

## Video Conferencing Display System Sizing and Location

As video conferencing systems become more widely installed, there are often questions about what size monitors and how many are required. While fixed Telepresence systems make this choice easy, most video conferencing systems come as a base unit (generally a small box the size of a mini-PC), and a camera and a table-top speaker. The selection the video displays and mounting/positioning is generally left to the customer or an integrator. The challenge is that often the resulting placement and room set-up leave much to be desired. To best understand the placement, distance and positioning of video monitors in a meeting space, a basic understanding of how humans see and use video is required. Using simple trigonometry it is possible to define the variables to assure optimal positioning and impact of a videoconferencing system. This white paper will review those factors and then cover basic room set-up. It will also discuss how the new 4K displays may enhance the room video experience.

### Relative Monitor Sizes

Video Display Monitors come in a variety of sizes. Generally these are described by their diagonal dimension. The diagonal relationship to the vertical and horizontal sizes is based on the aspect ratio. The aspect ratio is the ratio of the width to the height. Generally monitors come in two aspect ratios: 4x5 and 16x9. The 4x6 ratio is the older NTSC video ratio and is generally not deployed for video as it does not align well with room views. The 16x9 display is better for the width versus height of the usual participants in a room based video conference.

Figure 1 shows a comparison of a similar meeting with 16x9 and 4x5 views. As can be seen, the

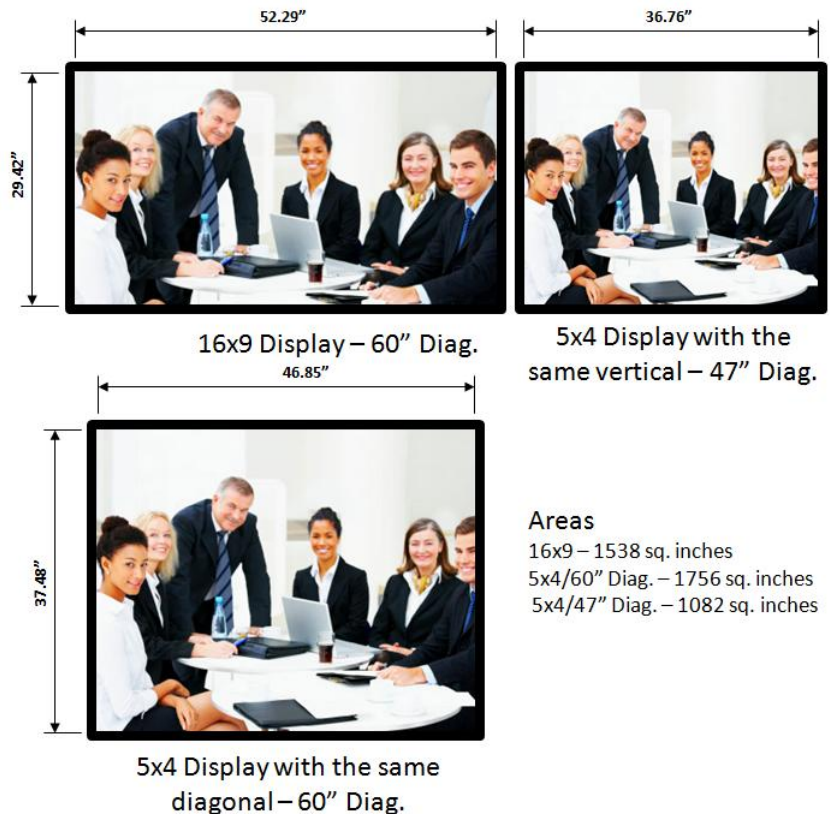


Figure 1 Relative Ratios of Screens



5x4 display with the same vertical as the 16x9 is much smaller, while the 5x4 with a similar vertical of 60" is actually larger in area by 14%, though the actual displayed images are slightly smaller, even with cropping the edges of the room. For these reasons, 16x9 is the accepted standard for video room systems. It is also the standard for home use and therefore dominates the manufacture of displays.

Screen sizes vary greatly with size. The actual range of video screen sizes is shown in complete form for both single, dual, and triple screens in the associated Video Room Help Sheet on the PKE Consulting web site, but for example, a 50 inch diagonal screen is 43.6 inches wide and 24.5 inches tall. For comparison, a 60 inch diagonal screen is 52.3 inches wide and 24.5 inches tall. While the ratios of the width and height reflect the 60/50 or 1.2 times larger of the 60 inch screen, the actual viewing area of the 60 inch is 44% larger than the 50 inch.

Figure 2 shows relative sizes for single screens.

### Single Screens

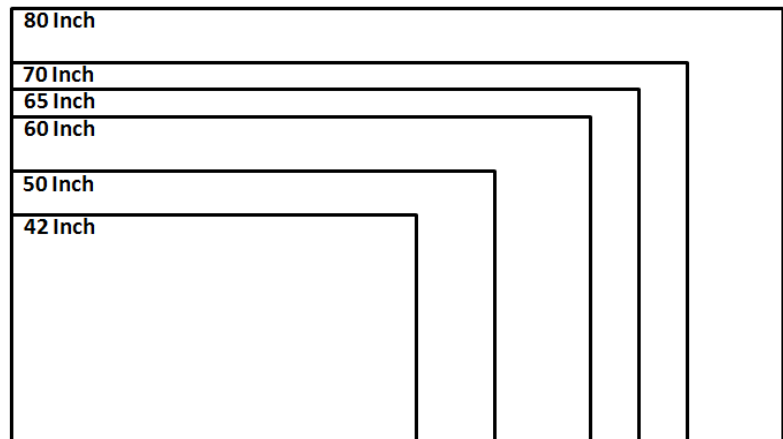


Figure 2 Relative Screen Sizes - Single Display

Figure 3 shows a similar comparison for dual screens as this is a common implementation in many video conference rooms.

### Dual Screens

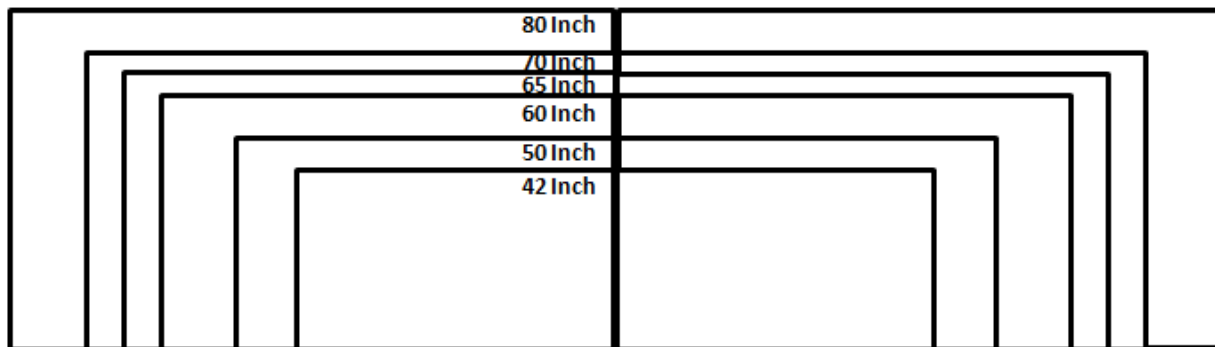


Figure 3 Relative Screen Sizes - Dual Display

## Pixels versus Video Value

As was discussed in the Video Value white papers from PKE Consulting, the value of video is the capability to see the details in facial and body movements that enable the interpretation of reactions to a conversation. This concept, defined as selling collaboration is where the visual feedback is critical. For good visual feedback, both high resolution to see details as well as torso views (to see arm movements) are important. This generally resolves to HD video, where 1080P is generally the highest resolution available today. However, if you are too close to the display you can see pixels, the dreaded "screen door" effect of video. The challenge then is how to have that great video for most or all of the participants, without having the pixels visible to some.

First, it is important to understand video projection and how it works with the human eye. The human eye has about 2000 cones (pixels) of resolution in the diameter of the core non-peripheral vision. This is where you see detail. Though the human eye is capable of receiving light through almost a 200 degree arc, the acute vision is limited to about 15-20 degrees. Of the about 7 million cones in the core visual field of that 15-20 degree arc (Cones are for resolution, rods are for movement - there are about 100M rods in the peripheral field), a HDTV image captures the circular field of about 3.9M as shown in Figure 4. As the rods are denser in that 15 degree core, this is probably closer to 4.5 million cones in the average eye. So, when viewed at exactly the right distance, a 1080x1920 (or called 1080 for short) image exactly matches the eye's inherent resolution.

Even if the image had twice as much resolution, and if you sat at a distance where the screen matched the back of your eye, you could not see the additional resolution. The Society of Motion Picture and Television Engineers (SMPTE) recommends an angle of no less than 30 degrees and no more than 60 to watch a screen based video. The THX standard recommends a 40 degree angle for 16x9 pictures. The point of this is that at the distances associated with these angles for a given screen size, the pixels on the screen are optimized to the cone density in the eye. The reason for a slightly larger angle than the acute angle of the cones is that slight eye movement increases the immersion in the event. Similarly for video conferencing,

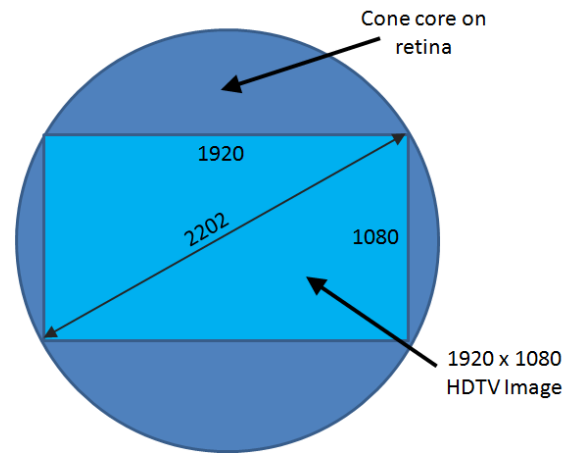
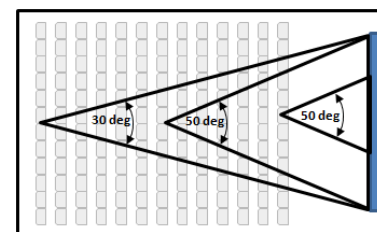
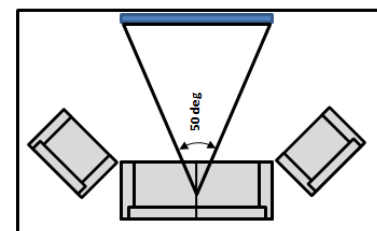


Figure 4 Human Eye Cone Density



Public Theater



Home Theater

Figure 5 Home versus Theater Viewing Distance

causing sys movement between participants creates a better "perception" that the event is like a face to face meeting. This is part of the reason that a telepresence room with 3 screens and participants arrayed across the screens is perceived as more life-like as you have to track to the speaking participant.

Figure 5 shows the difference between home and theater viewing. While recently 4K video (versus the 2K horizontal pixels of HDTV at 1980) has had a lot of discussion, the primary requirement is where customers are seated closer than the 50 degree angle and therefore are only able to see a small part of the screen as shown in Figure 5. For these users, they can only see half the screen, so there needs to be 2,000 pixels in that half or 4,000 in the whole. Similarly, these same effects impacts users in a video room closer than the minimum 60 degree angle to the screen. As you will see, while the 4K displays may not be better for home use, they could be of significant value in the video conferencing domain.

Another way to think about ideal video is to think about the range. If 30 degrees is the least and 60 degrees is the maximum, these translate into a range of distances from a specific size display. This is similar to the theater diagram in Figure 5. Figure 6 shows this concept for a 60 inch diagonal monitor with actual distances and angles in a room. The

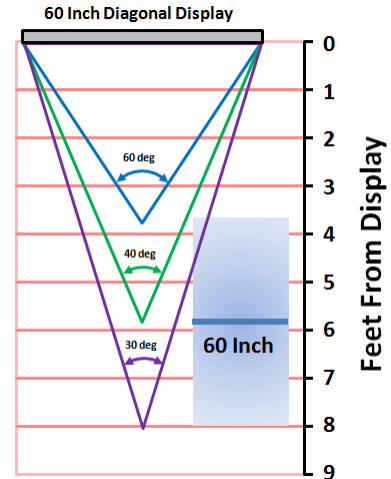


Figure 7 60 inch Display Viewing Distances

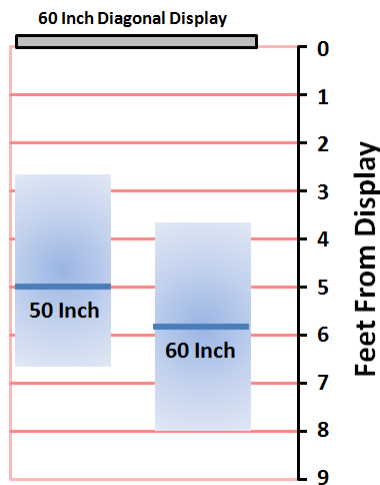


Figure 6 50 and 60 inch Display Distances

blue angle is the 60 degree minimum angle (as far from the display as a viewer should be for an optimal experience), the green angle is the 40 degree "ideal" THX angle, and the purple is the maximum 60 degree angle (as close as a viewer should be for an optimal experience). The blue box is an overlay on the distance that shows the acceptable limits for this monitor with the solid blue line positioned at the THX ideal viewing position. ). The challenge with this is that the range of viewing distances for the typical video monitor is relatively limited.

If you sit beyond the 30 degree mark (about 8 feet for a 60 inch diagonal display), you will begin to lose the detail. If you sit closer than about 3.75 feet you will begin to see pixels.

The value of this modeling mechanism is that different monitors can be shown on a single diagram as to their ideal viewing distances. Figure 7 shows both a 50 and 60 inch viewing distances in a similar way. From this diagram it is easy to see how both the ideal viewing distance and the acceptable ranges of the displays are different. If viewers are in a range of 3-6 feet, the 50 inch is better as the 60 display pixels would be visible to the closer viewers. However, if the viewers are in the 5-8 foot range, then the 60 inch is better for size of image at the 8 foot distance.

Figure 8 shows a calculation of all viewing distances for screens at the 30, 40, and 60 degree angles.

Viewing Distance Calculations for Different Screen Sizes															
Basic Screen Sizes	Screen Size Inches			SMPT E 30 Degree = 1.6 X Diag				SMPT E 60 Degree = 0.74 X Diag				THX 40 Degree = 1.17 X Diag			
	Diagonal	Horizontal	Vertical	Inches	Feet	Millimeters	Meters	Inches	Feet	Millimeters	Meters	Inches	Feet	Millimeters	Meters
42	36.6	20.6	67.2	5.6	1706.9	1.7	30.975	2.6	786.8	0.8	49.14	4.1	1248.2	1.2	
50	43.6	24.5	80	6.7	2032.0	2.0	36.875	3.1	936.6	0.9	58.5	4.9	1485.9	1.5	
55	47.9	27.0	88	7.3	2235.2	2.2	40.5625	3.4	1030.3	1.0	64.35	5.4	1634.5	1.6	
60	52.3	29.4	96	8.0	2438.4	2.4	44.25	3.7	1124.0	1.1	70.2	5.9	1783.1	1.8	
65	56.7	31.9	104	8.7	2641.6	2.6	47.9375	4.0	1217.6	1.2	76.05	6.3	1931.7	1.9	
70	61.0	34.3	112	9.3	2844.8	2.8	51.625	4.3	1311.3	1.3	81.9	6.8	2080.3	2.1	
80	69.7	39.2	128	10.7	3251.2	3.3	59	4.9	1498.6	1.5	93.6	7.8	2377.4	2.4	

Figure 8 Viewing Distances for Different Display Sizes and Viewing Angles

## Actual Videoconferencing Rooms

The information above and the modeling can be used to show how actual rooms would look with different sizes of monitors. Most meeting rooms are rectangular, so to accommodate the largest number of participants, the video system is generally placed on a narrow wall. Figure 8 shows a typical small conference room with the ideal viewing distances shown for different display sizes. This room is 12 feet by 11 feet. It has a 7' x 4' table accommodating 5 participants for the conference and the displays mounted directly to the 11 foot wall. The ideal viewing distances can be seen, with the ideal display size probably either the 60 or 65 inch. With the 50 inch display, three of the participants will have poor visibility and with the 70 inch the

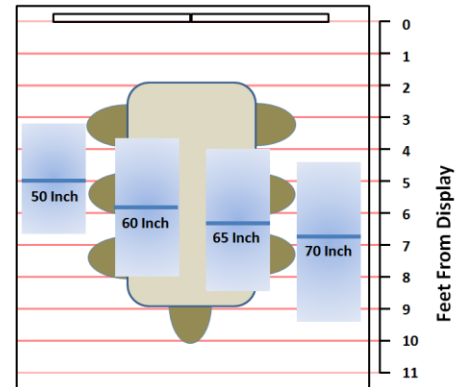


Figure 9 12x11 Video Conference Room

two closest participants will have serious issues with seeing pixels.

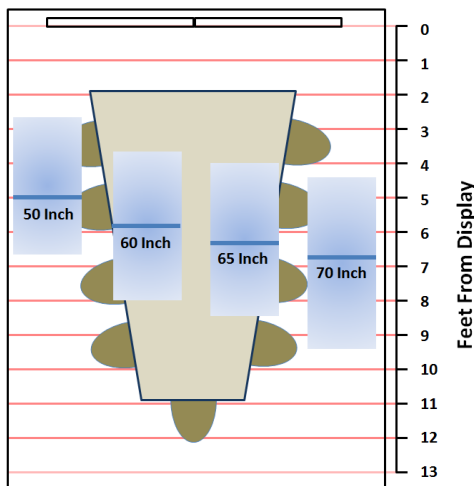


Figure 10 14x11 Video Conference Room

In a longer room the issues are even more severe. Figure 9 shows a longer room at 14 x 11. In this room the table is 9 feet long and is a special video conference optimized design for seeing the participants. However, the issues with viewing distance are actual acerbated by the longer room and are not eliminated by the table. As can be seen, the 70 inch display is probably best, but the viewers in the closest seats will be able to see pixels. This is where the new 4K displays may have value, if they come down in price. A 4K wide 70 inch display would still have the optimal long range distance at the same point, but the pixel visibility point would be less than 3 feet from the screen, assuring that the nearest

participants would not see a degraded image.

## Telepresence Rooms

The key difference in viewing distance in particular is that in telepresence rooms, just as in home theaters, the distance from the screens for all of the participants can be made relatively constant due to a single "layer" seating. Figure 11 shows a typical telepresence room and the associated display distances. As can be seen, either the 60 inch or 65 inch displays have the ideal 40 degree viewing distance at the seating position of the majority of the participants. However, in contrast to the other rooms shown earlier, this room is really only usable for video conferences.

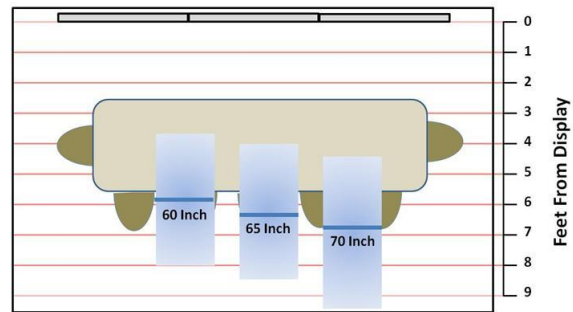
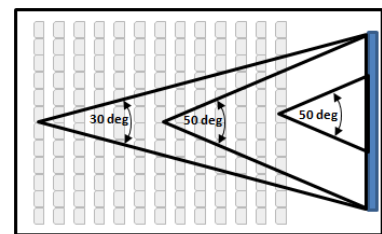


Figure 11 10x16 Telepresence Room

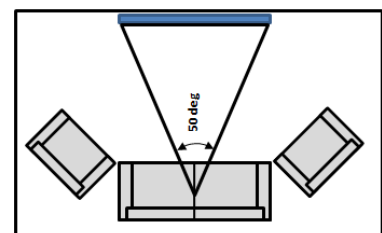
## 4K Video Conferencing Displays

In the home theater world, there is discussion of 4K video displays for the home. In fact, a number of the companies that make displays and projectors for home theater have announced their intent to deliver a 4K video experience to the home. As the monitors used as displays in video conferencing are based on these displays and technology, is 4K coming to video conferencing soon? While it may not mean more resolution for the video stream, the use of 4K displays in video conferencing rooms may have great value in video conferencing rooms.

For those unaware, the 4K in "4K video" is based on the image having 4,000 (actually 4096) pixels in screen width versus the 1920 of today's "2K" HD displays. While today's typical top of the line display is 1080x1920 pixels, a 4K image is 2180x4096. The result is 4 times as many pixels on the screen. 4K is becoming common in theaters as it allows customers to sit closer to the screen and not see pixels. Figure 12, shows a typical home theater and a commercial theater with viewing angles based on SMPTE) viewing angles. As can be seen, in the home, the viewers tend to sit at about the same distance from the screen, while in the theater there is a much broader range of distances. For this reason, 4K is needed for the closest customers.



Public Theater



Home Theater

Figure 12 Home versus Theater Viewing Distance

The additional resolution of 4K displays could be very valuable for video rooms. One of the key reasons that telepresence rooms have better perceived experiences is that all of the viewers are typically located at a common distance from the

displays as shown in the telepresence figure. As can be seen in Figure 11, a 65 inch monitor delivers ideal (40 degree) viewing in this type of system. By fixing the viewers to one side of a fixed distance table, the experience is optimized. However, this has two significant drawbacks; the number of participants and the relatively fixed nature of the space, not enabling non-video meetings.

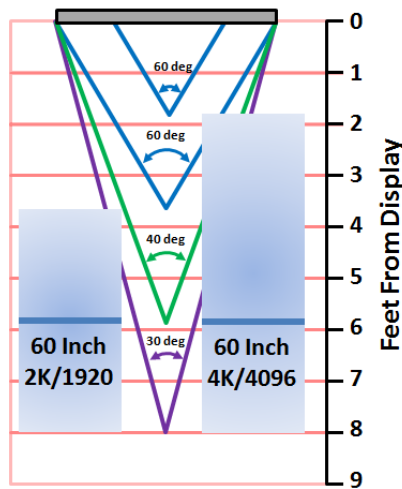


Figure 13 Visual Range Comparison of 2K and 4K 60 inch Diagonal Displays

The potential of 4K in the video conferencing arena is shown in Figure 13, contrasting 2K and 4K video ranges. While the viewing angles do not change, the different is that, just like in the theater, pixels will not be visible until the viewer gets half the distance closer to the screen. The smaller 60 degree angle illustrates this. So the short distance viewing area is now extended 50% closer to the screen as shown in the right blue box for a 4K display. Much like the vaunted "retinal displays" of tablets and Smartphones, even sitting fairly close to the 4K monitor will not reveal pixels.

The last figure shows a comparison of 65 and 70 inch 2K and 4K displays in the same conference room shown before. As can be seen, the 70 inch display provides the best overall viewing for almost all of the participants. The farthest participant is just beyond the 30 degree arc, and the closest participants will not see pixels. In fact, an 80 display would be ideal, but these are not yet

common in video conferencing due to their high cost. The point is that for video conferencing, bigger displays are generally better, unless you are sitting too close. 4K displays solve that issue.

With the video display vendors moving to 4K, this is a real potential. Both Sony and JVC have shown 4K projectors that use interpolation to create a seamless 4K image from a 2K video stream. And Canon has announced a commercial 4K flat panel display for video mastering that is claimed to not be pixel visible, regardless of distance. It is of relatively small size, only 30 inches, and more tuned to desktop use (the same issues apply for a large display at short viewing distances). LG has indicated they plan on introducing at least one 4K LCD/LED flat panel display late in 2012. With challenges in how to differentiate and compete in video displays becoming clear, 4K is probably the next frontier of competition.

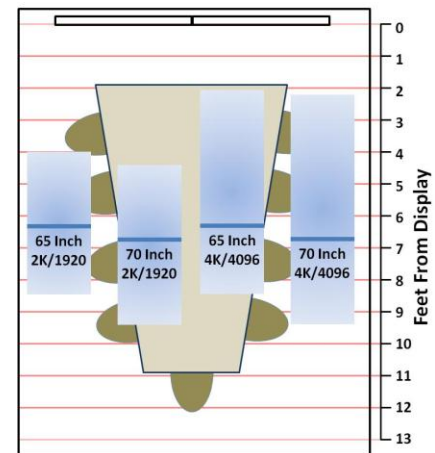


Figure 14 Comparison of 2K and 4K Visual Ranges for 60 and 65 inch Diagonal Displays in 11x14 Foot Room

As it is probable the video conferencing streams will generally stay 2K due to bandwidth and the cost of codecs, the adoption of 4K displays will really just eliminate the pixel visibility for close viewers. As is clear from the earlier discussions of how we see information, in reality, 2K is all most of the participants



can actually see. However, the "clear" conclusion is that 4K displays could have a major impact on the perceived quality of the viewing experience in non-telepresence video conferencing rooms. For telepresence rooms with their fixed viewing distances, the 4K displays may be of little value. If the display vendors and installers respond, room based video conferencing in traditional meeting rooms may get significantly better.

In addition to the 4K display resolution value, the next generation video systems, such as Vidyo, use SVC with a video router instead of an MCU. In this type of system, each video stream is sent to the core and then forwarded at the useable rate to each end point. So if an end point user is watching one image large and the others small, the bit rate on the smaller images can be reduced. 4K displays will open a new opportunity when combined with this technology. As long as any individual image is less than 25% of the entire screen, the image resolution will match the display resolution. This opens a new potential for the room displays to be used in new ways with the users of the room able to assign images to spaces as they see fit. As the room can receive many images at full 1080P/60 resolution, this will enable a new experience, even beyond telepresence. So a two display room can now be seen as a 8000x2200 pixel space to use. Images of other transmission, whether video from rooms, users, or even content, could be moved and assigned wherever they fit best to optimize the experience.

## Conclusions

With the data and information in this white paper, it should be possible to optimize both the seating and distances for most video conferencing rooms. If possible, the telepresence orientation should be used, but for dual purpose rooms that must function as both normal meeting rooms as well as video rooms, choosing the right display can optimize the video experience.

As 4K video monitors become available, their use in room systems will significantly enhance the user experience by enabling the use of larger screens with broader (closer) viewing distances.

On the PKE Consulting web site there is a 2 page pdf Video Room Help Sheet that can be used in designing rooms. Using this sheet with masking tape and a tape measure, it is possible to lay out ideal distances from display locations in a room to determine both orientation and optimal size. This design effort will pay off in assuring optimal video value and room use.