DO:

- Use progressive scan. The motion portrayal and realism is so much better.
- Use spatial oversampling in cameras and displays.
- Use the highest frame rate possible, say 72 or 75Hz.
- Look at the whole chain to make sure every link can pass the required quality.

DON'T:

- Use interlace. It's a primitive analogue compression tool that was rendered obsolete by MPEG.
- Capture, produce, broadcast and display in the same pixel array size. It's inefficient.
- Expect a small-sensor prosumer camcorder to give full HD resolution.
- Think static resolution has anything to do with what television looks like.

High Definition picture

Television is going digital and Hi-Def is looming. JOHN WATKINSON looks at some of the issues surrounding the choice of new formats.

AFTER DECADES IN which high definition television was always five years away, it is nearly with us. Even now, though, it seems that there is still a gulf between what is known and what the television industry knows, but not as big as the gulf between what is known and what politicians say. Ask a dozen people for their definition of high definition and you get as many views.

Actually, I don't even like the term. It's as if definition is the only thing that matters, when in today's moving image portrayal systems there is a whole slew of shortcomings and artefacts that need to be addressed. It's analogous to concentrating on frequency response in audio while neglecting distortion, crosstalk and noise.

In audio it is necessary to understand the human auditory system to make any progress. It's the same in image portrayal. It has to start with what the human visual system (HVS) can and cannot see. It has to be followed by a systematic and necessarily

cynical review of the popular wisdom about how moving pictures are perceived.

Actually even that is incorrect. We presently do not have a moving picture technology. Instead we rely on the presentation of a series of still pictures. The HVS then has to make its best guess at what is going on, and, by a process called fusion, may accept that what is being portrayed was originally moving.

Clearly the picture rate is an important choice. What should it be? Well, if you believe the popular wisdom, anything above the critical flicker frequency of 50Hz or so will do. Connect an LED to a suitable AC supply and it flickers at 50 or 60Hz. To the HVS it appears to be continuously lit. However, put the same LED on long wires and swing it around and then you can see the individual flashes.

You can also try running the LED from an audio generator so the frequency can be varied to find the lowest frequency that doesn't flicker. Try it in the centre of the field of view and then try it in peripheral vision. Flicker is much more visible in peripheral vision because it's a way of alerting the senses to anything approaching.

I thought that large screen Hi-Def TVs were intended to be viewed from close by. Add in the wider aspect ratio and it's easier to see that more of the picture is in peripheral vision where flicker sensitivity is greater. Thus as well as putting more lines in, shouldn't we also be raising the picture rate? Well, the television standards bodies don't seem to grasp that.

There are picture rates and picture rates. The confusion is due to the traditional use of interlace. Interlace takes a frame and sends the odd lines in one field and the even lines in the next. The conventional wisdom is that the flicker perceived is that of the field rate. Actually it's an early compression technique allowing the frame rate, and thus the bandwidth, to be halved. In European systems, 25 pictures per second results in 50 fields per second. Unfortunately it doesn't work as well as the simplistic explanations suggest. With everything else the same, I can tell an interlaced picture from a progressively scanned picture on a 19-inch monitor from over 100-feet away. Basically interlaced pictures do not only contain field rate flicker. They also contain a strong component at frame rate that is visible. That, however, is not the worst news. Interlaced pictures can only be de-interlaced on the retina or electronically if nothing moves. Thus it's the height of irony that we use interlace for moving pictures. We measure the static definition and tell everyone it's great. This is like measuring the performance of a car while it's parked. Lovely handbrake, guv'nor.

What we need is a metric that is more representative of the viewing experience. Dynamic resolution is the thing to measure. Analysis with this metric shows that interlaced high definition television is an oxymoron. The resolution falls so rapidly with motion that the static resolution is only achieved a few percent of the time on typical material. A non-interlaced system with only 720 lines beats the crap out of an interlaced system with over a thousand lines.

During the debate about how the United States should proceed with digital television and Hi-Def, the FCC and the ATSC asked for views. Virtually every academic establishment and the military told them clearly the truth about interlace and recommended progressive scanning, as did the computer and software industries.

The standards bodies listened to this advice without hearing it, because in my view they preferred the strident voices of a few vested interests and weren't smart enough to know who was right. The resulting standard can't even be called a standard because it allows some 18 picture formats, half of which are interlaced.

Fortunately the EBU avoided a repeat of this fiasco by very firmly choosing progressive scanning for future Hi-Def services. They are to be congratulated for doing so.

Another choice for Hi-Def is how many pixels should be in the picture. Note that the modern idiom is to quote the visible picture size, rather than the old analogue system of quoting all the lines, including blanking.

It's important to realise that Shannon's sampling theorem only applies to infinitesimally small point pixels and requires ideal anti-aliasing and reconstruction filters. We get fairly close to the ideal in digital audio, but it's not as easy in sampling devices such as cameras and displays. Steep-cut filters cannot be made in the optical domain. In the electrical domain, steep cut filters can use impulse responses with negative lobes. There cannot be an optical analogy because negative light is impossible. Similarly all practical sensors and displays use pixels that are so big they virtually touch their neighbours in order to capture or generate enough light. Thus the ideal sampling system is compromised by two zero-order-hold, or aperture effect, processes: one at the camera and one at the display.

The consequence is that a picture having n-lines cannot have n-lines of resolution. Thus it is inefficient to have the same line count in capture, production, transmission and display as analogue was forced to do for simplicity. Instead the optimal solution is to capture with high line-count cameras and then to extract the useful resolution by down-sampling to a smaller number of lines for transmission. At the display, an upconversion stage can be used so that the display's own aperture effect can be used to help make the raster invisible. Typically cameras and displays having about 1000 lines can be connected by a 720 line channel in this way and no-one would know the difference. It's worth pointing out that picture resizing of this kind is easy in progressive scan and a nightmare with interlace. Thus I favour 720P for Hi-Def broadcasting as it up-converts to 1024 line displays very well. To make it better still, 720P at 75Hz is riveting.

Naturally the raw data rate of Hi-Def is pretty frightening and without effective bit rate reduction, broadcasting it isn't feasible. Fortunately the MPEG (Moving Pictures by Educated Guesswork) standards have proved very useful in this application, especially the subset of MPEG-4 known as H.264 or AVC. This takes a step forward from MPEG-2 by refining every coding tool for higher performance and emphasising the use of prediction.

Interlace is a compression technique and it is not a good idea to concatenate compression schemes. MPEG supports interlace because there's a lot of it about, not because it's a good idea. Most of the power of compression schemes comes from motion compensated prediction. In interlaced video, field differences could be due to vertical detail or motion and it's virtually impossible to tell which. Consequently coding performance (quality for a given bit rate) is higher in progressively scanned systems.

We now have the opportunity to deliver large, crisp pictures in the home, but I don't think I shall be buying a Hi-Def TV set until there is a quantum leap in programme quality. Presently we have a situation where the same amount of creative talent is being spread over more and more channels so that effectively the programmes act as screen savers between commercial breaks. Many years ago Clive James said that television trivialises everything it touches. He was right then and is still right. I don't care how many pixels there are in the picture, the dumbed-down, patronising, mind-shrivelling, inconsequential banality will still be there. ■