

# 4K and Beyond: A Survival Guide

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As the High Definition video revolution has come and gone, content creators have been left wondering what's next. The answer appears to lie at the crossroads of rapidly advancing display technology and the growing expectations of sophisticated media consumers. Whether streaming a program like Game of Thrones, or simply watching the latest product pitch reel on an in-house corporate network, all of us are demanding more, higher quality media.

Market research firm Strategy Analytics studied global Ultra HDTV unit shipments and found 4K Ultra HDTV adoption is accelerating in the US market. The report goes on to say that the global demand for 4K UHD TVs is being driven by entry level price points starting below \$1,000, and consumers who are looking for the latest technology as they upgrade the displays purchased during the switch from 4:3 to 16:9 high definition broadcasting.

The Consumer Technology Association reports consumer adoption of 4K-capable TVs has been outpacing, and will continue to outpace, the transition to HDTV sets. CTA said Q4 2016 shipments of 4K/Ultra HD TVs to the US hit 4.5 million units, driving total sales in the category for 2016 to 10 million, a 40% jump versus 2015.

By 2025, other studies predict more than half of US television households will have at least one 4K capable display. If the trend holds, adopters of 4K display technology are on pace to beat the High-Definition technology adoption rate. As another tipping point is reached, consumption patterns will force producers to make and manage increasingly massive amounts of digital media.

We are truly part of a revolution - and to borrow from 70's lyricist Gil Scott-Heron, this revolution will be televised.

If you're someone struggling to keep up with that unfolding revolution, you've got help. Cutting Edge is a Media Systems Integrator with a successful record implementing file-based production workflows for organizations transitioning to 4K and beyond. We've prepared this white paper to bring the sometimes-fuzzy world of 4K production standards into sharper focus for you.

A word of caution: the information presented here is high-level, and we encourage readers to use this document as a foundation rather than an exhaustive reference.

That totally gets us off the hook if we generalize a little bit, right?

## What Does 4K Really Mean?

Let's agree that 4K refers to a range of digital file-based video specifications for digital television and cinematography. The term most often describes content produced for display devices capable of rendering approximately 4,000 pixels in width, hence the name 4K (also written as 4k for fans of the metric system). There are cameras that shoot 5K, 6K, and even 8K video... but let's save those for later discussion. In case you're a little new to the *buzz speak*, a pixel is a dot on the display screen which, when rapidly changed from one color to another, helps create a physiological phenomenon called persistence of vision. Humans see the dots changing, but their brains fill in the blanks and it appears as motion.

For the purposes of this paper, there are two primary bodies of 4K production standards: video and cinematic. For television production, the video standard typically applies. For content created for theatrical release, the cinematic standard prevails.

Let's start by differentiating each in terms of their respective pixel dimensions and aspect ratios.

- ▶ Video – Ultra-High Definition (also called Ultra HD and UHD-1) 4K images are 3840 pixels wide by 2160 pixels high. Not surprisingly, nearly all UHD content for over-the-top delivery services like Netflix and Amazon is in 3840 x 2160 format. UHD-1 is four times the HDTV 1920 x 1080 standard, but keeps its familiar aspect ratio of 16:9, or 1.78:1.
- ▶ Cinematic – the Digital Cinema Initiatives (DCI) standards specify a wide range of video resolutions, including 2K and 4K. The DCI 4K specification is slightly wider than UHD, at 4096 x 2160 pixels (1.9:1). However, DCI also provides for a digital film scanning resolution of 4096 x 3112, and Digital Cinema Package (DCP) standards for delivery of content to theaters, usually expressed as 4096 x 1716 (“scope” or 2.39:1), 3996 x 2160 (“flat” or 1.85:1), or 4096 x 2160 (“full container”).

The comparative video and cinematic formats stack up as follows:



Format	Pixel Dimensions	Width: Height	Aspect Ratio	Pixels
HD 720	1280 x 720	16:9	1.78	921,600
HD 1080	1920 x 1080	16:9	1.78	2,073,600
DCI 2K	2048 x 1080	~17:9	1.89	2,211,840
UHD 4K	3840 x 2160	16:9	1.78	8,294,400
DCI 4K	4096 x 2160	~17:9	1.89	8,847,360

To complicate matters slightly, there are a few nuances to the topic of aspect ratios:

- ▶ Display aspect ratio (DAR) – the dimensional ratio of the viewable image (i.e. 16:9)
- ▶ Storage (or sample) aspect ratio (SAR) - horizontal versus vertical pixels (i.e. 3840 x 2160)
- ▶ Pixel aspect ratio (PAR) - the physical dimensions of each pixel (square versus rectangular pixels)

Nothing against the movie industry, but to avoid turning this paper into a book, let's confine the rest of our focus to video.

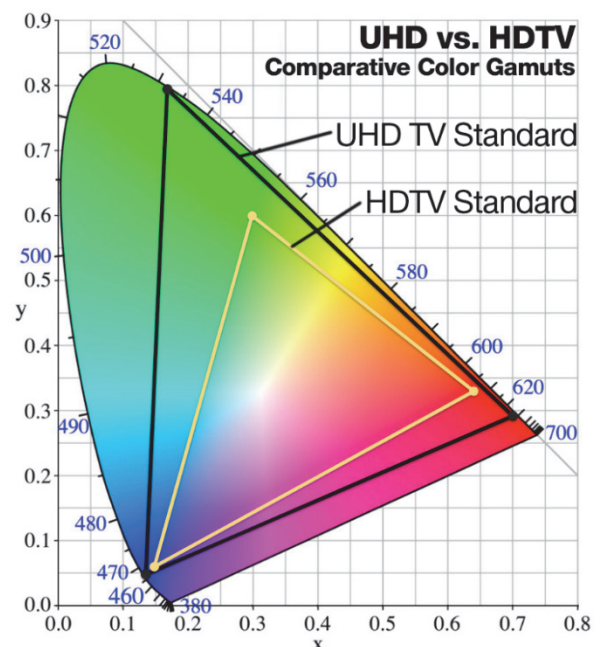
### Beyond Pixel Dimensions

The benefits of UHD video go beyond pixel dimensions. Color and dynamic range are greatly enhanced, and these factors mean the saturation and contrast differences in images for 4K are well beyond HDTV. UHD standard Rec. 2020 currently defines color in terms of 10 or 12-bit data, which translates into the ability to render more than 1 Billion colors.

UHD also allows for high dynamic range imaging, which is a photographic technique used to reproduce a greater range of luminosity or brightness in a scene. The result mimics the human visual system's ability to see detail in shadows or bright sunshine.

UHD currently provides for frame rates up to 60 frames per second. Faster frame rates mean action scenes like sports are much more dynamic and “real.”

So, in summary, UHD provides bigger and better visual impact by offering sharper images, more realistic action, and rich colors more closely approximating what the human eye can see. But it comes at a cost.



Warning: if arithmetic makes your head hurt, please take the appropriate medication before you read on.

Back in Ye Old Days of HDTV (meaning, this morning), clicking “record” meant you were typically capturing 1920 x 1080 pixels at a color depth of 10-bits per pixel and a frame rate of ~30 fps. Notwithstanding efficient compression, you could count on filling up roughly 896 Gigabytes of storage per hour.

In the new world order of UHD, a 4K image is 3840 x 2160 pixels at a color depth of 12 bits and a frame rate of 60fps. That can tie up as much as 8,057 Gigabytes, or roughly 8 Terabytes per hour.

Numbers like that are getting close to the national debt. Well, the debt is a lot more actually... but you get the idea.

Fortunately, techniques like spatial compression and chroma subsampling significantly reduce the data payload – both at rest and in motion.

And for the audio fans still reading along here, that’s just the video side of things! The audio standard includes 5.1 and 7.1 channel sound, all of which have their own data payload requirements. And that’s before adoption of audio innovations like “scene based Ambisonics” and technologies such as Dolby’s Atmos.

Just having the data at rest is one challenge. Moving it is another. To deliver 1920 x 1080 HD video at 60 frames per second (i.e. progressive) requires a data rate of 4.46 Gigabits per second. UHD video with 4:2:0 color subsampling requires 13.36 Gigabits per second. That underscores the need for a robust data networking infrastructure capable of meeting sustained bandwidth demands.

### It’s All About the Workflow

By now, it should be clear that the massive data demands of 4K means we should sharpen the proverbial pencil and figure out ways to economize – not only with regard to the amount of data at rest and in motion, but how to think about the process of actually using it. That is the science of workflow.

There’s a maxim in the production industry that, even if you’re only able to distribute your content in a lower resolution, it’s still best to shoot original images at the highest resolution you can afford. The emphasis on Computer Generated Imagery (CGI) has only deepened the desire to acquire original footage in higher and higher resolutions as a means of preserving options during compositing. If you’re still one of those who thinks we can “fix anything in post,” you get the idea that high-resolution original is good insurance.

The trade-off is the amount of data all those high-resolution images create.

Cutting Edge has learned that there are several key considerations when planning how your video production workflow will meet the 4K challenge:

- ▶ A well-considered Archive strategy is required so media can be moved into and out of online storage on a “just in time” basis
- ▶ Asset Management software and common metadata practices are important considerations so clips can be tagged and found without requiring editors to search through massive amounts of media, taxing system throughput
- ▶ Media Management oversight is an important personnel investment to avoid online storage downtime
- ▶ Constant workflow training and continual improvement practices help shore-up the most important foundation of your solution: the people who operate it every day.

As 4K production demands increase, Cutting Edge can help tune the operational workflow to the needs of each facility. For example, updating the organization’s metadata dictionary helps reduce online storage pressure while simultaneously streamlining the editorial process. Sports organizations shooting 4K content have found this step to be of particular benefit.

Having to store more media has given rise to a new function in many organizations: that of Media Manager. Asking editors to manage the flow of media into and out of online storage saps creative time, so the answer has been to consolidate hierarchical storage management under one or more individuals. These Media Managers can adjust acquisition and archive cycles by cleverly balancing the editor’s need for speed against a seemingly never ending shortage of online storage.

Distance often separates producers, directors, and their editors from each other. Digital production has given rise to collaborative editing techniques where stakeholders provide editorial guidance and “what if” ideas using proxy-resolution copies of high-resolution media. This speeds rough cuts, use of alternative takes, and simply posing questions about the pace and flow of an edit.

## Capturing 4K

Not to be ignored are the cameras capturing all this imagery. The MYSTERIUM-X® sensor in RED cameras, for example, provides a native full resolution aspect ratio 1.90:1. The RED DRAGON® sensor is slightly wider.

RED users tout the ability to shoot in 5K, 6K and even up to 8K, even though end products may only be delivered in 2K or 4K resolutions. Having many times the number of pixels as necessary creates flexibility when shots need to be reframed or effects need to be added. What’s old is new again, as such “pan and scan” moves were commonplace when broadcasters found they needed to reframe widescreen movies for the narrow confines of old 4:3 ATSC television broadcasts.

High Dynamic Range (HDR) video promises to make a huge difference by taking advantage of higher sensitivity to cover a wider range in a scene. Shadows retain detail, and highlights don’t appear as over exposed areas. Display manufacturers must now drive up the effective brightness to do justice to the improved contrast images.

Camera companies like RED have digital sensors capable of acquiring High Dynamic Range (HDR) images. Think of the way the human eye compensates for widely different lighting conditions like you experience when watching a sunset, and you begin to get a feel for what HDR cameras promise to do to further enhance dramatic storytelling.

## An Eye Toward the Future

Although 4K is frequently used to describe ultra high-resolution displays, there’s no reason to believe display technology will stop with 4K resolution. However, it’s likely to be a long time before 8K TVs are mainstream.

The UHD Alliance, an industry consortium of content creators, distributors, and hardware manufacturers, announced its "Ultra HD Premium" specification at CES 2016. It defines resolution, bit depth, color gamut, high-dynamic-range imaging (HDRI) and rendering (HRR) for Ultra HD (UHD TV) content in order to be labeled an Ultra HD Premium product.

UHD television technology is being deployed in phases. As you’ve seen by now, UHD-1 (Phase 1) is essentially multiple 1920 x 1080 HDTV images composited into a single frame). But resolution isn’t the only feature of UHD-1. The 60fps progressive frame standard means sports programming is noticeably crisper when compared to HDTV. The other significant change is in color rendition. While the current HD standard is limited to 8-10bit color depth, UHD’s Rec. 2020 standard supports 10 and 12-bit color depth. This expands the color gamut, giving colorists significantly more latitude making the camera original match a desired look and feel without compromising detail.

The industry is currently rolling out UHD-2 (Phase 2), which builds on Phase 1 by adding:

- ▶ Frame rates of 120 frames per second
- ▶ High dynamic range video
- ▶ Further audio advancements

The 120fps picture promises a significantly improved 3D viewing experience that more closely approximates human vision (at least for those of us who don’t wear glasses).

UHD-3 is targeted to coincide with the 2020 Tokyo Olympics, and will add 4320 x 7280 resolution images. This is generally referred to as 8K, and in Japan, has been labeled Super High Vision.

Well, that’s the overview. Thanks for reading, and please let us know if we can answer any 4K production questions for you.

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Cutting Edge Audio & Video Group is a Media Systems Integrator providing technology solutions, professional services, and support to content creators nationwide. With offices in Los Angeles and San Francisco, our clients include some of the most recognizable brands in media and entertainment, Fortune 500 corporations, and world-class sports organizations. For more information, visit [ceag.com](http://ceag.com), or feel free to call us at our headquarters in San Francisco at (415) 487-2323, or in our Los Angeles office at (818) 962-2445.

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