during compression.

The only time this should be a concern is when you are converting between a 486-line format like Digital Betacam and a 480-line format like DVD. However, the extra six lines are typically not visible on an analog television.

## Pixel Aspect Ratio

A *pixel* usually refers to a physical picture element that emanates light on a video display. But a pixel is also a term for a *sample* of light intensity—a piece of data for storing luma or chroma values. When stored on tape or on hard disk, the intensity of a pixel has no inherent shape, height, or width; it is merely a data value. For example, one pixel may have a value of 255, and another may have a value of 150. The value of each pixel determines the intensity of a corresponding point on a video display. In an ideal world, all pixels would be captured and displayed as squares (equal height and width), but this is not always the case.

The ITU-R BT.601 specification makes it possible to transmit either NTSC or PAL information in a single signal. To achieve this goal, both NTSC and PAL video lines are sampled 720 times. In both NTSC and PAL video, the frame displayed has an aspect ratio of 4:3, yet neither 720 x 486 nor 720 x 576 constitutes a 4:3 ratio. The solution to this problem is to display the pixels (the samples of light intensity) taller-than-wide, or wider-than-tall, so that they fit into a 4:3 frame. This results in the concept of “rectangular pixels”—pixels that must be stretched or squeezed to fit in the 4:3 frame. Most SD video devices actually use 704 or 708 pixels for picture information but stretch these pixels to 720 when recording to tape.

None of this was obvious in the days of linear editing, when video was simply copied from one tape to another, because the video equipment always compensated automatically. However, as people began using computers to work with video, digital video captured to the computer looked distorted (squashed vertically or stretched horizontally) because the computer displayed the pixels as squares, without compensating.

Some video formats use rectangular pixels to reduce the amount of information stored on tape. For example, DVCPRO HD effectively records 1280 pixels per line (when using the 720p format), but to save space on tape, the intensity of every 1.33 pixels is averaged together (a process known as *subsampling*) and only 960 pixels are recorded. These pixels are not representing a square area, but a wider, rectangular portion of each video line. This results in a 4-to-3 reduction in the amount of information recorded on tape.

Video and image editing programs like Final Cut Pro and Photoshop must compensate for these rectangular pixels so they appear correctly on a computer display. However, there are several different pixel aspect ratios in use, and there is unfortunately no single accepted standard in the industry. The exact aspect ratio used may vary slightly from one software application to another, as well as among different third-party video interfaces.

These days, the biggest challenge comes when exchanging graphics between applications that use different pixel aspect ratios, or when using an application that does not support rectangular pixels with one that does. The key to a simple workflow is to use applications that can work at the native, non-square pixel image dimensions and compensate on the computer display. Fortunately, major video and graphics applications such as Photoshop, After Effects, Final Cut Pro, and DVD Studio Pro can work with graphics and video at native resolutions. This way, you are always working with the exact pixel dimensions that you will eventually output to videotape or DVD.

## Understanding Digital SD Video Non-Square Pixels

When creating graphics for SD video, you need to consider the fact that the digital video pixels are considered to be non-square (taller than wide for NTSC video, or wider than tall for PAL video) compared to your computer graphics program that uses square pixels. Non-square pixels are also referred to as *rectangular pixels*.

**Note:** Some computer graphics programs support non-square pixels, making it simpler to create graphics for SD video formats like NTSC and PAL. For high definition (HD) video formats, you can simply create square pixel graphics, which means designing graphics with exactly the same image dimensions as your HD format.

Reconciling the difference between non-square pixels and square pixels can cause a lot of confusion for beginning video graphic designers, but the best rules of thumb are to:

- Use a graphics application that supports non-square pixels, such as Adobe Photoshop. In this case, you create your graphics with the proper dimensions and pixel aspect ratio throughout the entire post-production process.
- Keep your destination video frame size in mind and follow the table in the section Frame Size Chart for Creating Graphics when designing graphics in your graphics application.

**Note:** There is no accepted standard for the exact aspect ratio of non-square SD video pixels. Different manufacturers may assume different pixel aspect ratios when designing their software. Fortunately, these differences tend to be very small, so in many cases you may not notice a difference between pixel aspect ratios of, say, 0.9 and 0.89.

Since every non-square video frame size has an equivalent square frame size that will look correct in SD video, it's easy to create your graphics with a usable frame size. The steps below tell you how.

See Pixel Aspect Ratios in SD Video Signals Versus Computer Displays for more background information on this topic.

Graphics for projects that will be output to HD video, or for video that will be played only on computers and doesn't use any captured SD video footage, simply need a frame size that matches the sequence frame size. No alterations are needed.

### To create graphics that look correct when output to video

1. In your graphics application, create a frame size that's the square-pixel equivalent of the video frame size of your sequence.

To select the correct frame size for your video format, see Frame Size Chart for Creating Graphics.

2. Create your graphic.
3. Do one of the following:
  - Save your image from the graphics program to your media folder on disk.
  - In your graphics program, first save your image at the original dimensions with a name such as MyGraphic\_original (this is a working copy that you can always use to make further changes). Then, rescale the graphic from the square-pixel frame size you created it with to the non-square equivalent shown in Frame Size Chart for Creating Graphics. This makes the image look distorted in your graphics application, but it will look right when you output it to video. Save this resized graphic to the folder in which you store your media.
4. Import your image file into Final Cut Pro.

If your imported image dimensions match any of the SD digital video formats supported by Final Cut Pro (such as DV NTSC, PAL, or widescreen), Final Cut Pro automatically assigns the appropriate pixel aspect ratio associated with those dimensions. If you want to change the pixel aspect ratio, you can change the image file's Pixel Aspect property in the Browser column or in the clip's Item Properties window, as described in Working with Projects, Clips, and Sequences.

## Frame Size Chart for Creating Graphics

Use the chart below to determine the frame size you need for creating graphics. For example, if you're working in DV PAL (which has a frame size of 720 x 576), your graphic should have a frame size of 768 x 576 to look correct on an SD video monitor.

If you are using this format	The video sequence frame size is	Use graphics with this frame size
CCIR 601 NTSC 4:3 <sup>1</sup>	720 x 486	720 x 547
CCIR 601 NTSC 16:9 anamorphic	720 x 486	853 x 486
DV NTSC 4:3	720 x 480	720 x 540
DV NTSC 16:9 anamorphic	720 x 480	853 x 480
CCIR 601/DV PAL 4:3	720 x 576	768 x 576
CCIR 601/DV PAL 16:9 anamorphic	720 x 576	1024 x 576
720p HD	1280 x 720	1280 x 720
1080i or 1080p HD	1920 x 1080	1920 x 1080

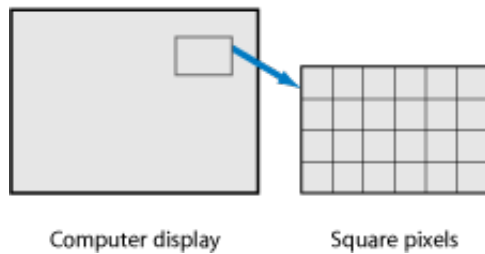
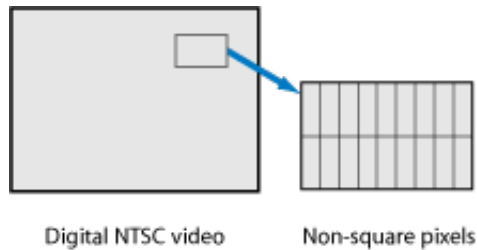
<sup>1</sup> Refers to ITU-R BT.601.

**Important:** Final Cut Pro uses slightly different square-pixel image dimensions than other video and still-image applications. For the most accurate results, you can avoid creating and converting square-pixel images by using a graphics application that supports non-square pixel aspect ratios. These applications allow you to create and preview your graphics at their native resolution.

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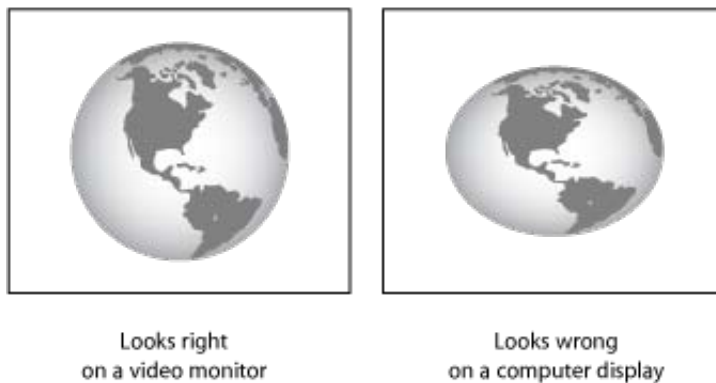
## Pixel Aspect Ratios in SD Video Signals Versus Computer Displays

SD video images use pixels with a non-square (rectangular) aspect ratio, whereas computer displays represent images using a grid of pixels with a square aspect ratio.



SD NTSC pixels are taller than computer pixels and SD PAL pixels are wider than computer pixels. As a result, a 720 x 480 pixel image looks different (taller) on an NTSC video monitor than it does on a computer display. For example, if you capture a clip of video with a globe in the picture, export a frame, and look at this frame in a graphics application, you'll see something like this:

### NTSC square vs. non-square pixels example



The Viewer and the Canvas let you display non-square pixel video correctly on the computer's display. You can choose this option by choosing Show As Sq. Pixels from the Zoom pop-up menu in both windows.

## Pixel Aspect Ratios in HD Video

Uncompressed HD video transferred via an HD-SDI signal has pixel dimensions of either 1280 x 720 or 1920 x 1080. However, HD video recorded on tape is often horizontally compressed to reduce the data rate. DVCPRO HD, HDV, and HDCAM are three examples of formats whose native horizontal dimensions are squeezed. For example, 1080i60 DVCPRO HD is 1280 x 1080. 1080i50 DVCPRO HD is 1440 x 1080. Because of the discrepancy in dimensions even within a single format, it's usually best to create HD graphics at either 1920 x 1080 or 1280 x 720, depending on your final output format. If you are uncertain which HD format you plan to output to, you can always be safe by creating your graphics at the largest size possible (1920 x 1080) and then scaling down if necessary.

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## Image Dimensions and Aspect Ratio

The horizontal and vertical pixel dimensions of your format determine the frame size and aspect ratio. For example, SD NTSC video is 720 pixels wide and 486 pixels tall. HD video is either 1280 x 720 or 1920 x 1080, and is usually referred to by the vertical dimension (for example, 720 or 1080) and the frame rate. In addition, Final Cut Pro refers to interlaced HD formats according to their field rate rather than frame rate; for example, 1080i60 (59.94 fields per second) rather than 1080i30 (29.97 frames per second). Digital cinema formats are generally referred to using their horizontal dimension as either *2K*, *3K*, or *4K*, shorthand for at least 2,000 pixels, 3,000 pixels, or 4,000 pixels wide.

The aspect ratio of a video frame is the width with respect to the height. SD video has an aspect ratio of 4:3, while HD video uses 16:9. Digital cinema formats use the 16:9 aspect ratio as well as closely related film-based aspect ratios.

**Note:** You may notice that 1280/720 or 1920/1080 is equivalent to 16:9, while 720/480 is not equivalent to 4:3. This is because SD digital video uses pixels that are rectangular, not square. For more information, see [Video Formats](#).

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