The 4K Format Implications For Visualization, VR, Command & Control and Special Venue Application

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1 - Abstract

There is an emerging trend in display and in particular in projected display that requires new strategic thinking in terms of application, design and integration. The driver for the change is an explosion in resolution brought about by the availability of 4K format displays. The affects include a shift from a long-standing one-to-one relationship between a source and a display, to a new paradigm where the display acts as a container for any source or many sources windowed into it. This shift challenges many long held integrations and display design standards and must be considered by anyone who is implementing large-scale displays for visualization, VR, command and control and special venue applications.

Keywords: video, video resolution, 2K, 4K, XGA, SXGA, cube walls, 1080, HDTV, visualization, command and control, special venue, VR, projected arrays, monitor arrays, blended arrays, edge blend, SXRD,

2 - One-To-One Relationship

For many years there has been a direct relationship between sources and their display. A media source would typically be connected to its associated display. Of course in many instances, several sources might be connected to a single display using a switcher of some type.

If you need to view multiple sources at one time, then each source would typically be connected to a different display. This seems simple and obvious enough, but it often results in highly chaotic visual environments, whose intent is probably to provide some clarity of overview.

It also leads to much more complicated switching or routing systems that allow one to direct any input to any output in a matrix configuration. These input and output configurations range from relatively small, such as 8 input - 4 output matrixes, to large configurations such as 64 input - 64 output matrixes. In any case, the designs for these environments tend to support a one-to-one sources-to-display relationship.

Fig 1: Command and Control center with many sources/displays

This relationship is also generally maintained even if the displays are arrayed in some fashion. This could include a bank or group of monitors or projectors placed adjacent to one another. In other instances this might include a bank or group of projectors arrayed together with blended overlaps to create large seamless images.

Display arrays have been a large evolving trend over the past 10 years, driven by great advances in real-time graphics.

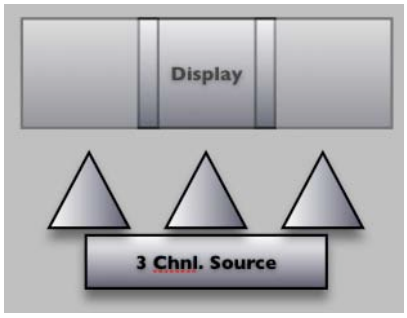

Fig 2: Three channel blended projector array

These were first pioneered by companies like Evans & Sutherland for flight simulators, brought to commercial applications like oil/gas by companies like Silicon Graphics and now brought to the masses for gaming by graphic card companies like NVIDIA.

Real-time graphics evolved to offer greater resolution than single displays could handle. The solution has been to stream multiple graphic channels that can be applied to arrayed displays. This creates larger, higher resolution results for applications that range from the desktop to visualization rooms, to command & control centers.

Even though multi-projector or multi-panel arrays provide a single cohesive image on the array, the solutions still typically maintain a single source to single display relationship.

For these solutions, the projector array acts as a container for the higher resolution graphic capability of the computer. This is true whether the display is seamless, adjacent, flat, or curved.

3 - 4K Resolution Revolution

Driven by the digital cinema opportunity, the newly introduced 4K display format is so incredibly high in resolution that it promises quite a disruptive influence on the previous 10-year display trends. There is now clearly more resolution available in a single display than can typically be generated by a single source.
Below is a table of some comparative highlights in the evolution of resolution:

Format	H Pixels	V Pixels	Resolution	% increase
VGA	640	480	307,200	
SVGA	800	600	480,000	56%
XGA	1024	768	786,432	64%
SXGA	1280	1024	1,310,720	67%
SXGA+	1400	1050	1,470,000	12%
1080p	1920	1080	2,073,600	58%
4K	4096	2160	8,847,360	327%

Fig. 3: Simplified display resolution chart

The VGA (640h X 480v) display resolution was essentially the progressive scan version of NTSC broadcast television, adapted for use with the PC. It was the running standard for several years.

When computers came into greater prominence, this TV like resolution quickly became inadequate to support the text being generated by the machines. The need for higher resolution spawned Super or SVGA (800h X 600v). From a percentage-of-increase standpoint this provided 56% more resolution over the previous standard and represented quite a move forward.

XGA (1024h X 768v) came along with the evolution of graphics rather than text on computers.

Not many years later SXGA (1280h X 1024v) crossed the "MegaPixel" threshold bringing 1.3 million pixels to the screen.

Now the 'standards' progression arguably fell into chaos… Graphics cards evolved rapidly with the ability to be formatted to all sorts of outputs. New formats have since come so fast and furious – it is questionable that the word "standard" is applicable. This includes UXGA, QXGA, WQXGA, UWXGA, QQVGA, WXGA, WXGA+ and many more. In other words, there are so many formats there is effectively no standard. For a more comprehensive listing, please refer to "computer display standards" in the Wikipedia encyclopedia.[1]

[1] http://en.wikipedia.org/wiki/Computer_display_standard

Breaking through the clutter of all these formats is one that is absolutely unprecedented and wholly remarkable in the progressive history of display resolution. Whereas new formats typically represent some 50-70% improvement in resolution to the previous generation, 4K represent an over 325% leap in a single step over the just establishing 1080p (1920h X 1080v) standard. It represents an incredible 500% leap over the current DLP based SXGA+ (1400h X 1050v) format!

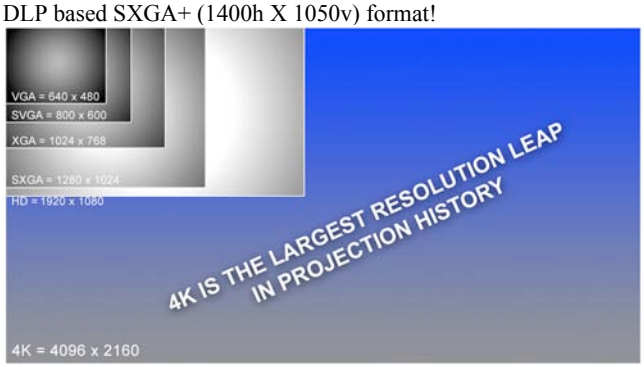

Fig. 4: Relative aspect and resolution changes over the formats

The 4K format is a direct result of the Digital Cinema race. The 4k SXRD (Silicon X-tal Reflective Display) imaging device announced by Sony in 2004 [2] is 4096h X 2160v providing an unprecedented 8.85 million pixels in resolution. The first projector using this new imager started to appear at trade shows in 2005 and went into commercial production in 2006.

4K has been a strategic goal for digital cinema all along. Its resolution mimics the number of silver grains available in large format film, thus 4K represents a true resolution parallel to film.

Although its intended application is aimed at replacing 35mm and 70mm, any electronic projection device with this much resolution can also be well applied to a variety of commercial, visualization and command & control applications.

To begin with, it flips the lower-resolution-display to higher-resolution-source order and changes the long standing one-source to one-display relationship.

You can now contain many sources windowed into a single display.

[2] http://www.sony.net/SonyInfo/News/Press_Archive/200405/04-027E/ Sony Press release

Up to 24 VGA or video signals, various combinations of different resolutions and even four full resolution 1920 X 1080 HD sources fit onto this vast canvas with pixels to spare.

Fig. 5: 24 VGA signals at native resolution on one screen

Fig. 6: various sources at native resolution on one screen

Fig. 7: Four 1080 sources at native resolution on one screen

All the sources are at their native resolution and no scaling artifacts are introduced into the image because of the need to scale down sources to fit them onto a display.

These scale-down artifacts have been a genuine problem with previous windowing applications.

For example, if a user wishes to window four computers into a standard SXGA (1280h X 1024v) display space, it is very probable that all four computers are at SXGA resolution themselves. The only way to fit them onto the display is to reduce the size, or scale down the sources to make them fit into the projection space. Because there is a direct relationship to size and resolution, this necessitates throwing away one out of four pixels. This type of scaling works fairly well with real-world or video type imagery, but for data imagery, extremely undesirable artifacts can result.

For example, the number “8” might suddenly look like the number “6”, or a “0” might look like an “8”. Depending on the application, these artifacts can cause errors in decisions, sometimes with catastrophic results. Many users who envision using “picture-in-picture” to bring sets of computers onto a projection screen experience great disappointment with results that can be unacceptably flawed.

The reasons for the artifacts have often been blamed on the windowing device, but in fact they are the inescapable results of trying to contain multiple channels of higher resolution images in a lower resolution display space.

4 - Cube Walls

There is a class of windowing technologies that can be directly applied to the new 4K format. These processors were mostly developed for displays that use adjacent image “cubes” arrayed in an XY pattern. These cube walls are intended to provide larger, higher resolution display surfaces onto which one can put higher resolution images or many sources in windows at their native resolution, thus avoiding the scaling artifacts.

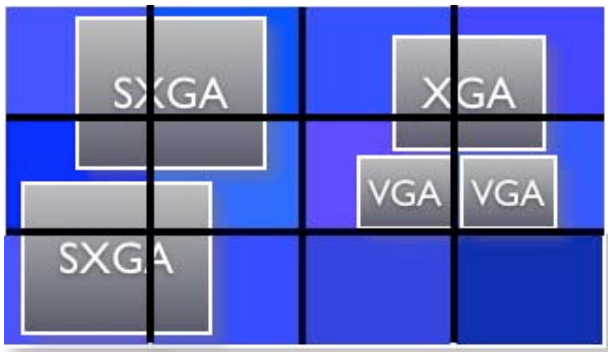

Fig. 8: Cube wall solution for achieving resolution

For example, an array of 4 X 3 XGA cubes is roughly the same resolution as a 4K display at 4096h X 2304v.

However, there are new undesirable artifact issues introduced by the solution itself.

First of all, keeping all 12 cubes matched in brightness, color and alignment over time is problematic. It is not unusual to see some very poor looking cube walls. Then there are the breaks between the cubes. These have shrunken significantly since the days when CRT monitors were used to create these arrays. Today, you still have a grid over the image, which tends, with Murphy’s help, to fall exactly into the wrong place. Finally, the cubes are a fixed size, which defines the overall size of the array. To get a larger display you need more cubes.

In contrast, with a 4K projection, the alignment, color and brightness uniformity are inherent and require no maintenance. Of course it is a single image with no overlay grid. Also, because it is a projection, by varying lenses and throw distance, the display is highly scalable to fit the application and the venue.

It is a reasonable conclusion that the 4K format represents a highly disruptive technology to both projected arrays and to cube wall systems.

5 - Progression of the 4K format

Over the next few years, 4K will expand in prominence driven interactively by both digital cinema and commercial application. It is worth tracking both of them as they each affect the progression of the standard.

On the digital cinema side, theaters will incorporate the format but this is highly dependent on the availability of features in the format. The strategic pivot point may well be the 4K Digital Intermediary[3] (DI) not the projector technology. Native digital 4K feature releases will expand if 4K DI become the de-facto standard in the post-production process.

Based on the history of film, it is likely that shooting in digital and specifically in 4K digital will evolve slowly. Directors and Directors of Photography are very comfortable with their tools and processes to achieve their intended results. Shooting in 35mm or 70mm film will be standard for another generation or more.

However, Digital Intermediaries themselves are a fairly recent step in feature film post-production. They involve scanning of the original film negative into a high-resolution digital form so that color timed prints can be laser scanned back onto film. Meanwhile a lot of digital manipulation can go on. It is becoming increasingly more common for all the original scenes to be scanned into digital form for special effects, compositing and other manipulations that take place in the digital domain.

These processes will combine and DI will move easily from 2K to 4K without much disruption to the workflow but with a significant increase in quality at the price of render times, disk space requirements, and so on. With the transition to 4K in the workflow, 2K (HD), 35mm, IMAX, DVD, Video AND native 4K digital releases of the films become possible and potentially cost effective. If there is product available, there will be more and more screens showing it.

How does it affect visualization, VR, Command & Control and special venues? The answer lies in user expectation and the strategic timing of applying the format. The 4K format is coming fast.

Commercial Integration: Several of the visualization system integrators have been working with the format for over two years now. They have developed engineered solutions using the format that include stereoscopy, arrays, caves and as if 8.83 million pixels were not enough, they have even shown warped and blended solutions using multiple 4K projectors.

Flat Panels: There are already several manufacturers who have announced 4K flat screens in the 50"+ range. This is driven by the availability of 4K LCD panels from Taiwan.

Digital Camcorders: High-end commercial 4K camera/recorder systems have been shown by both Sony and by Olympus in the past 2 years, but the hot buzz in this area belongs in Southern California. An amazing new digital video camera called the RED ONE has been shown at trade shows. Jim Jannard, the founder and CEO of Oakley, and a team of technicians at the Oakley Bunker labs, developed the camcorder. Their goal is to provide a sub $30K camera and recorder system that shoots and plays back in native 4K.

Digital SLR: All of the new 10+ megapixel and most of the 8 megapixel digital still cameras provide incredible imagery at native resolutions that are compatible with 4K. Even 2007 models of standard consumer compact snapshot cameras have been sporting 7.1 megapixel resolutions. By next year they will surely be over 8.5 million pixels.

6 - 2K and Other Wide-Aspect Ration Implications

There is one more implication to consider when looking to incorporate the 4K standard to your application. That is the relationship of 4K to the 1080p, HD, and 2K formats. These three formats are all effectively the same 1920h X 1080v if not the exact same standard.

HDTV was announced over 25 years ago. It took a long time but one could consider 2006 as the tipping point for the format. Standards built around 2K form a nexus for broadcast, entertainment and computer applications.

With millions of wide format 1920 X 1080 flat screens moving into family homes worldwide at a dizzying pace, it is surprising and a bit amazing that most of the "professional data projectors" and standard computer monitors are still 5:4, 3:4 aspect ratio devices at substantially lower resolution than 1920 X 1080.

Everyone who works with visualization, VR, Command & Control and special venues should be changing over to a 1920 wide-aspect standard as quickly as possible. This will happen quite automatically as the nexus of broadcast, entertainment and computer application drive the volume, and therefore the most advantageous cost curve for display components to 1920 X 1080. This will not be shaped by industrial, professional or government application but by Monday Night Football and American Idol.

What does this mean to the 4K standard? It means that you can begin adapting the majority of your workflow to the 2K standard immediately and part of your workflow to the 4K standard in a very compatible combination strategy.

[3] http://en.wikipedia.org/wiki/Digital_intermediate

It just so happens that the 4K standard (although just slightly wider) is basically four 2K systems in a two-by-two array.

This makes 4K with its 1.85:1 aspect ratio[4] a perfect visual container for 2K with its 1.77:1 or 16:9 ratio. XGA (1.33:1 or 4:3), SXGA (1.25:1 or 5:4) and SXGA+ (1.33:1 or 4:3), have aspects that are much more square. Scaled up to fill a 4K screen top to bottom, they will exhibit quite a bit of vertical letterboxing on the sides. Meanwhile a 2K single image scaled up to fill a 4K display top to bottom will show very little black on the sides.

7 - Summary

This is perhaps the first times in the digital age where the display technology has leapfrogged the graphic systems' abilities to generate images. This changes many of the fundamental strategies that have driven advanced display integration for the past 10 years.

4K alters a traditional one-source to one-display relationship by acting as a "container" for any and/or many sources all at their native resolution.

4K is an unprecedented single-step leap in display resolution that advanced the standard by more than 500% as opposed to the traditional 50-60% step.

4K flips the source/display relationship that prompted the existence of display arrays. The need for multi-display arrays capable of containing the real-time graphics capabilities of computers is now changed to multi-window arrays of computers all contained in a single display.

With its dual entertainment and commercial roles, adoption of the 4K standard will be accelerated for commercial applications by the need to fulfill user expectations to access the same qualities they experience in their leisure time.

Adopters of the 4K standard need to consider the parallel and fortunately highly compatible strategy of combining the transition to 2K for many workflow elements and the simultaneous transition to 4k for other elements.

The 4K format changes many of the precepts and conventions we have held for over a decade in the visualization, VR, command & control and special venue worlds. It is a welcome technology that promised higher quality, more flexibility, betters reliability and in general the ability to see more, understand better and decide quicker.

ABOUT THE AUTHOR

Theo Mayer is the former CEO of Panoram Technologies, Inc. Over his 15-year tenure with Panoram, Mr. Mayer helped to define and produce many of the technologies and methodologies that are now considered the standard in collaborative visualization for oil/gas, automotive, aerospace manufacturing, and scientific computing. His reputation for visionary application and integration of off-the-shelf media technologies to help people see more, understand better and therefore make better and faster decisions spans a number of industries and continents.

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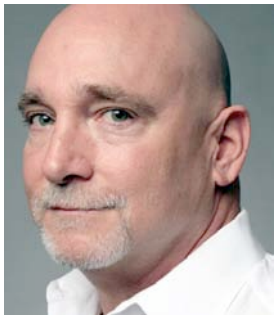

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[4] http://en.wikipedia.org/wiki/Aspect_ratio_%28image%29