



4K
ULTRAHD

Preparing For The 4K Content Workflow Transition

Quantum

StorNext



Introduction

Consumer demand for ‘better than HD’ content is unlike anything seen before – the accelerating pace of consumer technology adoption consumer expectations for around-the-clock content delivered on any device, at any time – is the most disruptive change to our industry in recent memory.

The HD to 4K transition is proving to be dramatically different than the SD to HD transition – and is accelerated by new all-digital mediums and viewing platforms and new expectations about how that content should be delivered and personalized.

Meeting these new content demands requires new thinking about how to not only meet the immediate 4K content demand, but ensure that the entire production workflow can adapt to the demands of this always-on, ever-changing adaptive content paradigm.



Table of Contents

Introduction	2
4K Ascendant.....	3
4K Top Five Tips.....	5
4K Workflow Challenges.....	7
Ingest, Edit, Finishing	8
Quantum’s 4K Manifesto: What We Believe	9
Building a True 4K Workflow.....	10
Summary	11
Additional 4K Resources	12

4K

4K Ascendant

If HD is commonly accepted to be 1920x1080 frames at 24-60 frames per second – the new, higher resolutions called UHD or 4K are as much as 3840x2160 or 4096x2160 at those same framerates or higher - the equivalent of playing 4 simultaneous HD streams at once.

The cameras and sensors that can natively create 4K content are a major leap in imaging capability – delivering instant, all-digital content with lush, ‘film-like’ capabilities, and very high framerates that open up new creative possibilities.

Format	Bandwidth per Stream per Second	Storage per Stream per Hour
4K RAW 24FPS 12bit	319.2 MB/s	19,152 GB
4K QuadHD ProRes 4444 23.98FPS (48KHz/24bitsx4)	149.06 MB/s	536.63 GB
4K REDCODE 36 23.98FPS (48KHz/24bitx4)	36.57 MB/s	131.65 GB

Example data rates for raw and compressed 4K streams

Customers today are much more discerning about the quality of their viewed content. They clearly appreciate the dramatic visual difference of 4K over older HD content and have been constantly reminded that the latest phones and televisions have 4K or UHD capability, as do many viewing platforms such as NetFlix and YouTube.

When the latest smartphone is capable of up to 2560x1440, and 4K televisions are available for as little as \$800, DVD and HD quality content appears very small indeed, driving consumers to seek out the highest resolution available.

When combined with the expectation of having all-digital content delivered instantly as opposed to waiting for a DVD or BluRay, these factors both have dramatically sped up the adoption rate for 4K, and clearly, this adoption is happening faster than the SD to HD adoptions that took over a decade. Digital movie purchases jumped 47% in 2013 to \$1.19B while DVD and BluRay sales and rentals have slumped over the same period – and this trend appears to be accelerating.

Existing SD content found a long life during the SD to HD transition as either cropping or 'upres' strategies were acceptable solutions for a long time. This is not the case when very high resolution viewing platforms are the norm – the savvy consumer does not value lower resolution content and will instead seek out higher resolution options.

Content owners must immediately assess content strategies to plan how to provide 4K content for both current content production, and re-ingesting owned content at higher resolutions to keep that content competitive and appealing in predominantly UDH and 4K marketplace.

At the same time that the viewing of ultra high resolution content is becoming easier and more prevalent – the capture of 4K content is similarly becoming more prevalent as well. Consumer and production cameras that can capture 4K content are becoming readily available at dramatically low prices.



The GoPro Hero Camera – popular as a multi-use production camera to add to the creative narrative – full 4K frame size and ideal for environments that larger and more expensive 4K cameras are not suited for.

A wave of consumer 'action cameras' such as the GoPro 4K are finding their way into television and film production as they are very inexpensive and rugged. Its becoming common to put several such systems on an actor, stuntperson or car rig and easily get multiple high resolution streams of dramatic footage to fold into a production.



AJA CION 4K camera – and example of relatively inexpensive yet fully featured 4K cameras. These cameras typically capture to solid state drive 'cartridges' or 'carts'.

Beyond consumer 4K cameras, the newest wave of 'prosumer' and broadcast cameras offer stunning image capture that are a very attractive alternative to high-end film cameras and scanning. These cameras employ much larger sensors capable of capturing astounding color levels and fine gradation from light to dark values, with excellent low light performance. Further, these cameras can easily accommodate very high framerates.

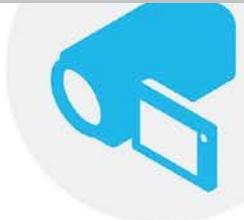
Television and independent film productions have been very quick to adopt these new cameras – the combination of 'near-film' levels of quality for all-digital, instantly editable content dramatically speeds production and eliminates film scanning steps.

4K TOP FIVE TIPS

Video production is entering yet another major transition—the move to 4K. Much like the move to High Definition several years ago, the new ultra-high definition, 4K resolution formats have the potential to disrupt workflows, strain existing infrastructure, and require costly unplanned upgrades. Those who remember how bumpy the change from SD to HD was are understandably nervous about what this looming 4K transition will bring.

With lessons learned from the past, the industry is ready to make the change from HD to 4K. The technology has evolved, the tools have evolved, and workflows have evolved. The challenge, however, is to make sense of all this evolution and put the right pieces together to enable a successful transition.

We've put together 5 key tips for helping you make the transition to full 4K production as smooth, non-disruptive, and economical as possible:



1 UNDERSTAND YOUR FORMAT REQUIREMENTS.

There are lots of choices today for capturing 4K images and working on them in post-production. The codec and bitrate you choose will have a direct impact on the infrastructure you will need to support your workflow. Just a single uncompressed 4K stream at 24 frames per second (FPS) can demand more than 1 gigabyte per second of data throughput. These demands only get higher if you happen to be working with stereoscopy and higher frame rates. Knowing your format requirements will enable you to design an infrastructure that will effectively support the work you need to do, without requiring time-consuming format conversion steps.



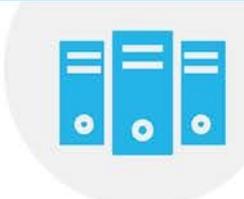
2 MATCH YOUR TOOLS TO YOUR WORKFLOW.

Most content producers want to produce their work at the highest possible quality level, and it is important that the production tools being used are capable of working with 4K material. Likewise, most production environments are becoming more collaborative, with teams of people (often geographically dispersed) sharing production tasks on stored content. An extremely important part of getting ready for 4K is understanding what kind of workflow you want, what applications your teams will work with, and then making sure that your underlying infrastructure can support those tools in your desired workflow. It also makes sense to ensure that your workflow system can grow as the tools change—the last thing you want is a platform that locks you in.



3 MAKE SURE YOUR STORAGE IS READY.

With 4K, there is a lot more data in every frame and the performance needs of your infrastructure are greater. This means having the right storage ready to support your workflow. At the same time, storing all this extra data on expensive storage can be cost-prohibitive. Keeping costs under control means being able to steer the right content to the right storage tier, something that not all storage systems are designed to provide. The ideal storage system allows you to mix high-performance and high-capacity disk and to move content between them in a way that is transparent to the creative team.



4 DON'T FORGET THE ARCHIVE.

Everyone knows that content lives forever, and in today's on-demand society, content needs to be always accessible. The move to 4K means larger files, which puts more strain on already stuffed content archives. Users need a way to hold more data, make it available for re-use, and to protect it for future monetization. Doing that cost-effectively means taking advantage of tape archives that can be accessed like disk, so be sure that your storage environment supports that option.



5 PICK THE RIGHT PARTNERS.

Moving into the 4K world will raise questions about technology capabilities, workflow considerations, and insight into where the industry is headed in the future. Make sure your vendors understand the market and have the right relationships in place with other vendors whose tools you will rely on. Taking advantage of the advice of companies—Quantum is one—that are experts in video production environments, committed to a long-term, open-system approach, and that collaborate with other vendors and integrators is critical.

Television production has quickly adopted 4K production for pilots and existing productions both for speed to edit, and competitiveness of that content for future syndication and sale

Television productions not only enjoy the faster time to delivery of a pilot or episode, they are looking ahead to the value of their production in the resale and syndication market when content is predominantly 4K – having a production in 4K now makes future content more desirable and give the content greater competitive life.

Independent film productions enjoy having more control over rich digital assets and bypassing the film, developing and scanning steps, thereby keeping those related production costs out of their budgets as well.

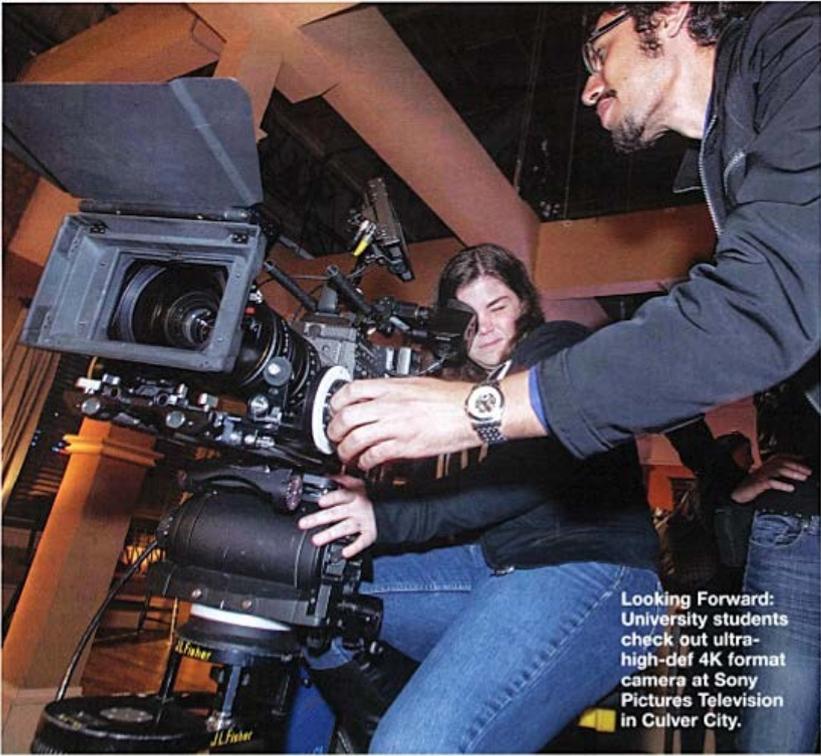
Content owners that seek to build ongoing revenue streams for existing content must now review all existing HD and DVD quality content, and remaster and reissue content in 4K or higher formats. Reissuing content in higher resolution is welcome to the 4K consumer and a key way to differentiate and monetize existing, unique content.

All of these factors are strongly pulling both the consumption of, and initial production of ultra high resolution content forward – yet manipulating that content from initial capture to 4K delivery requires careful consideration of the entire production workflow.

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Looking Forward: University students check out ultra-high-def 4K format camera at Sony Pictures Television in Culver City.

Future Focus

TV studios get jump on content for 4K sets

By **JONATHAN POLAKOFF** Staff Reporter

THE shine has worn off of HDTV, and 3-D TV never really caught on. But the major TV studios in town, most notably **Sony Pictures Television** in Culver City, are fast-forwarding to a newer, ultrahigh-definition format called 4K.

Studios think it's the next step toward improving home entertainment because it displays four times as many pixels per frame as HD. And they're making the switch now because 4K cameras have recently come down in price.

The higher-resolution TVs, which have began appearing in stores, produce images with stunning clarity and detail. Demo videos feature paintings that could be mistaken for actual canvasses in front of you.

But even if you bought a set, there'd be no broadcast 4K TV programming. Cable and satellite companies don't even carry the signal yet and

Please see TV page 74

4K Workflow Challenges

Adopting a 4K production workflow can have significant impact on the entire production workflow and each step of the process has different considerations.

Existing production environments built for HD production will find it a considerable strain to start producing 4K – storage performance adequate for a full team of HD production creative may only be able to support a few 4K editors, or that 4K ingest consumes so much storage performance that existing production is impacted.

For example, four HD streams may independently be streamed from a production SAN, each able to tolerate workstation-to-storage latency of around 40ms before editing or playout is affected and runs out of buffered content. By contrast, a single 4K stream only be able to sustain 20ms of latency before editing or playout is affected, and effect that is only amplified when multiple streams, and multiple editors are all working on the same production SAN.

While its true that editors will rarely need to work with uncompressed 4K streams, compressed or mezzanine formats remain much larger than their HD counterparts and demand high speed, low latency connections in a shared environment.

It is for this reason that Ethernet based storage solutions are a poor choice on which to build a production environment – not only is packetizing video for Ethernet delivery impractical in an editing environment that cannot tolerate latency or out of order data delivery, these systems need to be very large to scale to meet the demands of a collaborative shared environment.

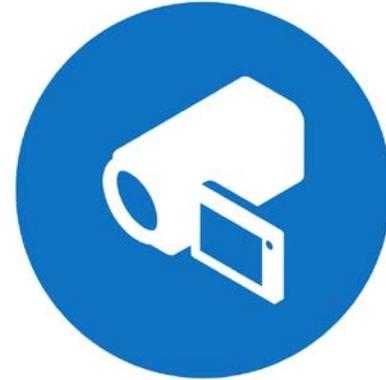
FibreChannel connected SAN clients and storage is highly predictable and efficiently scales to meet the performance needs of a 4K workflow that is truly collaborative for the shortest time to production and delivery.

Standalone or independent workstations may seem to be a way to guarantee high-speed access to storage with low latency, but gives up the collaborative benefit of a SAN and wastes time while waiting for one production step to finish and copy back to the SAN, and allows duplicated content is usually not acceptable in a production environment.



Ingest

Most cameras that capture 4K do so on flash storage ‘carts’ that must be periodically swapped out and its contents ingested into the production environment. Where film and tape were durable and relatively inexpensive– digital capture carts tend to be expensive and of limited size. The carts cannot be used again until its content has been safely ingested – and reshooting to make up for overwritten data is not an option for sports or documentary productions.



It is strongly recommended that this content be archived on ingest before editing begins and the camera carts are released.

Ingest of these large files and simultaneous archiving can put a strain on a production environment that is not built to accommodate this workflow – after all each 4K file is 4 times the data equivalent of an HD stream.

Edit

Once ingested into a primary SAN environment, these large files can be edited by modern non-linear editing systems such as Apple Final Cut, Adobe Premiere or AVID Media Composer. However, consideration should be given to the number of streams that each editing workstation requires and whether there is enough storage performance and client to storage bandwidth available to support how the editor prefers to work to maintain the highest productivity in this larger format.



Even if the editors are using a mezzanine or proxy format when editing 4K materials, its worth pointing out that this format will be HD, the format that almost all existing production workflows were built to output.

Finishing

Finishing steps such as color, titles and effects all need to adapt to the higher resolution format as well – to participate in the production workflow collaboratively these workstations will also need to be able to have sufficient bandwidth and storage performance to ensure the highest productivity so that there is no downtime or backlog in the production process.



Quantum's 4K Manifesto: What We Believe

We see five key market trends, five key workflow trends, and recommend a 3-step transition strategy.

Five Market Trends

- [1] The market for 4K content is developing quickly, with consumers driving demand at unprecedented levels.
- [2] 4K cameras and television adoption is ahead of widespread 4K content availability.
- [3] Producers are creating 4K content now despite limited 4K distribution channels
- [4] 4K content will be delivered via IP first
- [5] 4K content availability will vary by market segment: feature film and sports will lead.

Five Workflow Technology Trends

- [1] During this 4K transition, HD and 4K workflows will operate side-by-side in the same facilities.
- [2] Rapidly evolving delivery platforms and "always on, rich-bandwidth" access to content are reshaping the workflow as well.
- [3] Content creation and transcoding are occurring simultaneously, creating new requirements and putting pressure on the storage workflow supporting this new content creation.
- [4] NAS-based workflows that worked under HD will struggle with 4K content workflows.
- [5] The 4K transition is changing all aspects of the modern, creative content workflow beyond the storage component.

We recommend this 3-Step 4K transition strategy:

- [1] Keep your existing, highly productive HD environment, but stand up a dedicated environment for 4K projects.
- [2] Multi-mount clients and share finished files across 4K and HD environments.

- [3] When purchasing new equipment, buy components capable of 4K or better.

Background on Market Trends

The market for 4K content is developing quickly. Where the transition from SD to HD took over 10 years, the market will drive the transition from HD to 4K at a much faster pace, from 18-36 months.

Intrigued by 4K's superior image quality, consumers are driving demand. Content creators are now using 4K for part of storytelling in more impactful areas, where the difference in HD and 4K is most noticeable: sports (especially zooming in on action while retaining HD framesize), visual effects, landscapes, close-ups on faces.

New cameras deliver 4K at a price comparable to HD cameras, often with higher frame rates. The new breed of sensors in 4K cameras capture dramatically more color tone and range than HD cameras. These cameras typically offer choices of much higher frame rates as well, which is better for special effects, slow-motion, and anything with more action because the image stays sharper, doesn't look soft or muddy.

New television productions are enjoying much shorter production workflows with new cameras, and getting images that rival image quality that could previously only be had with film production and scanning. The combination of lower cost cameras, speed to production by leveraging 'born-digital' content, and the promise of 4K content that will fare well in future content markets are all driving television and independent productions now.

Producers are creating 4K content ahead of their ability to distribute it now. Producers expect consumer demand for 4K content to be greater in years to come than now, and want to maintain the value of the content over a longer life span by using highest quality imagery during post-production and for archive. Capture in 4K ensures they will

be able to deliver with the highest quality, even if only in HD today. In addition, restoration projects for re-monetizing legacy assets are captured in a minimum of 4K. For restoring Lawrence of Arabia, it's 8K.

Early adopters for 4K content will have it delivered over IP. While 4K televisions are becoming available for broadcast content, 4K is made for IP delivery. Unlike satellite or cable, IP infrastructure doesn't have bandwidth limitations, which lends itself for higher resolution content delivery. With IP delivery, the download may take longer for 4K content, but it doesn't disturb the viewing experience.

Though some argue otherwise, the higher quality imagery of 4K over HD does enhance the viewing experience. Since the quality of 4K content is noticeably better, viewers can sit closer to larger televisions or monitors and still have the advantage of a sharper picture. 4K content make a more cinematic viewing experience more available in a home setting.

The adoption path will be 4K capture across all markets first, then delivery by market segment. Movies have been shot on film in the equivalent of 4K for years, and 4K digital cinema projectors were first appeared in theaters in 2011. For content that's traditionally been broadcast, cameras that shoot 4K are now standard, but 4K content delivery will come in waves. First with sports, then episodic TV for certain shows that offer digital delivery, plus all new content offered on Netflix and Amazon Prime. News will probably lag.

Background on Workflow Technology Trends

During the 4K transition, HD and 4K workflows will operate side-by-side in the same facilities. The lessons of previous transitions will aid in the transition from HD to 4K. Rather than making an overnight switch, the industry kept analog infrastructure live and in place while broadcasting digital, and did the same for the

transition from SD to HD. As a first step, many facilities will stand up smaller dedicated 4K environments with a few workstations. Then, 4K-capable workflow components will be purchased during the normal equipment replacement cycle and used for projects that may or may not be 4K.

New delivery platforms and "always on" access to content are reshaping the workflow simultaneously. HD workflows were primarily linear: ingest-process-archive. Now, with new platforms, 3rd screen, behind the scenes, alternate endings and other special features content being delivered, the workflow is not linear. Archived content is transcoded for new platforms and delivered, or re-processed into special features content.

Content creation and transcoding are occurring in the same workflow, creating new storage performance requirements. Storage must be able to stream multiple streams of high-volume 4K content at the same time SD-sized streams of transcoded content are being transferred. Storage must be designed to handle this mixed workload efficiently.

NAS-based workflows that worked under HD will struggle with 4K content, without changing users' existing processes. Many shared storage solutions that advertise 4K capabilities will require down-res editing.

The 4K transition will change the workflow beyond its storage component. 4K will change how content creators work: some will work in mezzanine, some will work in proxy, all will deliver more formats, and everything will be more complex. During the transition from SD to HD, people got accustomed to using 2-3 streams; with 4K it will be multi-camera. That's easily 10 streams with five cameras of two streams each, which is the volume equivalent of 40 streams of HD. Choosing the right codec becomes even more important.

Building a True 4K Workflow

There are different recommended approaches to adopting a 4K production workflow that range from standing up an entirely new 4K environment to building a pilot or smaller environment to work with an existing environment.

Option 1 – Build a New End-to-End 4K Environment

Some fortunate customers will be able to build a new environment with end to end 4K capability – from ingest through delivery. This is a superb time to assess the entire workflow, from asset managers to the complete content production and monetization lifecycle.

Sizing for a fresh, end to end, 4K capable production environment is similar to specifying an HD production environment, with the caveat that the system will require fast and highly capable SAN Metadata Controllers, and enough FibreChannel storage and bandwidth scaled to serve all clients for the number and size of streams that are required for the most efficient editing.

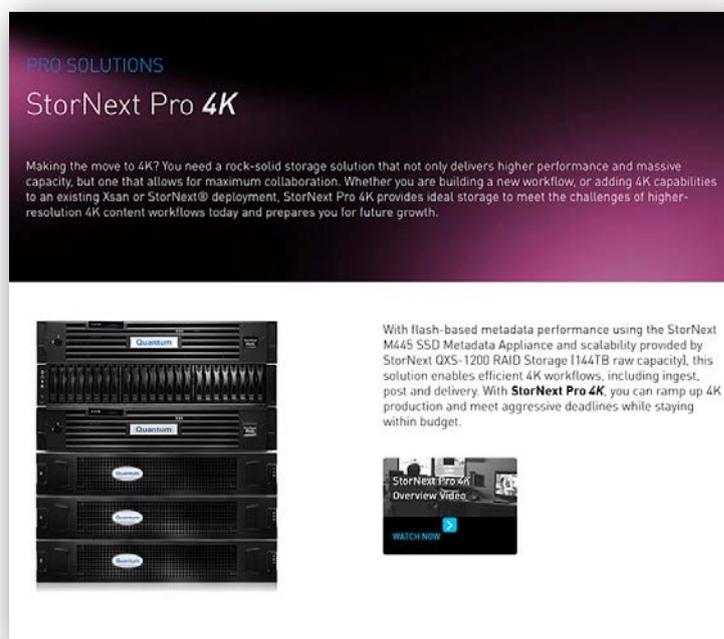
Option 2 – Stand Up a ‘Side-by-Side 4K Environment

Another option is to simply stand up a new, smaller 4K capable environment alongside an existing HD production environment. This smaller environment can realize all of the benefits of a true, collaborative workflow, while sharing key assets and finished files with the existing environment.

While it may be necessary to run additional FibreChannel or Ethernet networking to Accommodate both the HD and 4K environment

at the same time the impact is much less than having to create an entirely new environment from scratch.

Key production workstations can mount both the HD and 4K SANs at the same time to ease productivity between the two environments as needed – and as the 4K environment grows, it can begin to displace the existing environment over time.



The slide features a dark purple gradient background. At the top left, it says 'PRO SOLUTIONS' in blue and 'StorNext Pro 4K' in white. Below this is a paragraph of text: 'Making the move to 4K? You need a rock-solid storage solution that not only delivers higher performance and massive capacity, but one that allows for maximum collaboration. Whether you are building a new workflow, or adding 4K capabilities to an existing Xsan or StorNext® deployment, StorNext Pro 4K provides ideal storage to meet the challenges of higher-resolution 4K content workflows today and prepares you for future growth.' On the left side, there is a stack of four server units with 'Quantum' logos. On the right side, there is a smaller image of a server rack with the text 'With flash-based metadata performance using the StorNext M445 SSD Metadata Appliance and scalability provided by StorNext QXS-1200 RAID Storage (144TB raw capacity), this solution enables efficient 4K workflows, including ingest, post and delivery. With StorNext Pro 4K, you can ramp up 4K production and meet aggressive deadlines while staying within budget.' Below this text is a small video player icon with the text 'StorNext Pro 4K Overview Video' and a 'WATCH NOW' button.

This approach is an excellent way to cost-effectively gain 4K production capability while maintaining existing HD productivity and is much easier to implement and allows editors are able to gain 4K experience and familiarity over time.

Quantum’s StorNext Pro 4K solution was expressly designed to accommodate either of these approaches – Either is the foundation for an entirely new environment, or a small contained yet fully 4K capable environment that can live alongside an existing production environment.

Summary

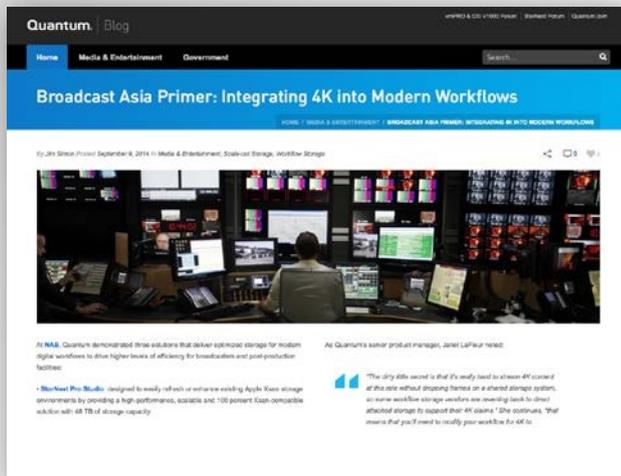
The rise in popularity of 4K is having a dramatic impact on the media and entertainment landscape, affecting not only 4K production and viewing, but especially in content production.

Every aspect of content production needs to be reviewed to ensure that from ingest, through editing and finishing, delivery and long-term asset monetization is fully optimized and able to keep up with the performance pressures of working with the much larger 4K/UHD file sizes.

While there remains a tremendous amount of existing HD production, getting ready for 4K with even a pilot or smaller 'side-by-side' 4K environment will prepare you to develop highly efficient, competitive 4K content.

Adopting 4K production capability can be done in stages to minimize the impact to already existing HD production workflows, develop familiarity and best practices, and ultimately scale to meet the largest needs and future challenges of 4K production and beyond.





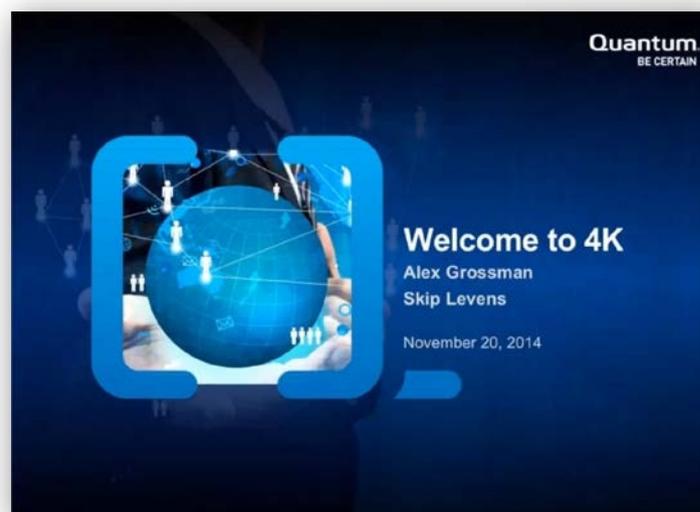
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Welcome to 4K



Quantum StorNext and Lattus production, archive & cloud storage solutions power media workflows, enabling teams to collaborate in real-time and keep assets accessible for future use and re-monetization. Evolving for 4K/beyond, new camera formats, delivery options & tighter deadlines, StorNext 5 manages content at every step of media workflows, from ingest to archive. Leading studios, broadcasters & thousands of smaller content creators rely on StorNext to create award-winning productions.

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