All you wanted to know about…

Pixel Count
&
Record speeds
&
CIF

But didn’t know what to ask.

By: Paul Broome
Date: 04/07/05

Pixels and Record Speed and CIF (Oh my!)

There is a lot of misinformation out there on the subjects of pixel count, CIF sizes and record speeds. This paper is an attempt to provide some of the answers.

Horizontal Pixel Count: The number of pixels per horizontal line varies from manufacturer to manufacturer. You will hear numbers like 640 (us,) 704 and 720. Logic dictates that the bigger numbers are better, right? I submit that the quality is the same. Here's why.

The pixel sample rate is controlled by hardware. 720 are the maximum number of pixels that can be sampled on a horizontal line with hardware typically used in multi-channel DVRs. The 720 pixels start at the beginning of the line and end at the other end. Since the ends of the line are less stable than the middle, the first eight pixels and the last eight pixels of each line are black.

Since the black pixels are irrelevant, some manufacturers don't use them, claiming only the remaining 704 usable pixels (720 minus 16). With years of experience doing this and extending the theory that the ends of the line are less stable, some manufacturers ignore the first forty pixels and the last forty pixels on each line, using the 640 pixels in the centralized stable area.

There are advantages to the 640 per line approach:

- When you think about it, the area covered by the 640 samples is the very same area covered by the center 640 pixels in the 704 and 720 format.
- The pixel count and quality in that area is the same.
- Since there are fewer pixels, the storage requirement is smaller.
- The 4x4 display using 640 pixels allows all individual cameos to be the same size. Larger formats often run the image off the ends of the viewing area making the cameos at the edge appear smaller than those in the middle.

Vertical Pixel Count: The vertical pixel count is fixed based on the video standard used. Each field has 240 scan lines available in NTSC. Field based pixel formats always end in 240 (like 640x240, 720x240). Frame based formats use both the odd and even interlaced fields from the same camera. Frame based formats will end in 480 in NTSC (like 640x480, 720x480). PAL single field will end in 288 and frame will end in 576.

Pixel format review: Pixel sample rates are the same, although some manufacturers sample the entire line, some don't. Full size images require all the pixels to display. If you capture one field, you have to artificially generate the second field to view a full size image. If you capture frames (two consecutive interlaced fields) you will have all the original information for a full image (at a higher quality), but you will have a larger file to record (with shorter record duration) and fast moving objects will probably be distorted due to the time difference between field captures ($1/60^{th}$ of a second in NTSC). Also with frames, you have to wait to capture two fields, so the record rate is slower.

CIF Formats: CIF (Common Intermediate Format) refers to the size of an image.

- CIF (or 1CIF) is a quad size image (one quarter the size of a full size image). In some applications, the image is viewed at this size. Some applications expand CIF images to full size by artificially generating every other pixel both horizontally and vertically. The result is lower in perceived quality than a recorded full image.
  Pluses: Small recorded file size, longer record duration and fastest transfer speed.
  Minuses: Low image quality when expanded to full screen. Less detail than a full image format.

- 2CIF is a full width, single field image. 2CIF images are usually recorded in this format. The second field is internally generated for viewing by artificially generating every other vertical pixel. The result is better than a one CIF expanded image, not as good as a recorded full image.
  Pluses: Good compromise between smaller and larger formats allowing good quality with reasonable record storage needs and record durations.
  Minuses: Not the fastest, not the highest quality. A tradeoff position.

- 4CIF is a full size (both fields from the same camera) image. The quality is as good as it gets. At least for the still portions of the image.
  Pluses: Highest quality image.
  Minuses: Distortion of fast moving objects in the image. Won't be appropriate for cameras with fast movement. Largest file size. Slowest record rate.

- Quad CIF is a $1/16^{th}$ size image. This is equivalent to a single pane in a 4x4 image. Not often used due to the lack of detail.
  Pluses: Really small image file sizes, but not much to look at. OK for information if identification is not an issue. Faster transfer speed.
  Minuses: Very low quality image.

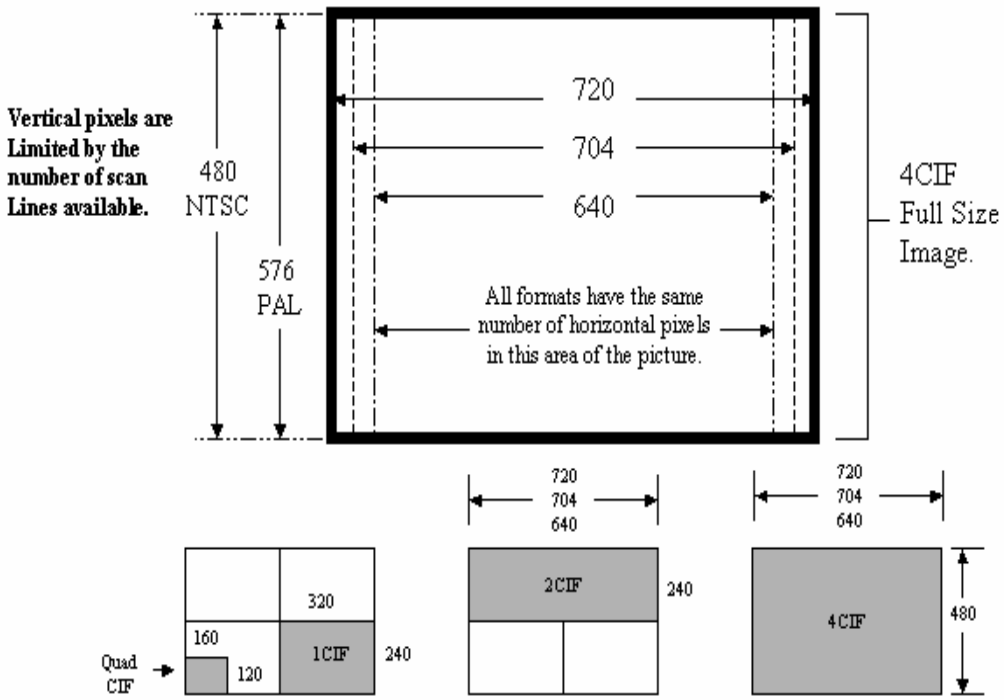
Typical Pixel Counts for CIF Sizes:

	4CIF	2CIF	1CIF	Quad-CIF
	Full image	Full width, half high	Quad size	$1/16^{th}$ size
NTSC	720x480	720x240	360x240	180x120
	704x480	704x240	352x240	176x120
	640x480	640x240	320x240	160x120
PAL	720x576	720x288	360x288	180x144
	704x576	704x288	352x288	176x144
	640x576	640x288	320x288	160x144

General Overview - Not Intellex Specific.

Pixels and CIF:

Horizontal images can be 640, 704, 720



What CIF size is best? As is often the case, the answer is that it depends. Each method has advantages and disadvantages. If you capture and record a 1CIF image you have the advantage of smaller files, longer record durations and smaller size files to transmit to remote software. The disadvantage is that you have less real information to work with. To display a 1CIF image as full screen you must internally generate additional pixels in both directions (every other pixel horizontally and vertically). So the expanded quality is not going to be as good as a captured 4CIF image displayed in the same area. If you capture a 2CIF image there is less information generated for display (vertical pixels only for full screen display). 4CIF images are already full images.

A 4CIF image sounds best if the highest quality image is your major concern. Further review shows that there are drawbacks to frame recording. You have very large file sizes taking a large amount of disk storage space, reducing record duration and requiring considerable bandwidth to transfer images to remote locations. The drawback that you must see to appreciate is the separation of moving objects in the image. Since you are capturing two consecutive images from the same camera that are separated in time by $1/60^{th}$ of a second, a fast moving object will show tearing in the image. To visualize this, imagine that you painted a delivery truck on a closed set of mini-blinds. The slats of the blinds mimic the interlaced fields of the image. Now move every other slat three inches to the right. The resultant distorted image is what you might see with 4CIF image capture. This distortion might show up in the live display as well, depending on how the live images are processed. You might be able to filter out some of the moving object distortion, or use a "deinterlacer" (separate and realign the fields), but I haven't seen good results yet. Most units that I've seen have considerable tearing, especially with a moving dome.

2CIF is a good compromise between 1CIF and 4CIF. (This is something we learned the hard way from a previous product that used 4CIF.) Image quality, file size, record duration and bandwidth requirements are a good tradeoff providing the most workable solution for CCTV applications.

On Intellex our ACC compression uses 2CIF, although it will work with any format. In fact, Intellex IP uses ACC in all formats. This proprietary compression scheme greatly reduces file size by recording only the moving portions of images and employing sophisticated noise-filtering algorithms. The result is a compression designed for CCTV providing a smaller average file size with high image quality.

CIF Size:	Image Quality:	File Size:	Record Duration:	Bandwidth Required:	Overall:
1CIF	Lowest	Smallest	Longest	Least	Best if image quality is not a priority.
2CIF	Middle	Middle	Middle	Middle	Best overall.
4CIF	Highest	Largest	Shortest	Most	Best quality with drawbacks.

Record Speeds: Fast record speeds are now commonplace. Numbers like 480 by 480 seem to roll off the tongue. Just a short time ago, numbers this size referred to the number of pixels in an image. Now they refer to live update speed and maximum record speed as well, leading to the resultant confusion. A true 480x480 DVR would produce live update rates of 480ips and total record rates of 480ips. The result is a real-time 16-channel DVR.

Live update speeds: For a marketer touting a 480x480 DVR, the first number refers to the total number of live camera updates per second. If you are recording single fields from a camera, the maximum updates you could have from that camera is 30ips (NTSC, 25ips PAL). The 480-number refers to a 4x4 live display on a 16-channel DVR. Each individual cameo in the 4x4 display is updating at a rate of 30ips. If the DVR has fewer than 16-channels, you could only have a maximum of 30ips per camera. So a 9-channel maximum is 270ips. So make sure you are doing an apples-to-apples comparison when comparing numbers.

Record speeds: For the same 480x480 DVR mentioned above the second 480 refers to the maximum number of images that can be recorded each second. For field based recording the maximum is 30ips per camera. So this 480 refers to 30-recorded images per second for each of 16-channels.

There are a few units that can actually display and record at these speeds. This is done using a 1CIF (320x240) image. When 2CIF and 4CIF images are processed the speeds are reduced. The best competitive units are getting better all the time. Today's numbers look like this:

- 1CIF record max is 30ips per camera.
- 2CIF record max is 7 – 15ips per camera.
- 4CIF record max is 5 – 7.5ips per camera.

One unit in particular will allow you to configure the record rate per camera (1-30ips at 1CIF, 7ips at 2CIF and 5ips at 4CIF). Most are either/or for all cameras. Some allow up to four cameras at 4CIF and all others at 1CIF. Some say they do things that don't really happen. Many say 480 but actually do less with inconsistent updates that are not evenly spaced. Rest assured that all are getting better. Whatever lies are told today seem to come true the following year.

Even the best I've seen won't play back a 4x4 multi-screen in real time. Individual cameras record and play at 30ips, but multi-screen takes a few seconds to playback one second's worth of video. All the images are there when you single step through them, but the multi-screen display doesn't have the processing horsepower to keep current. Wait till next year.

This is the story as of today. The future will provide rapid improvements.