Spatial resolution

In considering whether to move from today's HD to 4K, it is worth thinking about what the eye can actually see.

The definition of 20/20 vision is slightly arcane, but it equates to a pixel spacing of a little under an arc minute. So, if a screen is 1920 pixels wide, it needs to subtend an angle of roughly 30˚ to the eye for the individual to be able to see all the detail in a smooth image without obvious pixellation.

If you work through the geometry, at a viewing distance of 2 metres, 1920 x 1080 HD is a perfect match for the eye on a 44" diagonal screen. Many households will be comfortable with a 42" television, and this is almost perfect for watching high definition television.

To be able to appreciate twice as many pixels in each direction, as in 4K, the horizontal field of view needs to be almost 60˚. With the same viewing distance of 2 metres, you are now up to a 104" diagonal television screen.
So to appreciate 4K in the home, you either need to watch from further away or change viewing habits. The richness of a 4K picture could be explored rather than watched as a whole, but that implies a certain sort of content. Big dramas and nature documentaries, for example, would benefit from it, but for fast moving sports and events it would be a distraction.

Just to complete the geometry, 8K doubles again the spatial resolution in both X and Y, so the horizontal field of view is an all-embracing 120˚. If we assume that the typical living room will struggle to physically accommodate anything bigger than a 104" diagonal screen, that puts your viewing distance at substantially less than a metre if you are going to see the resolution. Practically, you are going to sit a lot further away, and explore the screen.

Production companies are now routinely shooting and finishing in 4K, with specialist channels offering this resolution to the home. Consumer electronics manufacturers have seized on the potential, and 4K screens are readily available for the home. Indeed, it is now hard to buy a television which is not 4K ready, at least theoretically.

Primetime dramas are being offered in 4K, particularly from the new to the market streaming companies. Inevitably, sport is leading the way for broadcasters, although there is one very specific challenge for Ultra HD in sport.

Imaging chips have been the same size since the move from tube cameras to solid state imagers. This uniformity has made it easy for lens manufacturers, and for camera operators to know intuitively what angle of view they can expect from a given lens. But trying to get four times more photosites onto an imager – still less 16 times more for 8K – will only lead to very poor noise performance. Simply put, fewer photons will be captures per pixel.

So Ultra HD cameras have moved to larger imager chips, which changes the lens requirement and in turn makes the depth of field of an image much shallower. For drama this is good news, making the pictures much more film-like. For sport, it places greater demands on the operator to keep the shot in focus.

Frame rate

A simple increase in spatial resolution is not the only proposal being put forward for Ultra HD and beyond. One of the most persuasive is the use of higher frame rates.

When the content of the programme involves rapid movement, like sport, then increasing the frame rate yields a remarkable improvement in perceived sharpness. This really has to be seen to be believed: without changing the number of pixels in an image, but having more images a second, it appears much sharper and clearer.

We are already aware of this phenomenon through the difference between interlaced and progressive video. In the early days of high definition television, much was made that 720p seemed much sharper and clearer for sport than 1080i, because of the higher frame rate.

High frame rate video implies moving on a further step, to 100 or 120 progressive frames a second. For most viewers, 100fps HD is subjectively a better experience than 25fps (or 50i) 4K, at least on material where an increase in sharpness is appropriate.

That is an important point to consider: the increased perceptual sharpness is only appropriate where there is a lot of fast moving action (or camera moves), which in practice means sport. As movie critics have pointed out, drama requires a suspension of reality to disappear into the story, where too much pinpoint accuracy is not welcome. The broadcast system of the future is likely to be dynamic, capable of changing display parameters between programmes, and indeed within programmes to suit the content.

Dynamic range and colour

HD, as with SD before it, has a relatively limited colour gamut, defined by the capabilities of the electronics at a time. The gamut was also limited by the capabilities of the television display, which had a relatively low maximum light output. The dynamic range and therefore the colour gamut had to be limited by the brightness the screen could display, and therefore the levels of shading available below that.

New display technologies mean that we can now get a very much wider dynamic range on screen, from a true black up to a very bright white. In turn, that means we can allocate more than 8 bits per colour and increase the subtlety of the colour shading.

Finally, increasing the white point in each of the colour channels means you push the colour gamut out in all three directions, allowing the system to show colours which were previously impossible in video.

HDR could be seen to be an easy fix, as moving from eight bits to 12 per colour is only an increase of 50% in raw data, whereas going from 1080 to 4k is 400%. Increasing the frame rate from 50i to 100p is also a 400% growth in data.

However, pushing up the screen brightness makes the flicker inherent in video pictures more obvious: the flicker fusion threshold is in part dependent on absolute brightness. So HDR will probably need to be combined with HFR to produce a satisfying viewing experience.

Variability

What is clear is that the different forms of extending the resolution will be appropriate for different types of content. 4K pictures might be very attractive for big nature documentaries; high frame rate for sport; and extended dynamic range and colour for atmospheric dramas. But a period drama might be negatively affected by HFR, for example, with too vivid colours becoming a distraction.

The conclusion is that any future successful Ultra HD system has to not only support high spatial resolutions, HDR and HFR, but allow each of them to vary by each individual piece of content.

It makes sense, therefore, to choose technology platforms which are software-defined. Just as we include screen resolution as part of the metadata in a file wrapper, so in future we will be able to define frame rates and bits per colour. Most wrappers already support this in theory, so this is not a huge leap.

Software-defined platforms will work with today's content and, provided the hardware has sufficient processing power, with any element of Ultra HD or beyond in future.

As the industry moves to IP connectivity in all parts of the chain, including live production and delivery, so the various elements of Ultra HD become parameters in the system's configuration Provided there is sufficient bandwidth in the network and processor power, it is as simple to deliver 8k as HD.

Flexibility will continue to be the watchword.

Roll out

It is notoriously difficult to predict consumer trends with any accuracy. But there are some points we can consider for Ultra HD.

First, the consumer electronics industry is keen to promote 4K resolution. The computer industry has driven up screen resolutions so the raw glass is widely available for 4K resolution, and increasingly for 8K. New display technologies like QLED make for very attractive images; 8K television receivers are readily available even here in the UK, where there are no 8K services available.

On the other hand, just because the sets are in the stores does not mean they necessarily change consumer behaviour. 3D television received massive promotion but was largely ignored by consumers. It may be that we have the situation where the next generation of television sets are 4k-ready – and indeed probably still 3D-ready – but few will want to connect to 4K services especially if these are offered at a premium price.

Reed Hastings, the CEO and co-founder of Netflix, famously said that broadcast television would be extinct by 2030 But it remains a very efficient way of delivering mass audiences. Terrestrial and satellite broadcast systems do not care at all whether 10 thousand or 10 million people are watching. For programmes attracting a realtime audience – which means particularly sport, entertainment game shows like The X Factor and reality television – broadcasting is the most effective delivery platform. Will broadcasters see a business case in re-equipping playout and content management infrastructure for Ultra HD, and pay for the extra bandwidth to deliver the high bitrate signals? That will depend upon consumer interest. If consumers are clamouring for content the business case may look stronger.

Many broadcasters are still in the early stages of transition from SDI to IP connectivity. For them, 4K Ultra HD means either four bundled 3G SDI signals, or the limited range of 12G SDI. 8K is generally regarded as impractical without IP connectivity. Incorporating Ultra HD into a legacy master control environment is a significant undertaking.

Higher resolution content may make a bigger impact in downloaded content, particularly as broadband speeds get faster and 5G looks set to bring huge capacity to mobile devices. This is a disruptive shift in the industry, handing the technical edge to the (relatively) new players like Netflix and Amazon Prime and away from the traditional broadcasters. It is significant that these streaming services are looking to move into the live sports market.

Finally, there is the question of 8K. Will 4K be seen as just a stop-gap on the way to the huge advances of 8K?

Pixel Power

Pixel Power products sit in the delivery workflows of content providers, whether they are true broadcasters or online and mobile services. Whatever the output, it will need branding and promotion, and that is where the Pixel Power advantage lies.

The company is now part of the Rohde & Schwarz group, which provides finishing products for Ultra HD, like Clipster and Venice. Technology sharing between the two lines ensures very high performance and resilience.

Because our products are microservices-based, fully virtualised software systems, users can plan their migration to higher resolutions to meet their own commercial requirements. All the elements are ready in place: 4K and 8K capabilities are ready for our graphics and automated content production systems. Pixel Power and Rohde & Schwarz take active roles in the technology standardisation process, and continue to track developments to ensure maximum compatibility with other elements in the delivery chain.

The key commercial advantage is that, because of the microservices architecture, the functionality can be added on flexible licenses. If you need 4K or HDR branding, you can add it simply by adding the appropriate licenses, for the period you need them.

The significance of this is not just that it future-proofs any system. It also means that broadcasters, production companies and service providers can experiment with 4K or 8K delivery, either as a proof of concept in-house or on a trial channel. We will happily support these test cases with short-term licences.

Take a facility that is already using the Pixel Factory automated content production system to generate promos, trailers and other interstitials. If a business case is made for an Ultra HD version of a channel – probably an online service, but it could be broadcast – then all the operator need do is order a 4K licence for one channel. Enter the licence key and the system will immediately start rendering the content at the higher resolution.

Conclusion

Production and delivery of the various flavours of Ultra HD is one example of a broader challenge for the industry. Across all the areas of technology, change is accelerating. New resolutions, new ways of working, new means of recording, sharing and transporting content, new platforms for consumption and more are appearing ever more frequently.

This barrage of constant change leads to uncertainty. Which of these new ideas and capabilities will find a resonance with audiences? In what areas, therefore, should broadcasters, production companies and facilities make investments, and will those investments see a return through new revenues.

The solution is to move, as far as possible, towards a software-defined architecture, in conjunction with vendors who are dedicated to the industry and have a proven record of continuing innovation.

At Pixel Power we only supply the broadcast and post production markets: we are not going to take our eye off the broadcast ball by the demands of a different business stream. For more than 30 years we have been giving our customers creative control, workflow flexibility and uncompromised quality.

Pixel Power products have always been software-defined: our secret sauce is our software. Today, that software can run on standard IT platforms in the machine room, in the corporate data centre or in the cloud. Basing our offering on virtualised software means we can very rapidly adapt to new challenges – like Ultra HD – as our customers demand it.

The broadcaster that plans for a software-defined future can at least be confident of agility: you can use the technology you have today to experiment with, or roll out new features and capabilities, as your business develops and responds in the future.