VIDEO AND TV
LINES OF RESOLUTION

"Lines of resolution" is a rather confusing term in the video and television world. This type of measurement is a carry over from the early days of analog television. It is poorly understood, and it is inconsistently measured and reported by manufacturers. But we're stuck with it until all video is digital, at which time we might just possibly change the convention and start reporting resolution in terms of straight pixel counts perhaps.

There are some common misconceptions. "Lines of resolution" is not the same as the number of pixels (either horizontal or vertical) found on a camera's CCD, or on a digital monitor or other display like a video projector, and so forth. And it is also not the same as the number of scanning lines used in an analog camera or television system such as PAL or NTSC or SECAM etc. It is easy to get a confused or incomplete idea about the real meaning of the term "lines of resolution".

"Lines of resolution" is a technical parameter that has been in use since the introduction of television to the world (so long before digital and pixels, and so forth). The measurement of "lines of resolution" attempts to give a comparative value to enable you to evaluate one television or video system against another, in terms of overall resolution. Note the reference here to "system" and "overall". So this measurement refers to a complete video or television system, which includes everything to record and display an image. It includes the lens, the camera, the video tape, and all the electronics that makes it the entire system work. This number (and it can be a horizontal or vertical value) tells us something about the overall resolution a complete television or video system is capable of. There are two types of measurement, (1) "lines of horizontal resolution," also known as LoHR, and (2) "lines of vertical resolution," or LoVR. However, it is much more common to see the term "TVL" (=TV Lines).

In precise technical terms, "lines of resolution" refers to the limit of visually resolvable lines per picture height (i.e. TVL/ph = TV Lines per Picture Height). In other words, it is measured by counting the number of horizontal or vertical black and white lines that can be distinguished on an area that is as wide as the picture is high. The idea is to make this measurement independent of the aspect ratio. So imagine a lot of horizontal lines drawn on a piece of white paper and all bunched up together pretty closely. If the system has a vertical resolution of say 500 lines, then the whole system (lens + camera + tape + electronics) can distinguish 250 black lines and 250 white spaces in between those black lines (250 + 250 = 500 lines). Now imagine a lot of vertical lines drawn on a piece of white paper and all bunched up together. If the system has a horizontal resolution of say 750 lines, then the whole system (lens + camera + tape + electronics) can distinguish 375 black lines and 375 white spaces in between

(375 + 375 = 750 lines). In either case, if you add any more lines per picture height, then you can't tell where a black line stops, and the adjacent while space in between, starts. In other words it can't resolve the lines and spaces in a distinguishable way, and the system has reached its limit of resolving detail.

Lines of horizontal resolution applies to not only cameras, but also to television displays, to signal formats such as those produced by a DVD player and so forth. Most TV's, for example, list ludicrously high numbers for their horizontal resolution. That is because manufacturers can bend and twist these measurements to make their products look good in the eyes of consumers. Same with cameras, by simply changing the lens to a much higher quality one, or even using a much higher grade of tape, you can change these numbers considerably (even if the camera is not normally used in this configuration in the field, or they only sell it with a much cheaper lens, or whatever). Different manufacturers use different measuring techniques, so direct comparisons of brand "X" camera against brand "Y" camera can be misleading. So take these TVL numbers with a grain of salt. However, they are certainly a guide nonetheless when you want to compare one camera with another, or one monitor with another, or one video projector with another, and so on.

So when people talk about "lines of resolution", but don't specify if they are horizontal or vertical lines..... then you already need to be cautious. If a manufacturer doesn't make the reference clear, then you can assume they are horizontal numbers, because they are always bigger numbers, and therefore they sound more impressive.

Perhaps an another anomaly when talking about lines of horizontal resolution, is to remember that vertical lines are being measured on the test chart (which is the opposite of the way it might seem, intuitively speaking). Horizontal resolution is the ability to resolve vertical lines, and vise versa. If the basic idea of this measurement is not clear, then one might think horizontal resolution is referring to horizontal lines, which is not the case.

You can't get any more than 480 vertical pixels with mini-DV because that it strictly defined by the format itself. If it has more, it simply wouldn't be DV any more, but some other format (and therefore incompatible). But you can shoot the DV format with a camera with say 500 tv lines of resolution or 750 tv lines of resolution and so on (it can be any number in theory, but ultimately governed by the quality of the technology). But you definitely aren't getting 500 or 750 pixels across your image. So remember the 500 and the 750 refer to the overall resolving power of the whole system, and doesn't tell you about how many pixels the format has.

True Pixel Count

"Lines of resolution" may ultimately be replaced by a true pixel count when referring to resolution in the future (especially in all-digital systems). In the future, as digital technology becomes much more uniform across manufacturers, the main difference in overall resolution of future video system will be more or less directly related to true pixel count. So this provides a simpler, more definite point of comparison, and therefore might make more sense that using the older "lines of resolution" method. However, "lines of resolution" will remain a technically more accurate measurement, as it takes the whole system into account.

For example, since the current DVD format has 720 horizontal pixels (on both NTSC and PAL discs), the true horizontal resolution can be calculated by dividing 720 by 1.33 (for a 4:3 aspect ratio) to get 540 lines. (On a 1.78 [16:9] display, you get 405 lines) In practice, most DVD players provide about 500 lines instead of 540 because of filtering and low-quality digital-to-analog converters.

TV lines

TV lines of resolution is one of the trickier numbers. It measures limiting horizontal resolution of the system, but it's odd in two ways. First, a "TV line" consists of a single distinguishable detail. In our hypothetical case of alternating black-and-white vertical lines, each black line and each white line is a TV line, in contrast with the more normal measurement of line pairs or cycles used in film, lens measurement, and the audio worlds. Thus a resolution figure of 500 TV lines means that 250 black and 250 white lines could be resolved, or 250 line pairs, or 500 TV lines in total.

Second, resolution is always normalized to a square screen resolution is always specified in TV lines per picture height (TVL/ph). The normalized measurement lets you compare the horizontal resolution of a TV system (the figure normally quoted) with the vertical resolution, which is fixed by the number of scan lines used and the kind of scanning performed (interlaced or progressive), and eliminates any dependency on aspect ratio (4:3 or 16:9). A camera resolving 600 TV lines resolves those lines across a width of the image equal to the picture height. If the camera shoots 4:3 images, the camera can actually resolve 800 TV lines across the entire picture (4/3 times 600); if the camera shoots true 16:9 images, it resolves 1067 TV lines across its entire picture width (16/9 x 600 = 1067).

This explains why true 16:9 switch-able cameras list the same resolution in both 4:3 and 16:9 modes the figures are normalized to picture height, even though more pixels per line are used in 16:9 than in 4:3. You'll sometimes see 16:9 camera specs that say things like "700 TVL in 16:9 mode, the equivalent of 930 TVL in 4:3 mode." What these guys are saying is, "Look, if you took all the pixels available on the 16:9 chip and squeezed them in to make a 4:3 picture, that picture would have a resolution of 960 TVL, and it therefore sounds more impressive this way.

If that isn't bad enough, there's also the question of what sort of picture you'll get as you approach the specified resolution figure. What happens as you reach the absolute limits of resolution? In all video systems, aperture response tends to decrease as frequency increases. In other words, resolving power starts falling apart as the limit is approached, as the detail being captured actually becomes smaller than the individual pixels on the CCD (or smaller than the diameter of the scanning beam in analog systems). At least one manufacturer specifies resolution at the point where the response is only 5 percent, which is a more reasonable spec. But others may measure the point where the curve actually intersects the noise floor and no detail can be seen at all. Limiting resolution can be precisely that limit, and not necessarily the usable limit from a more practical point of view.