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Technology Cycles in AV

An Industry Insight Paper

How History Is Repeating Itself and What it Means to You

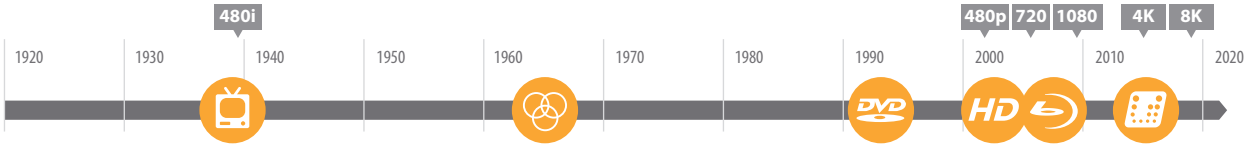
Since the beginning of video, people have been demanding more. Consumers and professionals want their video to look more and more like what you see with the naked eye. Because of this pressure, there has been continuous improvement. From black and white TV to color, from analog to digital, from DVD to Blu-ray, the industry has seen regular improvements in image quality.*

Specifically, since the beginning of digital video, update cycles have been driven by display resolution. This trend isn't stopping. In fact, we're due for another round of updates very soon. It's been about a decade since the introduction of HD resolution and the Blu-ray standard. In that time, we haven't seen a significant improvement in image quality. We're past due for the next round of updates, and we know they're coming in the shape of new Ultra High Definition (UHD) standards.

To understand what the newest video updates will mean, it's helpful to look at the past.

** Image quality is subjective, and it means different things to different people. We use "quality" to refer to the subjective experience of media viewing--incorporating traits like greater resolution, realistic colors, etc.*

Timeline



1939
First TV broadcast

1960s
Majority of TV broadcast in color

1990s
DVDs

2000s
Digital TV broadcast

HD digital TV

Blu-ray

2015
UHD

As Bitrate Grows Logarithmically, Bandwidth Must Expand with it

Each resolution upgrade cycle has improved video quality significantly. Of course quality is a subjective measure, but between higher resolution and advancements in color technologies, audio processing, and more, we can agree that modern video looks better than it did a few decades ago! All of these improvements make video look better, but they also make the files bigger. Much bigger.

Here's a graph that shows video bitrate as it's changed through the last decades, and is projected to develop over the next few years:

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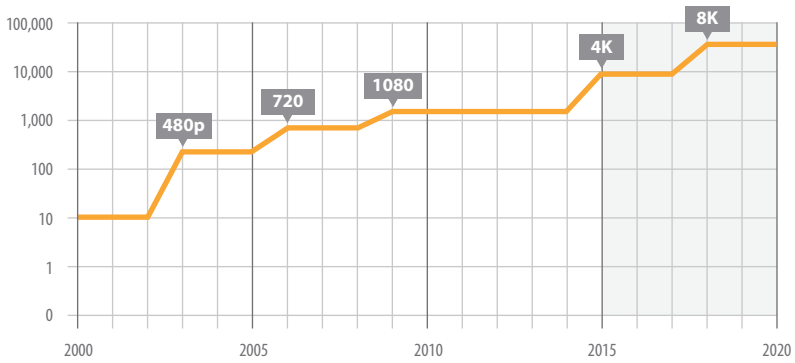
Uncompressed Video Size

(in Mbps)



Each step corresponds with an increase of resolution: 480i, 480p, 720, 1080, and then projected bumps to 4K and 8K. Note that on this logarithmic graph, each step represents a roughly tenfold increase in file size. **Video is getting big.**

Compression Fills the Gap While Bandwidth Catches Up to Video Size

Bandwidth is always a limitation when it comes to streaming video. The bandwidth necessary to stream uncompressed top-quality video has always surpassed what's widely available for consumers. Enterprise bandwidth comes closer to meeting streaming needs, but even enterprise bandwidth is often inadequate due to the timing of infrastructure creation.

Here's where our current place in the upgrade cycle matters. Right now, we've been using the same resolution standard for so long (1080p) that bandwidth has had a chance to catch up. In any high-tech application, bandwidth has been adequate for streaming video for a while now.

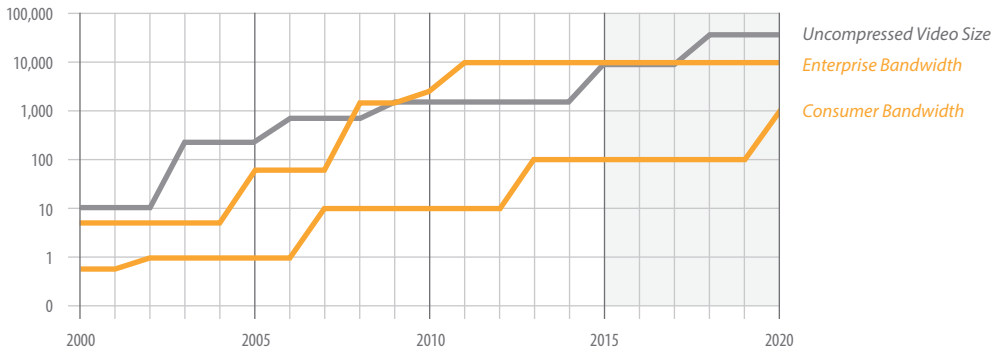
With UHD, that's about to change. **We're on the verge of another technology upgrade cycle--one that will bring with it a new challenge to bandwidth.**

Once the bump to UHD happens, bitrates will increase significantly. A 4K video will take at minimum four times the bandwidth of a 1080p video of similar quality. Given that UHD is about more than resolution and includes improvements in color, brightness, and numerous other features, the pipeline will need to be bigger still.

When we chart video size along with bandwidth, we begin to see the challenges associated with large video files.

Uncompressed Video Size vs. Bandwidth

(in Mbps)



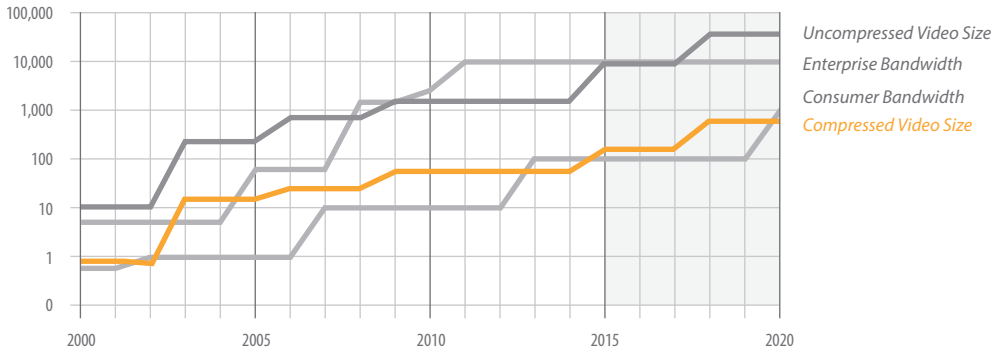
(continued)

Compression Fills the Gap… (continued)

Faced with these challenges, an increasing number of AV applications will be forced to move to compressed video, and those already using compressed video will need to move to a new codec. Consider the significant bandwidth savings that comes from using compressed video:

Compressed Video Size vs. Bandwidth

(in Mbps)



Compression has a bad reputation in some AV circles. This makes sense because early compression technologies resulted in poor video quality. Decades of technological advancement have continued to optimize compression to preserve information while shrinking file sizes. You can see this in the chart above. The difference in bandwidth efficiency between compressed and uncompressed video bitrate is actually growing. This means that compression technology is improving.

Along with the bump to UHD, we will see widespread introduction of H.265 (HEVC), the next-generation codec. Roughly twice as efficient as H.264, HEVC will keep even UHD media to a reasonable bitrate for professional and consumer bandwidth limitations.

The video cycle lets us know what to expect. A bump in resolution leads to pressure on bandwidth, which increases the appeal of compressed video. There's one more step in the cycle. When a new technology is emerging, it challenges existing standards for processing power. How does this challenge contribute to the cycle?

Codecs Initially Require Dedicated Processing Power

New codecs come into the market because they're better than old ones. They're more efficient, getting files smaller while keeping video looking good. But that improvement requires significantly more powerful processors.

When a new codec is introduced, it's a software solution running on dedicated servers. It's not practical to include this sort of solution in a product, though--it's too large and consumes too much power. General processing power isn't enough to run these cutting-edge codecs. In order to meet the power and form factor requirements for most products, the new codec will require a dedicated hardware solution. FPGAs or advanced SOCs are the only options.

This means that early adopters, at the cutting edge of the AV cycle, need to rely on hardware solutions. We've seen this with previous upgrade cycles. Consider when DVD was first introduced. You couldn't play a DVD on a PC because the processor wasn't powerful enough. We had to use add-in cards: specialized hardware solutions optimized to run the MPEG-2 codec.

After a year or two of living with add-in cards, general purpose processing began to catch up. The MPEG-2 codec was optimized, and eventually an all-purpose desktop processor could run the codec without dedicated hardware.

This is a crucial, and often overlooked, part of the AV cycle. A bump in resolution and/or a new codec brings with it a need for hardware solutions. Then as general purpose processing power continues to increase, software solutions become a more viable option. At that point hardware solutions are no longer necessary (though for some applications they're still ideal)-- until the next bump in resolution or new codec.

New codecs help improve compression but require dedicated hardware until mainstream processors are able to catch up.

The Advent of 4K and HEVC Signals a New Technology Cycle

Currently, we're at the very beginning of another advancement in AV and a new technology cycle. HD (1080) is being upgraded to UHD (4K); H.264 is being replaced or augmented by H.265 (HEVC); and many other technologies are combining to make video that just looks better. Given what we've seen before, this bump is going to lead to much larger video files, making compression more necessary than ever before. At the same time, hardware solutions will be the most practical way to get the HEVC codec into products.

Over the next five years or so, we will see bandwidth begin to catch up, and software solutions will become increasingly viable (as we've seen in past cycles). Will that be the end? Processing catches up, bandwidth catches up, and uncompressed video is the way of the future? Nope. After a while we'll face 8K, H.266, and whatever future technologies we don't even know to expect yet.

This raises an important question. Some businesses are asking whether they need to participate in the 4K UHD upgrade cycle, since we know that 8K will be coming soon.

Should they wait for 8K? We don't think so. 8K has been demonstrated, it's true, but 4K was demonstrated in the early 2000s, and it's still not widely available. Additionally, different industries adopt and deploy new technologies at their own pace. Cable, for example, still widely uses MPEG-2 technology. It might seem like you can skip 4K because 8K is almost here, but that's just not the case.

Resisting the UHD upgrade could leave you unable to work with certain customers/industries, not only until 8K arrives but also afterward. The key is to be ready in markets you address today or plan to address tomorrow. At some point, almost all AV markets will require UHD.

Video will keep getting better, and as it does, this cycle is going to continue to repeat.

Moving Forward, Here's What We Believe Will Happen

5 things to remember as you plan for the UHD tech cycle.

1 Video will keep getting better.

People won't be satisfied until the Holodeck is real. Improvements in resolution, color, frame rate, and hundreds of other variables will continue to push this upgrade cycle.

2 Each time there's a technology cycle, bandwidth will become challenged.

Bumps in video quality/resolution increase bitrate, meaning that (at least at the start of an improvement cycle) necessary bitrate will exceed bandwidth.

3 Compression will be essential.

Customers will be unwilling to sacrifice quality or cut back on the quantity of video they consume. In order to conserve bandwidth, compression will be essential.

4 Hardware solutions will prevail at the start of the cycle.

In the early days of each cycle the compression algorithms will be too complex for software-only solutions on general purpose processors. They will require specialized silicon in hardware solutions.

5 This cycle won't end with UHD.

Soon, 8K will be on its way, and even if we do reach an endpoint regarding resolution, we will continue to see improvements in color, contrast, audio, and all of the other things that make video better. Compression is not going to be a choice for very long. As compression gets better and video files get bigger, it will be an absolute necessity.

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