Angles of Reflection

Collected Edition

DA-LITE®

Angles of Reflection

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Angles of Reflection VOLUME I - 2007

ANGLES OF REFLECTION

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We have all heard the recent news of projector manufacturers boasting about their new 1080p capable projectors. With this newly created resolution is there an impact on some of the rules we have been using for screen selection? Perhaps we should reexamine such decisions as are we..

Too Close for Comfort?

As time goes by for those of us in the audiovisual industry, we have all seen some very interesting and exciting technology come to the forefront. One such item that is setting the visual side of the equation on end is HDTV and 1080p capable projectors. Whether you are in the residential or commercial side of the audiovisual industry, you have no doubt heard the buzz that is being created by the introduction of projectors with a native resolution of 1080 x 1920. The advent of this chipset has pushed the proverbial resolution envelope once again. As that envelope is pushed, it creates a perfect opportunity for those of us in the screen business to reevaluate the rules we have in place for sizing a screen to a room.

If you recall not too many years ago, many in the industry decided that the rules that were used for sizing a screen needed to be evaluated due to the changes and advances that occurred in projection technology and the ever increasing need for audiences to not just look at a projection screen but be able to read or evaluate what was being presented on the screen. Much of this need was driven by the fact that software manufacturers were developing programs that allowed a presenter to put the highlighted text points in front of their audience, on a projection screen rather than on a piece of paper. For those of us in the PC world, we know this as the introduction of Microsoft's PowerPoint software. When this occurred, we learned that the rules we had been using, when all we were doing was looking at video images, were outdated and inadequate for the task at hand. From the reevaluation, we determined that for a commercial venue we needed a screen height that was at least one sixth ($^1/_6$) the distance from where the screen will be placed and the most distant viewer for applications where we had to read the content and one fourth ($^1/_4$) if we were to inspect the image. To date, this has served us well. Now, let us take a look at whether or not the new 1080p formats will have an affect on this rule.

Perhaps one of the biggest challenges we face with these new high resolution formats is making sure that the font size of the projected text is large enough for everyone in the audience to be able to read. It seems that every time I get a new monitor or computer it is higher resolution. When I turn it on for the first time, I am taken back as to how small the fonts on Windows have gotten. This is a result of the same font size being used by Windows but at the larger resolution. In other words, a 10 point text in one resolution might look like **this**, while the same 10 point text might look like this with a higher resolution. The reason this occurs is because the computer is using the same number of pixels to create the letters but since the pixels are smaller, and more of them, the same text is much smaller. For that reason, it is very critical that in any presentation we have control over the ability to change the font size in order to compensate for these discrepancies between resolutions.

Let us then look at this from a more mathematical standpoint. For purposes of this example, let us take a screen that is sized to 45" x 80". If we are using a projector that has a native resolution of 720 x 1280, we can easily multiply those two by each other and determine that we have 921,600 pixels being displayed on the screen. From that, we can determine that each pixel is 0.0625" in height by 0.0625" in width. By contrast, if our projector has a resolution of 1080 x 1920, keeping the screen size at 45" x 80", the pixel height now becomes 0.0417" in height by 0.0417" in width. As you can see, there is a fairly significant disparity between these two. Now let us look at how a computer presents text and fonts. How this occurs is worth an article in itself. So, for the purposes of this example, we will assume that for most Windows based software the 10 point Arial letter T is made up of a pixel structure that is 10 units in height. Armed with that information, we can now determine the percentage of difference between our Arial letter T in the two different resolutions. The smaller of the two resolutions will result in a height of 0.625" for our character versus 0.417" for the denser of the two resolutions. As you can see, with the new 1080 resolution our character is nearly 50% smaller.

To take the character height issue one step further, we learned from Volume III of "Angles of View" that in order for the human eye to recognize the smallest character being projected, that it must subtend at least 10 arc minutes. (An arc minute is a unit of angular measurement equal to one sixtieth of a degree or 60 arc seconds.) Through a long and involved set of calculations, this equates to the rule we have used to date that states we need at least ¼ inch in character height for every 7-feet of viewing distance. Considering that this rule is not impacted by the resolution of the display, it is still valid and should be followed. However, as we just learned, with a higher resolution display it is very likely that the font size that was used with a lesser resolution may not work with the higher resolution and is the reason why it is critical that we can change font size on our presentations.

Alright, so we know that we can potentially have a problem with the current rules and we need to make sure that our font sizes are large enough to ensure all of our audience members can read the text. However, what about seating distances and the screen size? When most of us see a movie at the local cineplex, we generally like to sit somewhere between half way back and in the middle of the screen. This, we feel, is the best seat in the house. No doubt this is in most cases just that. However, show up a little late to the screening of that "must see" new movie and you will find that the only seats left are those in the front row and perhaps are the seats that are to the far left or right of the screen. These are by most standards considered the worst seats in the house. Why is that the case? Well, as you would assume, the angles at which you are required to watch the movie, both horizontally and vertically, are sometimes uncomfortable. The human eye's visual field of view is 135˚ High by 160˚ Wide. Although this is a very impressive range of vision, it is possible, as we know from the movies, to be too close for comfort. So, exactly when is this the case in a commercial boardroom or a residential home theater?

In Volume I of “Angles of View”, we learned that for most commercial applications that the closest we should sit to the screen is 1½ times the width of the screen and furthermore we learned that this row could be 2 screen widths across. So, does this still apply in the 1080p revolution? In order to answer this question, we need to see how this rule came into being. The calculations behind this recommendation were based on the off-axis angle at which a text character becomes more elliptical and less recognizable. The maximum angle at which we can acceptably view this character is 45˚. Therefore, by drawing sight lines from a respective screen out from the left side of the screen to the right side of the audience and vice versa, we end up with an ever increasing cone which has an intersection point that is .5 widths out from the screen. At this point, only one person would be within the acceptable viewing position. Taking this out, further reveals our rule of 2 screen widths at 1½ times the width back from the screen. So as you can see, this rule has nothing to do with the resolution of the screen. It has only to do with the angle of which we are viewing the screen. Therefore, in the commercial world, we can make the assumption that our guidelines are still applicable.

As for the residential side of the equation, things become a bit stickier. If the room in which the screen is located is one that is multi-purpose and has seating that may be off-axis at harsh angles, the rules we use for the commercial world should be applied. However, if instead, we have a dedicated theater room with seating arranged much like the local cineplex, the rules change just a bit. If we apply the same logic that was used for the commercial boardroom application above, then we would say that a row that is 1 width back from the screen is able to be 1 width across. After all, the math works correctly.

However, let us think about this from a real world perspective. As an example let us look at the same 45" x 80" screen that was used above. Our normal rules for sizing a screen say that we should be no further back than 3x the height or 11.25 feet. In order to then determine the closest seating distance, we would say that it is equal to the width or 80". Is this too close? According to our maximum off-axis viewing angle, no it is not, but what about the pixels? Will we see them seated this close? In order to answer this question, we need to look at the human visual system. If we are lucky enough to have 20/20 vision, that basically means that we can clearly distinguish one arc minute of contrasting information, from 20 feet away. Converting that to inches, tells us that in order for us to distinguish the contrast of that item, in this case the gap between two pixels, the pixel will need to be larger than 0.069 inches in height.

Looking at our examples from above, we learned that our pixel is 0.0625 inches in height for the lesser of the two resolutions and 0.0417 inches in height for the greater of the two. As you can see from 20 feet back, neither one of them becomes an issue. However, once we move forward on the 720 x 1280 resolution we begin to have potential issues where as the 1080 x 1920 image does not cause problems until we get to somewhere around 12 feet from the screen. So as you can see the scenario where we would be seated one screen height or 80 inches from the screen is way too close and we would likely be able to see the pixels. Since we have determined that at 12 feet is where we will potentially begin to see the pixels, let us use that information to determine the optimum seating area for the screen and ultimately provide us with a formula for determining the proper screen height. By taking the 12 feet and dividing our screen height of 45 inches, we have determined that the optimum viewing distance for a 1080p projected image is equal to 3 screen heights. So, our ⅓ rule that we have been using in the residential world is indeed still applicable and is not too close for comfort.

— Blake Brubaker

ANGLES OF REFLECTION

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As we begin to transition from images that are 4:3 to those that are 16:9 not only in the consumer electronics business but also the commercial audiovisual world, it allows us to take time out and ask a couple of questions. First, is there anything we need to consider in terms of screen gain and lens selection with this new format? Or further yet…..

Wider is Better, Right?

To answer those questions, let us first look at what has occurred and why we are talking about wider screens. The U.S. television broadcast industry started many years ago and was given, by the Federal Communications Commission (FCC), a set of analog frequencies under which it could operate. In 1940, the FCC then established what we now know as the NTSC (National Television Standards Committee) to help standardize the broadcast industry and the types of signals being transmitted. Since many of the original members of the NTSC came from the film industry, the standard chosen for picture size was identical to that of film at the time, and they decided to use the 4:3 format.

Until now, the standards set forth by the NTSC have served us well and likely helped promote the video industry to where it is today. The search for always being innovative and creating new and more advanced technology is what has brought about the latest changes in the broadcast industry. Couple those advances with the need for the FCC to "free up" many of the frequencies used by the analog television industry and you get the push for DTV and HDTV. Common sense tells us that an image that consists of either 720 or 1080 lines of vertical resolution will be better than one that is only 480 vertical lines. This is where the new technology benefits us as consumers. The images being broadcast, providing they were recorded properly, are stunning and nearly lifelike, all from a television. The benefit to the FCC, however, may be a bit more difficult to understand. You see the analog frequencies that are currently being used by many broadcasters are very precious. Years ago when the FCC issued those frequencies, they never considered that nearly every person would have their own portable telephone that would need to operate in a designated area of the communications spectrum. Nor did they consider the growth of our population back then and the communication needs of emergency service providers to support the population growth. Since television in it's analog form takes up an entire frequency, that ties up much needed space in the communications spectrum and limits not only the number of television channels but also limits the number of frequencies available for other much needed communication needs. That is why the U.S. Congress passed a law on February 1, 2006 that provides a final mandate for television broadcasters to cease their analog communications on February 1, 2009 and use the new “digital” means of sending out their signals. By converting to digital signals, they can now break up those analog frequencies into digital sub-frequencies and absorb only a fraction of the space that was once needed to provide us with television broadcasts.

So, what does all of that have to do with us in the audiovisual industry? Well, since the broadcast industry is part of the audiovisual equation, they have quite an impact on what we do, not only in the residential industry, but also in the commercial audiovisual world as well. After all, where does much of the new technology that we use in corporate boardrooms and home theater systems come from? Yes, a great deal of it comes from the broadcast industry. Hence, since they are changing from the analog 4:3 NTSC systems to a new more advanced digital 16:9 HDTV format, we too will need to follow their lead.

Since we are now faced with the task of designing systems in the 16:9 format, we must consider a few things. First of all, the images are now one third wider than what we have used in the past. This, in itself, can have a significant impact on not only our screen size but also the type of screen surface that should be chosen.

We determined that our screen size decision, whether in a commercial application or in a residential home theater, should be made taking the height into consideration first and the width second. Well, with 16:9 that is not different. First we determine the screen size based on the most distant viewer divide by the appropriate factor (6, 4 or 3) to determine the height. The width then is based on the 16:9 aspect ratio. Therefore, simply divide our height by 9 and multiply that result by 16 to determine the width of our screen.

Alright, so far everything seems pretty normal with regard to changing to the 16:9 aspect ratio. However, when we begin to choose a screen surface and a throw distance from our projector that is where the normalcy ends.

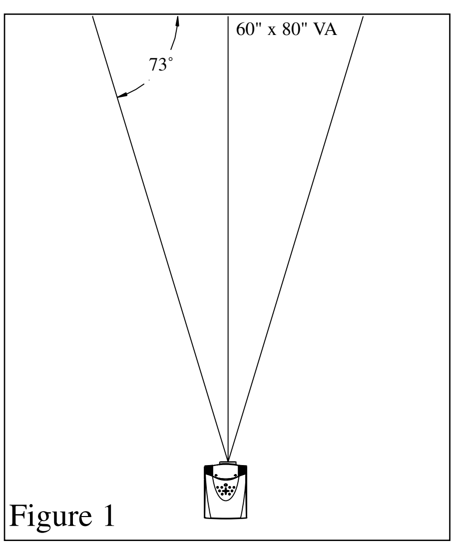


Figure 1

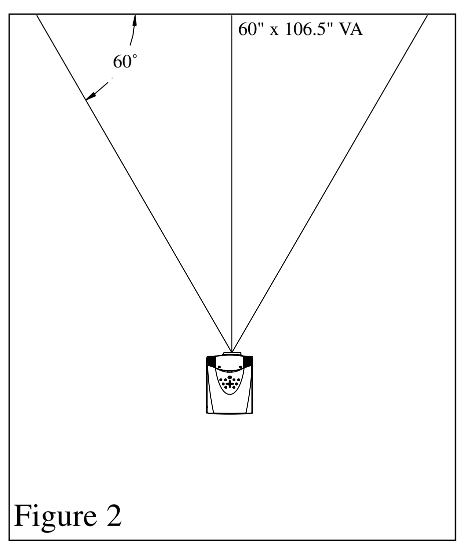


Figure 2

Take a look at Figures 1 and 2. You will notice that both of the rooms are identically sized. However, Figure 1 has a 4:3 screen located on its front wall and figure 2 has a 16:9 screen located on its front wall. The projector used in Figure 1 is an ordinary 4:3 XGA projector with a throw distance that is equal to 1.67 times the screen width. Let us also consider that the throw distance shown is the middle of its range. From that, you will see that the light impinging upon the left and right most portions of the screen are doing so at a 73˚ angle.

Now, let us look more closely at Figure 2. It is shown using the same size room but with a 16:9 sized screen. The projector used in Figure 2 is a common 16:9 projector with 768 x 1280 resolution and a throw distance equal to 1.32 times the screen width. It too has been placed in the middle of the throw range for demonstration purposes. With the 16:9 image size and the throw distance chosen, you can see that the angle of the light striking the left and right most sides of this particular screen are doing so at a 60˚ angle.

What does this mean? In order to answer this question, let us first go back to Volume 1 of “Angles of View”. Here we learned that all screen surfaces with a gain higher than 1.0 reflect light based on its angle of incidence. Therefore, the starting point for determining the off axis viewing cone of those outer most light rays is equal to the angle of incidence. That in turn will narrow the ideal viewing area when that angle is more severe. Conversely, if we were to use a longer focal length lens and decrease that angle of incidence, our ideal viewing area will increase. This phenomena also has the potential of creating a “hot spot” within the image.

Some projector manufacturers have decided to use shorter focal length lenses on their 16:9 units in order to allow installation where the previous 4:3 projector has been placed. This in turn increases the severity of the incident angles for the far most left and right sides of the screen. While this is not a problem when we are utilizing a screen that has a gain of say 1.0, it can become an issue if we increase the gain of the screen. The reason this occurs is because a Matte White screen will diffuse the light evenly regardless of the incident angle and the resulting image will appear uniform. However, if we have decided to use a screen with a higher gain, say 1.3 or higher, then the potential for creating dim areas or a hot spot increases.

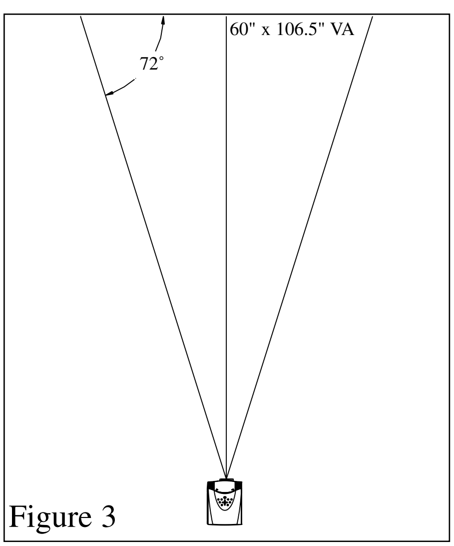


Figure 3

The ideal design when using a 16:9 projector and a high gain screen is to use as little zoom as possible. In other words, if a projector has a zoom range of 1.37-1.64 times the screen width, we should design our system to utilize a throw distance that is as close to 1.64 times the screen width as possible. This will ensure that the angles of incidence are not too great at the extremities of the image and create a much more uniform image. Figure 3 displays how the longer throw distance provides us with a much better incident angle.

To take this one step further, the issue of using too short a focal length can not only be applied to front projection, but even more so to rear projection. We also learned in Volume III of “Angles of View” that 1.3 gain front projection screens and 1.3 gain rear projection screens do not have the same viewing angle. This is due to some reflection off the back surface and absorption by the rear projection screen. Keeping that in mind, it is even more critical in a rear projection design that we make sure we use a longer focal length lens for applications where a higher gain screen is necessary.

Based on extensive testing done by Da-Lite’s Chemists and Optical Engineers, it has been established that the nominal focal length of the projection path should be 1.6 times the screen width or greater to ensure a uniform image with even the higher gain rear projection surfaces.

So, is wider better? As long as we take into consideration the gain of the screen, the focal length of the projector and the placement of our viewing audience, the answer is most definitely, Yes!

ANGLES OF REFLECTION

May, 2007 ©Da-Lite Screen Company Volume 1 Issue 3

As we look forward to higher and higher resolution capacities from the latest and greatest projectors on the market, is there anything that needs to be considered when choosing a screen?

Reflecting Brilliance

Think back to when you were in grade school and your teacher brought in the 16mm projector for an instructional movie or perhaps when your family had friends over and Dad pulled out the old 8mm projector to show movies of your last vacation. Depending on the time frame in which this occurred, it is a pretty good bet that the screens used in those situations were made with a glass beaded surface on the front. One of the reasons that a glass beaded surface was the popular choice back then was because the projectors were not very bright and, as such, we wanted to get as much light directed back to the viewing audience as possible. Also, keep in mind that we normally needed to view these images with the lights off and the curtains drawn in order to observe an acceptable image. So, along comes the CRT projector. They had a bit more brightness but because of uniformity issues inherent in a CRT projector, we used screens that were a bit lower in gain and had other means of creating reflectivity. Here too, we had to have the room dark in order to view an acceptable image.

Then in the early 90's came the first LCD and DLP projectors. These were different in not only the brightness output and uniformity; they were a great deal brighter and much more uniform, but also in the way in which their image was presented. Before that time, nearly every projector on the market created its image by either an analog scan line or through changing the film piece in the projector's gate. When these new "digital" projectors came along, we in the screen business were challenged to make a few changes to our products. What had occurred was that we were now faced with images that were made up of thousands of tiny little pixels with small gaps between them. In addition, due to the brightness of these projectors came the desire of many technology users to place them in applications where the room was not completely dark. So as this occurred the demand on fabrics that had a moderate amount of gain to them and at the same time did not create resolution issues with this new pixel structure became greater. Where we were once only concerned about creating really bright images, we were now faced with making sure that the screen did not create resolution problems. That is why our optical engineering group at Da-Lite made changes to many of our fabrics and introduced surfaces such as our High Power® material.

Okay, so fast forward to the present and the ever increasing resolutions of today's high output projectors. Are we facing a similar situation that we did when the LCD and DLP projectors were first introduced? For some, the answer is yes, while for others it is no. In order to determine if there is a potential problem with a given front projection screen material, let us look at the size of the particles used to create gains higher than 1.0. However, before we look at particle sizes we need to have an understanding of how these particle sizes are measured. In this case, they are measured in what is called microns. A micron is the abbreviation for micrometer and is a unit of measure that is equal to 1 millionth of a meter, or 1 thousandth of a millimeter. It can also be expressed as 0.001mm, 1µ or sometimes 1 µm. For reference purposes, a human hair is 100 microns in diameter, a human cell is typically several microns across and on a DVD, the track pitch is 0.74 microns and the pits are 0.4 microns wide. So, as you can see, these are very tiny measurements. Regardless, they are very important to the overall performance of a projection screen.

Now that we have an understanding of the measurements, let us begin to look at different screen materials. Traditional glass beaded materials, like the one your father used, has a typical particle size measuring 65µ. Da-Lite's High Power® material has a typical particle size of 9µ. The pearlescent materials used to create Da-Lite's Cinema Vision, High Contrast Cinema Vision, Pearlescent and High Contrast Matte White screens have an average particle size of 15µ. In addition, the average particle size used to create Video Spectra 1.5 is 35µ. Once again, these are very small measurements.

So what do all of these numbers mean? To answer that question, let us go back to the issue of pixel size for a given screen size and determine how many particles will be in each pixel. We would naturally assume that the smaller the particles, the higher the concentration per pixel, hence the better the image will appear. Let us use our 45" x 80" screen size again with a 1080p projector from our favorite manufacturer. Given our pixel structure is 1080h x 1920w; we can determine that each pixel will be 0.0417" in height by 0.0417" in width (only slightly larger than 1/32" x 1/32"). Therefore, each pixel has a surface area of 0.0017 in^2. Since our measurements for screen size are represented here in inches, let us convert our particle size from microns to inches as well. From the conversion we find that 1 micron = 0.0000394 inches (a very smallish number). After determining that, we can say that if a particle is 15µ that it will consume 0.000591 inches of space. In this case, if we were to place these particles side by side in an orderly fashion, we can fit more than 4900 of them in one single pixel. Doing the same math for a screen surface such as the traditional glass beaded material reveals the disparity between the two types of surfaces and yields only 264 optical particles per pixel. The improvement, therefore, is increased by a factor of more than 18. That is one of the reasons why traditional glass beaded surfaces are not a good choice for today's high resolution projectors.

So, what does all of this tell us? Plain and simple, the particle size of the materials used to make the screen's reflective surface can cause problems with resolution if those materials are not small enough. However, even more important to us in today's applications is the issue of scintillation. Have you ever looked at a screen with either a moderate or high gain and thought you saw a bad pixel or a tiny bright spot on the screen? There can be a couple of different types of phenomena causing this. In order to better explain why that occurs, let us examine more closely how these screens work. In order to increase the gain of a screen, we must introduce some type of material that either refracts or reflects the light that is incident to the front surface. Refraction is what a glass beaded screen does and the issues associated with it are addressed in Volume 1 of <u>Angles of View</u>. The materials that reflect the light are the ones we are most concerned about for this particular discussion. If we again go back to Volume 1 in Angles of View, we learn that these types of screens have a diffusive base with platelets of mica strewn across its surface in a regular fashion. These crystals are also coated with Titanium Dioxide (TiO_2), which then makes them highly reflective and behave like thousands of tiny little mirrors. We also learned through this article that these materials reflect light incident to their screen surface in a fashion that is equal but opposite the angle of incidence. Keeping that in mind, if one of those particles land on the screen surface at a very severe angle, this is one potential cause of a bright spot or sparkle, depending on your viewing position. The second potential issue is if the particles are too large and do not allow at least a portion of the light to strike the diffusive surface behind the reflective particles. This too can be a source of a bright spot or scintillation.

A number of years ago, this particular issue was presented to the Chemical Engineers at Da-Lite. They conducted a number of tests to replicate the issue of the fabric sparkling. As a result, they made changes in the way the fabric was made to ensure that the particles were placed on the screen in a much more even pattern. In addition, they began using much smaller particles to ensure the fabric would work with future generations of high resolution video projectors. This is what has brought us to where we are today. As you can see from the numbers on the previous page, the size of the materials used to create a good number of Da-Lite's fabrics are extremely small and even the highest resolution projectors available today will not cause a resolution or scintillation problem.

So, even as projectors continue to become more powerful and have higher resolutions, choosing a screen surface continues to be an important factor in the overall success of the installation. With that in mind, let us keep the sparkle in the eye of the technology user and off the screen.

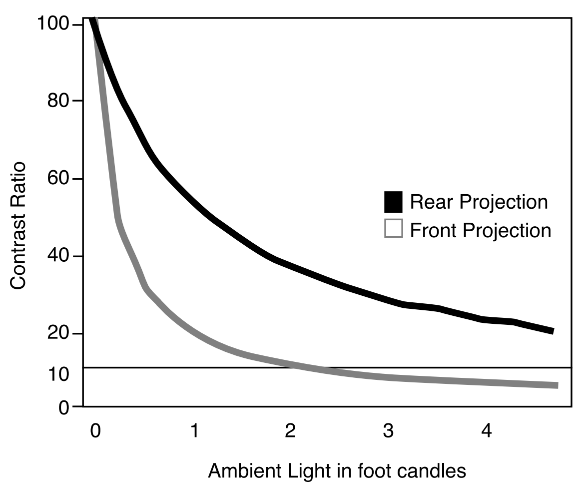
- B. Brubaker

ANGLES OF REFLECTION

June, 2007 ©Da-Lite Screen Company Volume 1 Issue 4

Brightness VS. Contrast

It seems that one of the most frequent questions I receive from designers and audiovisual engineers is "How do I determine if the visual system I have designed will be bright enough?" In order to answer that question, we must first evaluate what is really being asked. Probably one of the biggest misconceptions in the industry is the fact that an image must have "brightness" in order to look good. While that is partially true, the main attribute that affects our perception of whether or not an image is "bright" is actually the **contrast** of the image. After all, when we look at contrast, we are looking not only at the "brightness" of the image but also the "blackness" of the image. We have learned from not only Angles of View but also many other publications in the audiovisual industry that contrast is a comparison of these two attributes. In addition, we discover that the "blackness" of an image has much more of an impact on the contrast ratio than does the "brightness". With that in mind, one of the things we have to consider in a projection system is that the "blackness" of the screen is equal to that of looking at the screen with no projected light and only the ambient light in the room impinging upon the surface. This is exactly how dark the black parts of the image will be under projection. For this reason, it is critical that we attempt to control ambient light near the screen. As you will see from the following chart taken from Angles of View, even a few foot candles of light will have a major impact on the screen's black level.



From <u>Angles of View</u> Volume V, we also learned that we should design systems such that the contrast ratio should be at least 10:1. All right, that is all well and good but how do we determine this? First we must look at the equation we were given from this article. It states the following:

$$\text{Minimum Light Output (Lumens)} = \frac{9 x \text{Image Area } x \rho \ x \ L_{amb}}{(\text{Screen Gain} - 0.2)}$$

At first glance this equation might look a little intimidating. However, upon further review, we will see that is can be a very useful and friendly equation, given we understand the factors it utilizes. As we review these factors, we will do so in an order which will provide the best result. First, let us look at *Image Area*. We have learned previously that we must determine the screen size based on the 4 and 6 rule. Therefore, if we have a room where the MDV (most distant viewer) will be 24' away from the screen, then we would use a screen that is 48" in height for reading applications or 72" in height for applications where inspecting the screen is necessary. In this case, we are using the inspection rule and based on the fact that our source material has an aspect ratio of 4:3, our optimum screen size would then be 72" by 96". When we multiply these two numbers together and divide by 144, (inches in one square foot) we learn that our chosen screen size is equivalent to 48 ft^2. This will be the number we insert into the equation for the ***Image Area***.

Next, let us look at the *Screen Gain* portion of the equation. While this is one of the factors that can be manipulated in order to change the outcome of the equation, it is one of those items where it is best to determine this based on factors such as viewing angle and ambient lighting. For our example, let us say that we have chosen to use a screen of 1.5 gain based on the fact that our audience is seated within a cone that is equal to 70º from the center of where the screen will be placed and the fact that we are utilizing a ceiling mounted projector. Therefore, we will plug in 1.5 as the ***Screen Gain*** factor.

Now we look at the ρ portion of the equation. This is a constant that is based upon whether we are utilizing either front or rear projection. The constants here are 1.0 if front projection and 0.2 if rear projection. In this example, we are using a front projection screen. Therefore, we will plug 1.0 in for the ρ portion of the equation.

Lastly, let us look at the $\mathbf{L_{amb}}$ portion of the equation. This is representative of the ambient light that is incident to the screen's surface, measured in foot-candles. Utilizing a basic light metering device for existing rooms or giving careful consideration and planning in rooms that are not yet completed can achieve this number. In an existing application, all that is needed is to point the light meter from the wall where the screen will be placed out towards the audience seating area. For rooms yet to be built, it becomes a bit more involved. Here we need to consider what type of lighting is being utilized and determine based on the output of the light source and the direction at which it is aimed, how much will be incident to the screen's surface. For example, if we follow the IESNA (Illuminating Engineering Society of North America) Lighting Handbook rules for designing a properly lighted conference / meeting room, we learn that there should be 30 foot candles falling on horizontal surfaces and 5 foot candles falling on vertical surfaces. Given our screen should be parallel with the vertical surface, we can assume 5 foot candles. So for the purposes of our equation we will use 5 as our **L_{amb}** portion of the equation.

So, we almost have a completed equation, right? Technically, yes we do. The only remaining factor is the **Minimum Light Output (Lumens)**. While all of the other factors in the equation can and do affect the others, this is one of the areas that can be adjusted to meet our minimum requirements for the 10:1 contrast ratio. After all, the Minimum Light Output (Lumens) is what we are trying to determine based on the other factors. In other words, we are attempting to determine how much output we need from the projector in order to achieve our desired 10:1 contrast ratio for the projected image.

We can now complete the equation and see the results.

Minimum Light Output (Lumens) = (9x48x1.0x5)÷(1.5-0.2)

Minimum Light Output (Lumens) = (2160)÷(1.3)

Minimum Light Output = 1662 Lumens

For purposes of comparison, let us see what happens if we change the screen gain portion of the equation. Instead of using a 1.5 gain screen, our application requires a screen with a wider viewing angle and the 1.0 gain screen fits that requirement. In this case, the equation looks like the following:

Minimum Light Output (Lumens) = (9x48x1.0x5)÷(1.0-0.2)

Minimum Light Output (Lumens) = (2160)÷(0.8)

Minimum Light Output = 2700 Lumens

As you can see, by only making one small change in the screen gain, we need a projector that is nearly 62% higher in its light output.

Now let us look at what happens when we take the same equation with the 1.0 gain screen and reduce the amount of light incident to the screen's surface from 5 foot candles to 2.5 foot candles.

Minimum Light Output (Lumens) = (9x48x1.0x2.5)÷(1.0-0.2)

Minimum Light Output (Lumens) = (1080)÷(0.8)

Minimum Light Output = 1350 Lumens

Even though it has been mentioned a number of times before, you can see based on these numbers that the ambient light in the room has a very significant impact on the amount of light output that is necessary from a projector in order to achieve our 10:1 contrast ratio. In this example, by reducing the ambient light in half, we are able to use a projector that is also nearly half as bright to achieve the same results.

To take our contrast ratio one step further, we can also review the following formula from the same Volume V of Angles of View.

$$CR = \frac{L_A + (\rho \ x \ L_{amb})}{L_B + (\rho \ x \ L_{amb})}$$

In this equation, we are trying to determine what the actual contrast ratio is of our display system. The $\mathbf{L_{amb}}$ and ρ factor in this equation remain the same as they were for the previous equation. $\mathbf{L_A}$ and $\mathbf{L_B}$ are new factors and need to be determined. $\mathbf{L_A}$ represents the Lumen output of the projector divided by the surface area of the screen multiplied by the screen gain (if any). $\mathbf{L_B}$ is then equal to the Lumen output of the projector divided by the surface area multiplied by 0.02. For purposes of our first example, let us first determine $\mathbf{L_A}$ and $\mathbf{L_B}$.

$\mathbf{L_A}$ = (1662÷48) x 1.5
$\mathbf{L_A}$ = (34.625) x 1.5
$\mathbf{L_A}$ = 51.9375

$\mathbf{L_B}$ = (1662÷48) x 0.02
$\mathbf{L_B}$ = (34.625) x 0.02
$\mathbf{L_B}$ = 0.6925

Now that we have all of our variables determined, let us plug all of our factors into the equation and complete it to prove we have at least a 10:1 contrast ratio.

CR = (51.9375 + (1.0 x 5))÷(0.6925 + (1.0 x 5))

CR = (51.9375 + 5)÷(0.6925 + 5)

CR = (56.9375)÷(5.6925)

CR = 10.002

So, as you can see, we did end up with exactly a 10:1 contrast ratio. These formulas are very useful and if they are used to design a visual display system should result in a system that has the appropriate amount of contrast along with the appropriate amount of “brightness”. So the next time you are asked, “How bright will my image be?” You can safely answer, “It will be sufficiently bright and have good contrast”.

- B. Brubaker

ANGLES OF REFLECTION

July, 2007 ©Da-Lite Screen Company Volume 1 Issue 5

If you attended the recent Infocomm trade show in Anaheim, CA there is no doubt that you saw several projector manufacturers touting that fact that they have the brightest projector on the market. There was one such manufacturer claiming to be outputting 30,000 lumens from their large venue projector. Obviously, these manufacturers are looking for new and more creative ways to get as much brightness out of their units as possible. With that in mind, is there anything we need to be concerned about from a screen selection point of view?

Uniformity – Revisited

Interestingly enough, I was recently posed a question about whether or not it was appropriate to use an extremely bright projector in a certain visual display system. The person who asked was concerned because they were using what they considered to be a moderately sized screen. The main focus of the question had to do with the potential of a "hotspot" with this extremely bright projector. My quick response to that question was to ask further questions about the project in order to help determine if we would, indeed, have a problem. After a bit of investigation, we determined that there were no significant issues or concerns which would point to the phenomena known as "hotspotting". I think the one item that struck me most about this conversation was the fact that there seems to be a misunderstanding about why a hotspot exists and the fact that more light output from the projector triggers one to think that it could be present. Let us examine those concerns a bit more closely to see if there is merit in them.

In order to evaluate these concerns, we must first understand how a projection screen works and, furthermore, how it is that a hotspot can exist. One of the most basic principles we need to understand about a hotspot is that the screen itself is not the factor at fault for the hotspot's existence. Therefore, it must be the projector. Correct? Well, not exactly. The cause of a hotspot has more to do with the fact that we are using a small lens to project an image onto a large screen and can further be exaggerated by a screen which has a high gain. Let us break this down further to examine both the screen and projector/lens portions of this display to see why this occurs.

There are three basic functions which a front projection screen can do with light rays that are incident to its surface. They are: Scatter, Refract or Reflect. A screen which scatters light has, as one of its main elements, Magnesium Carbonate ($MgCO_3$). It just so happens that this is also the material used as a reference point for determining gain of a projection screen. The reason $MgCO_3$ is used for both of these applications is its ability to scatter light incident to its surface in a fashion that is equal in all directions. The best way to think of this is to imagine one tiny little light ray hitting the surface and then being broken into countless other smaller light rays that bounce off the screen equally in all different directions such that one cannot detect from where the incident light ray originated. In other words, since this type of screen performs in what we call an Isotropic fashion, light incident to the surface will be bounced off equally in all directions regardless of the angle of incidence. With that in mind, one might already come to the conclusion that a screen which scatters light could not exaggerate a hotspot. While indeed this is true, let us look further into the other two types of surfaces. It is worth noting at this time, that screens which scatter light are typically those exhibiting a gain of 1.0 also commonly known as Matte White.

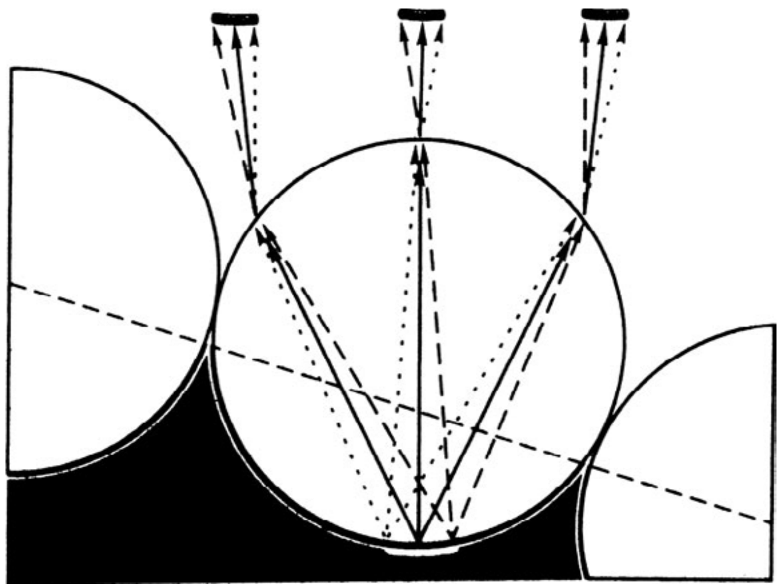


Figure 1

A screen which is said to have Refractive characteristics is one which has some type of glass structure to it. Do not, however, confuse this type of screen with a rigid rear projection glass screen. That is not the type of glass we are referring to for this example. Instead, we are talking about front projection screens which have glass beads either adhered to their front surface or imbedded into the structure of the screen itself. These are better known as glass-beaded or High Power screen surfaces. In Figure 1 below, we see what occurs with these surfaces as light incident to their surface passes through the thousands of tiny little beads and is bent at angles dependent upon where they strike the bead. After passing through the bead, the light ray strikes a surface similar to Matte White where it is scattered and then passed back through the beads before exiting the screen surface. This type of screen is also referred to as a Retro-Reflective screen because it bounces the light back towards the direction in which it originated. So, could a hotspot occur here? Before we answer that question, let us look at the third and final type of front projection screen.

If a screen is said to have Reflective characteristics, then it usually has a gain higher than 1.0. The make up of a Reflective surface is such that it has a specular material added to its surface which acts as an enormous number of tiny little mirrors. As the light strikes these mirrors, it is reflected off of the surface and back in a fashion which coincides with the degree by which the surface is coated with these mirror-like particles. In other words, the higher the concentration of the particles, the more reflective the surface will become. However, as we have learned through our infancy in the audiovisual marketplace, a projection screen cannot create more light and, therefore, the added brightness one receives from a Reflective screen has an associated fee attached. That fee is the directionality of such a surface and a narrower viewing angle. A Reflective screen does not reflect all of the light incident to its surface equally in all directions. It is, indeed, much more directional and deliberate about the way in

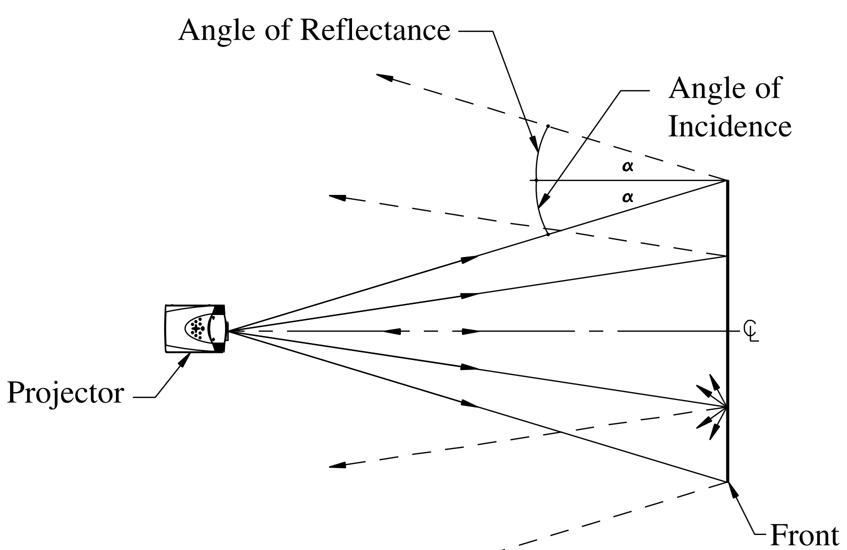


Figure 2

which it reflects the light rays incident to its surface. To be more precise, that "way" is such that the angle of reflectance is equal but opposite the angle of incidence. See Figure 2. Imagine, if you will, the cue ball on a billiard table being put into motion such that it strikes the side bumper of the table. When it does so, it will bounce off at an angle that is both equal but opposite to the way in which it struck the bumper. This too is how light rays incident to a Reflective screen behave. Some of the more commonly known reflective screens are: Cinema Vision, Pearlescent, Video Spectra 1.5, Silver Vision and Silver Matte.

Very well then, what does the way in which a screen scatters, refracts or reflects the light incident to its surface have to do with the potential for a hotspot? It actually has everything to do with it. You see what we need to consider when discussing a hotspot is the fact that light coming from the projector is striking the screen surface at many different angles. Take for instance a ceiling mounted LCD projector. The center most light ray is striking the screen at an angle that is downward in the vertical dimension but for the most part perpendicular in the horizontal dimension. Contrast that with the light which is emitted from the corner of the lens, specifically the upper right side of the lens as we look at the screen. These light rays are striking the upper right hand corner of the screen nearly perpendicular in the vertical dimension. However, the way in which it is striking the screen in the horizontal dimension is very different than the light rays emitted from the center of the lens. Also, take into consideration that a shorter focal length lens will compound these angles. If you bring the projector closer to the screen, the angles off to the side become increasingly harsh.

Alright, we now know the three characteristics of a front projection screen and the basics of how light from a lens strikes a screen surface. Let us put the two together and see if a brighter projector automatically creates the potential for a hotspot. Before we do, there is at least one item we must presume about the projector. With only a few exceptions, LCD, DLP and other "digital" projectors manufactured today provide uniformity across their fields that may vary from center to edge by as little as 10%. So, for the purposes of discussion, we will say that the projector we have chosen meets these criteria. This may seem a bit trivial, but it is very important when determining the uniformity of your overall visual display. If the projector itself is not uniform, then we could have severe problems with our display. Remember the old CRT projectors?

If we were to place the light coming from a very bright projector onto a scattering or Matte White screen, do we have the potential for a hotspot? The answer to this is definitely not. Remember even if we have harsh bend angles from the light striking the screen, a scattering screen disperses the light back in a fashion that is equal in all directions. So the potential here is non-existent.

Let us examine further a screen which is Refractive. Here we have a different scenario. Given that a Refractive screen will send the most concentrated portion of the light back towards the source, we do have the potential but not perhaps as great as one might think. Since this type of screen is very directional in its dispersion pattern, our audience will likely be seated within the parameters of the screen and this minimizes the potential.

As we learned above, a Reflective screen behaves such that the angle of incidence is equal and opposite of the angle of reflection. This then, provides a scenario where we could be off axis of the “sweet spot” of the reflection for differing portions of the screen. Given that, we can assume that our potential for a hotspot increases slightly as we use a Reflective screen. However, does more light from a projector infer that we will have a uniformity issue? The quick answer to that is also no. Remember a hotspot is not created by the brightness output of a projector. It is created by the relationship between the projector’s lens function and the screen’s directionality. Providing that we use a long enough focal length lens (by my experience at least 1.6), we should not have any issues with uniformity regardless of the screen chosen. If then, the display requires a short focal length lens, we now know that we must use a low gain “Scattering” screen to help minimize the potential for hotspotting. So remember, brighter does not always mean that we will have uniformity issues. We must make our decisions of screen selection and lens selection based on this knowledge.

ANGLES OF REFLECTION

August, 2007 ©Da-Lite Screen Company Volume 1 Issue 6

Ambient Light, Transmit or Reflect?

If you have been in the audiovisual industry for any length of time, it is likely that you have been amazed at the advances in video projectors over the last five to ten years. I know I sure have. Today's video projectors are lightweight, very powerful, extremely bright, have better uniformity and are much easier to install than their cumbersome CRT relatives that we used in the past. These advances have been welcomed with open arms by the audiovisual industry and the technicians who were once required to install and calibrate those dinosaur projectors.

During those CRT days, the one thing we commonly faced was situations where we needed a fairly large, say 120" diagonal, projection screen in rooms that were very bright and contained large amounts of ambient light. So, it became necessary at the time for us to consider rear projection as a way to help combat the low output of the projector and the high amounts of ambient light in the rooms. This worked very well and there have been many systems installed over the years that are similar to this exact scenario.

With the advances made in video projectors, it appears that there is an assumption being made today that, because projectors have become so bright and powerful, rear projection is not necessary anymore. Many think that you can just overpower whatever ambient light is present. I contend that these statements are false and in fact, rear projection is still an option which one should consider every time a system is designed. Some of you may be thinking I am a bit off my rocker for making such a claim. However, I challenge anyone to show me a rear and front projection system side by side, using the same exact projectors, sources and gain of screen and tell me that the front screen image is better than the rear. I guarantee you will agree that the rear projection system looks better, especially with ambient light present. Why is this the case and how can I be so confident? To answer that question, let us take a moment and *contrast* the two different methods of projection.

First, let us discuss front projection screens in terms of their advantages and disadvantages. A front projection screen's main objective is to reflect light that is incident to its surface in a pattern consistent with the amount of reflective, refractive or diffusive elements placed on the screen. From past articles, we have learned that with a diffusive screen, the light is bounced off equally in all directions and with a reflective/refractive screen, the light is directed off the screen in a narrower pattern to concentrate the light towards the audience. Therefore, the lower the gain, the wider the dispersion pattern and the higher the gain, the narrower, or more directional, the dispersion pattern becomes. Given this knowledge, we can now discuss what happens when not only the light coming from our video projector strikes the screen but what happens when ambient light strikes the screen. The ambient light is handled by a front projection screen in the exact same way as the projected light. In other words, the screen cannot discriminate between the projected light and the ambient light. Therefore, it scatters, reflects or refracts all light incident to its surface in the same manner.

The way in which a front projection screen works can be both good and bad, depending on many different factors. If we are placing the screen in a room that is very dark and the walls, ceilings and floors are covered with materials which are dark in nature and absorb light, then nearly any type of front projection screen will perform exceptionally well. One of the reasons why most screens will work well in this environment is because we have an exceptional "system black level". The "system black level" is how black the screen will be with a given amount of ambient light and the projector muted such that it is attempting to create a black screen. Remember, one of the main ingredients to making a good video system is to have one with enough contrast. Contrast is most affected by the black level so, therefore, a good "system black level", very low in the gray scale, is the goal of any good visual display system.

Now let us change things a bit. Say that our room with little or no ambient light and dark walls, ceiling and floor now has a fairly substantial amount of ambient light and some highly reflective surfaces around the room. Those reflective surfaces can include glass from picture frames, a white ceiling, beige carpet and even off-white walls. What do you think has happened to our "system black level"? As you would expect, it is higher up the gray scale into an area ever approaching white. While both of these scenarios are at the opposite ends of the spectrum, they are presented to point out the fact that the only way to get an acceptable "system black level" with a front projection screen is to have control over the ambient lighting and secondary reflections off materials in the room.

Other disadvantages of a front projection system are environmental in nature. First of all, if the room is being used as a training or presentation room, then the person providing the presentation may at some point walk into the projection path. This not only blocks the light from reaching the screen but it can also be very blinding to the presenter. Many presenters move around the room when discussing their topic and, if this is the case, a front projection screen may not be the best choice. In addition, the projector's fan tends to make noise. Try as they might, projector manufacturers still have to move air through their units in order to keep them cool. This can be a source of noise in the room which can raise the NC (noise criteria) level of a given room and require higher levels of speech reinforcement in order for the message to be conveyed. One other thing to consider in front projection is the fact that in order to combat high levels of ambient light, a very powerful and typically expensive projector is necessary. Here, instead of lowering the black level in our contrast ratio, we are attempting to raise the white level to help achieve a better ratio. The results of this method are much more risky and not typically as effective.

While we have been discussing the disadvantages of front projection, there are still a number of advantages as well. They include such things as less space required for a large image. In front projection, the presenter and audience share the room with the projection equipment and as a result less real estate is needed. Another advantage to front projection is the fact that many installers are more familiar and comfortable with front projection systems. Therefore, the time it takes for the installation could be shorter than a comparable rear projection system.

Now that we have established some of the pros and cons of front projection let us discuss rear projection in the same manner. Like we did with front projection, it is only fair that we discuss how a rear projection screen presents an image. What a rear projection screen does with light is *transmit* it through thousands of tiny particles suspended on the screen which then diffuse the light in a given pattern. Similar to front projection, the concentration of these particles has much do to with the dispersion pattern of the light being *transmitted*. However, in this case, the higher the concentration of the particles, the lower the gain of the screen and the wider the dispersion pattern. Conversely, with a lower concentration of particles, the higher the gain and the narrower the dispersion pattern.

While the gain and dispersion pattern of a rear projection screen is important and has everything to do with choosing the correct gain of the screen, it still does not explain why rear projection would be superior to front projection. Look back again at the last paragraph. One key word was used in the way a rear projection screen works. That word was *transmit*. When light hits any rear projection screen most of the light is *transmitted* through the screen towards the other side. If we have large amounts of ambient light in the room, this is no small factor. This *transmittance* is what causes the ambient light from the room to go through the screen into the projection booth behind the screen and allows light from the projector to travel through the screen and into the audience's eyes. This optical characteristic is very significant to the success of a rear projection screen.

As opposed to front projection, where the competing light sources are both traveling towards the screen and being reflected off in the same fashion, in a rear screen the competing light is traveling in a direction that is opposite to the projection beam and is absorbed within the dark room behind the screen. This provides us a number of benefits. The first is that the projected light is being aimed directly at the audience's eyes and we are not relying on the screen to bounce it back towards them. The second benefit is the fact that the ambient light is not significantly reducing our "system black level". This will provide us with a much better contrast level on the screen and make the image appear brighter.

In addition, there are secondary benefits to utilizing a rear projection system. The installation looks cleaner. You do not see the projector as a source of glare or distraction. The image is easier to interact with from a presenter's point of view. The presenter is not going to be blinded by the light of the projector. And lastly, the noise from the projector is now tucked away in a room that is dedicated to the equipment and may even have a separate cooling system.

Wow, this is great news, right? Well, yes, as long as you consider the two issues facing rear projection. The first and possibly one of the biggest objections to using a rear screen system is space. There is a space need associated with choosing this projection method. However, that hurdle is easily overcome with the introduction of a mirror system. Many screen manufacturers have a rear projection module in their product line and Da-Lite is no exception to that comment.

Also, one of the things you have to work through, as a designer, and ironically the second issue facing rear projection, is the possibility of a more costly overall system. When working through a design, one must weigh the cost associated with the front versus rear projection. If you use a more expensive, higher output projector to overcome the ambient light, how does that compare to using a rear projection system with a more reasonably priced projector which has fewer lumens? Or better yet, will you need to use two front projection screens to cover the audience because of the higher gain and directionality needed to overcome the ambient light? These are all questions to consider when making your choice.

Incidentally, there is a rule of thumb that can be used for determining if you have enough space behind the screen for a rear projection mirror module. This rule will provide you with a very rough estimate of the space required. First, take the throw distance required for the size of screen chosen. Then add to that the overall depth of the projector specified. Divide that total number in half and this is approximately the space a one mirror system will take. One can also draw a scaled version of the projector and its needed throw distance on a piece of paper. Cut out the drawing and then place it within a drawing of the proposed room (same scale). By folding the light path you will see how a rear projection mirror system performs its magic. However, if you need something a bit more exact in nature, it is best to complete a Mirror Drawing Request form and allow the optical engineers to design your system in a CAD-based program. This will ensure that every aspect of the system is worked through in great detail.

From all of this, you can see that rear projection is still a valid choice even with today's bright and powerful projectors. Though we try to overcome them, the laws of physics still exist and it is better to *transmit* ambient light than reflect it.

ANGLES OF REFLECTION

September, 2007 ©Da-Lite Screen Company Volume 1 Issue 7

Sizing Up 16:10, Why and Where?

Over the last few years there have been some interesting video display products come to market with varying aspect ratios. The first one that perhaps comes to mind are products which have a native 16:9 aspect ratio. Items like 16:9 video projectors and flat panels are currently sweeping the consumer electronics market place. It seems that the consumer products industry has finally accepted the fact that the change over will take place in February 2009 from our current analog broadcast systems to the DTV and HDTV standards. If you want proof of this, go to just about any city across America and visit a big box electronics store. With perhaps a few exceptions, the displays that are shown in these stores are native 16:9 and many are even capable of accepting 1080p images.

Further proof is in the format war being waged right now between HD-DVD and Blu-Ray DVD. Who will win this war is up in the air right now. Regardless, many of us either own or plan to own a 16:9 formatted display for our home. While it may take a few years for us to replace the secondary viewing devices in our home, I predict that eventually we will have only 16:9 formatted devices for our normal television viewing.

With that said however, let us look at the computer world. Here, we find that things are a bit different. The emerging standard for a widescreen computer format is rapidly becoming 16:10. For many years the most common format for a laptop computer has been 1024 x 768, which happens to be a 4:3 aspect ratio. Sure some people have had higher resolutions for specialty applications, but for the most part the largest selection of laptop computers came with this resolution and format. Today, however, we are seeing several new resolutions come to the forefront of the laptop computer market. They are 1280 x 800, 1440 x 900 and some are even 1680 x 1050. Once again take a look at your local big box electronics store. It is a good bet that the highest selling laptops at their store are one of these three formats.

Why 16:10 and how did they come up with that format, is something many of us have been trying to answer for a number of months. One of the most common answers to this question has to do with the process of manufacturing the LCD panels used in laptop computers as well as small desktop monitors. Apparently, the companies that produce these panels have found that they achieve better yield when cutting the larger pieces of glass down to the 16:10 formatted size instead of 16:9. I have not yet been able to substantiate that claim, but depending on the size of the original glass, with the LCD elements, that may indeed be the case.

One other reason I have heard is that you can still have full 16:9 video displayed along with the tool bar at the bottom of the screen. While, I doubt very much that this would be a reason to go 16:10, I do believe it is a benefit.

Perhaps another reason is because when Apple decided to begin doing widescreen units a few years ago, they chose the 16:10 format as the basis for their monitors. Why Apple did this is yet another good question. From the limited information found in other white papers and through an extensive Google search, only one reason seems to hold merit. That is the fact that you can display pre-press materials in a “two-up” format with a widescreen 16:10 display. What that means is that you can see two pages side-by-side on one display. Sure, we can do that now with our 4:3 displays but the content is very hard to read even with a large monitor. Also, in order to fit the width of two full pages within a 4:3 monitor, you need to reduce the height of the pages and that infers that the full monitor height is not being used. Since Apple’s Mac computers are, for the most part, the first choice of any graphic designer or pre-press printing company, it would appear that this is a very valid factor. As we all know, the battle between Microsoft and Apple has been waged for a number of years and it does not look like that will end any time soon. Therefore, when Microsoft introduced their new Vista platform earlier this year, it is of no surprise that they too chose 16:10 as the base for the graphics package. That is not to say that it will not operate with a 4:3 display, it was just optimized to the new 16:10 widescreen computer format. It is very likely that their reasoning behind this was two-fold. First, Microsoft wants to stay ahead of, or at least stride for stride with Apple. Second, the laptop and monitor manufacturers have been trending towards this wider format and Microsoft likely felt it was necessary to help promote this trend with its software.

Since the computer and flat panel display companies have been promoting this new 16:10 format, several in the audiovisual industry have chosen to follow their lead. At the 2007 Infocomm show, several projector manufactures introduced units with a native aspect ratio of 1280 x 800, a 16:10 aspect ratio. These manufacturers recognize that one of the driving forces behind the visual display market is the personal computer. Also, we at Da-Lite have recognized this trend and are now making screens available in the new 16:10 format. For us, this is simply a size change and as such we have added many new sizes to our line so that our products are compatible with these new projectors.

Okay, so we now understand why we have this new format and where it has come from. How does it apply to us as systems designers when we work out the details of a visual system? Well, the answer is quite simple. What we first need to determine is what our source material will be and from what device it is coming from. For instance, let us look at a training room for a large corporation. In this example, the corporation has all of their content, both PowerPoint and video, either on a local PC or on a content server. If the server, local PC and the confidence monitor are configured to run at 16:10 format, then the appropriate projector and screen combination is one that is native 16:10.

However, if the source material for the room is from a broadcast level server, DVD, HD-DVD or Blu-Ray player the choice would be different. Here, the better choice is a projector and screen combination that has a native resolution of 16:9. Especially since the source materials are likely to be

720p, 1080i or 1080p. Figures 1 and 2 below show the differences between the two formats and what occurs when one format is projected upon a display that is of the opposite aspect ratio.

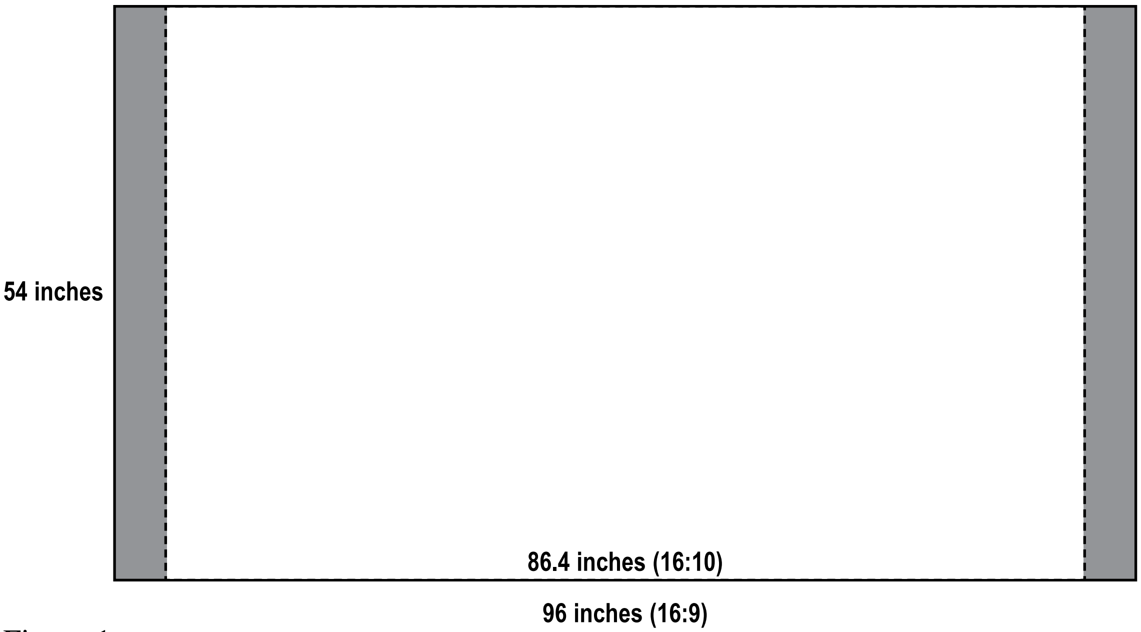


Figure 1

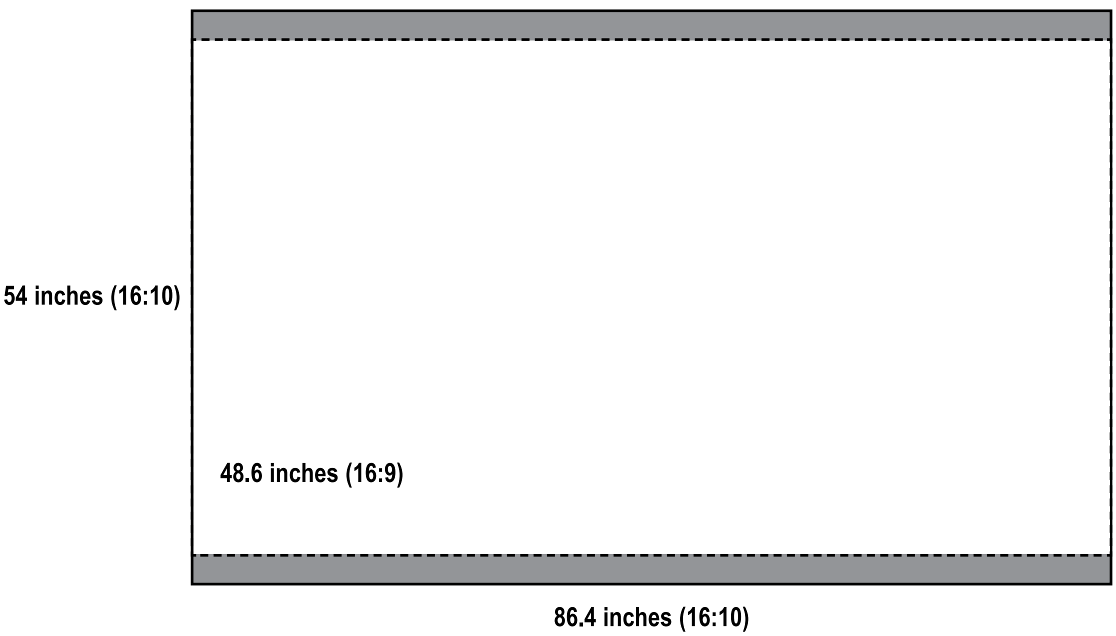


Figure 2

It is hard to tell exactly what will be the long term result of this format war, but for now it appears that 16:9 will remain a consumer based widescreen format and 16:10 is the new business widescreen format. Hopefully now, you can answer Why and Where?

Angles of Reflection VOLUME II – 2009

ANGLES OF REFLECTION

May, 2009 ©Da-Lite Screen Company Volume 2 Issue 1

Perhaps one of the most talked about and interesting technologies that has seen resurgence in the consumer and commercial audiovisual markets over the last few years is that of Three-Dimensional (3D) displays. It seems that nearly every major motion picture studio has either released or will be releasing box office films produced and displayed in 3D. What was once a technology reserved for theme parks and special movie showings, is now becoming mainstream and finding its way into our homes. With that in mind, let us take a look at:

3D – The Final Frontier?

For years the movie production industry has tried to find ways to maintain an edge over the television industry. The resurgence of 3D seems to be the latest in a long list of items that the motion picture industry is using to fill seats in the theaters and stay ahead of their rivals in television. As we have all seen through the years, a technology that starts at the box office, eventually finds its way into our homes in one shape or another. It seems then that 3D is not exempt from this trend. However, the real question is how and when will 3D make this transition? The answer to this question really depends on your definition of what you consider an adoption of a technology.

In order to understand how we might apply 3D to our home viewing systems, we must first gain a basic understanding of how 3D or stereoscopy works. Providing we do not have a major impairment in one or both eyes, we has humans are constantly processing two images in our brain, one from our left eye and another from our right eye. This is what most commonly referred to as binocular vision. Whether we realize it or not, because of the distance between our eyes we are actually processing two slightly different images when we have our eyes open and are processing visual information. This parallax or difference in the two images is what creates depth perception in our brains and provides the third dimension in our normal everyday 3D viewing. How then, can we recreate this imagery with a flat two dimensional video display device you might ask? The answer to this question is somewhat complex and depends on the display device itself and the level of quality desired in the 3D system.

Suffice it to say that 3D imagery can be achieved with fixed flat panel display devices such as DLP displays and even some LCD Displays. However, for the sake of brevity, we will save this for another article. What we want to address with this article is 3D in larger two piece projection systems.

In order to better understand how we can produce 3D images with a projector and screen combination, we need to understand how the 3D content itself is created. First let us look at real life images. Much like the two eyes in our head, a 3D camera has two lenses and captures two unique images with a predetermined parallax. Those two images are then stored in an electronic manner and processed and edited in similar ways to what a 2D image would be. The details behind this process vary widely and are often proprietary to the different studios. For animated images, the biggest difference between creating a 2D image and a 3D image is that 3D takes nearly twice the time because two different perspectives of the animation need to be created. Regardless of the method or the media, the only way to create 3D images is to capture or create an image for the left eye and a slightly different image for the right eye.

Once the content is created, the way in which the images are then presented to the intended audience can vary widely. Not only does the technology vary but the quality of those technologies also carries a wide amount of variance. Perhaps the most inexpensive and lowest quality way to present a 3D image is through a technology known as Color Anaglyph. With Color Anaglyph one of the two images is tinted with a red filter while the other is tinted with a cyan filter. The viewer then in turn wears glasses which have a corresponding red filter for one eye and a cyan filter for the other. When the eye containing the red filter views the red part of an anaglyph, that portion of the imagery appears white while the cyan sections appear black. Conversely, when the eye viewing through the cyan filter sees the red part of the anaglyph as black and the cyan portion is white. The difference between the two then help create uniquely separate images for each eye. This in turn provides the depth needed to give us a 3D image. In terms of its classification within the 3D world, color anaglyph is considered a passive technology because the image is presented smoothly on the display and the combination of the colored glasses and the tinted image creates the 3D effect.

When it comes to ease of use, a color anaglyph 3D system rates very high on this scale because of its ability to be reproduced by most projectors and televisions. However, the big trade off with color anaglyph is that some portions of the image can be skewed slightly by the color filters in the glasses and true color is sacrificed in the image quality. For those of us who watched the 3D half time show of the 2009 Superbowl, those images were created using the color anaglyph method. I am not sure about you, but I was certainly not impressed.

Another method for displaying 3D images is that of Alternate-Frame Sequencing also known as an Active Stereoscopic display. With Active 3D the left and right eye images are flashed on the screen in alternating sequence at a very high rate of speed, at or exceeding 100fps (frames per second). The viewer then wears shutter glasses that contain LCD lenses or some other light blocking material and they, in turn, are sequenced with the images to ensure that the left eye only sees its frame and the right eye only sees its frame. Our brains then fill in the gaps based on the high frame rate and we perceive it as one continuous image creating the necessary depth perception to see the image in 3D. While this type of technology is typically more costly than color anaglyph and a bit more complex, it has much better color reproduction and usually better resolution. Any issues with complexity are far outweighed by the increase in image quality and color reproduction.

The last method for producing 3D images with a projector screen combination is that of polarization. Much like color anaglyph, polarized 3D systems are considered to be a passive technology. Polarization is widely accepted in most multiplex theaters due to the fact that it is relatively easy to use and has a lower associated cost. With that said, how is it that polarization can provide a 3D image and for that matter, what is polarization?

In this particular instance we are using polarization in a way that is related to light rays. Have you ever purchased a pair of polarized sunglasses so that you can help reduce glare from the Sun off of a shiny object or the surface of standing water? If so, you are reaping the rewards of a polarizing filter. What a polarizing filter does is to only pass light of a given orientation through its surface and blocks all other light. While that is fairly easy to understand what may be a bit more complex is the difference between a linear and a circular polarizer. A linear polarizer is fairly easy to understand. It only allows light to travel through it which is aligned with the orientation of the filter and the two are orthogonal (differing by 90º). A circular polarizer however, only allows light through it which travels in a circular pattern, either clockwise or counter-clockwise. In either case, the key factor is that we can block a given percentage of the light while still allowing the remainder to travel through the filter. The reason this is key is because we can align a polarizer over the image for the left eye in one direction while aligning the polarizer for the right eye in the opposite direction. What that allows us to do is to match the polarizers from each image with the glasses worn by the viewer.

Basically, the polarizer used for the left eye needs to match that of the left eye in the glasses and the polarizer used for the right eye must match the right eye of the glasses. What this does then is make sure that each eye only sees it's image and the other is cancelled out creating our depth perception and in turn 3D. Of course the quality of the polarizer can affect the level of ghosting or cross-talk between the two images but a polarized 3D display provides some of the best images with very little eye fatigue or strain. The other reason movie theaters like to use a polarized system is due to the cost of the glasses. Paper polarized glasses are very inexpensive while active LCD glasses can be cost prohibitive, especially for a commercial movie theater. However, in a home application an active display may have some merit.

So the next question is with a polarized system how do we get two images on one screen? Well there are a couple of ways to do this. The first is by utilizing two projectors and streaming images to them with the appropriate output cards and 3D software. The second way is by creating a sort of hybrid active/polarized display. If we chose to only use one projector, we can place a rotating polarizing wheel, with the two different filters, in front of the lens and it spins at a rate that allows the light to pass through it polarizing the light before it strikes the projection screen. As long as the images are being presented in a frame sequential format, this is a very valid option for the home market.

Now that we have a base understanding of how we can project or display a 3D image, the next item to consider is the screen surface used in our two piece projection system. The question often asked is if you need a special screen surface for 3D projection. The answer to that question is not as simple as a yes or no answer. It primarily depends on the method utilized to present the 3D content. If the method chosen is color anaglyph or active-shutter projection, the answer is no. Pretty much any screen can be used for these two technologies. The choice of one screen over another then depends on the lighting conditions in the room, where the audience will be seated and the output of the projector. This is the same criteria we use when deciding on a screen surface for normal 2D projection.

If, however, the technology being used is polarization, a new set of rules must be followed. The reason we cannot choose the screen like we would for a 2D image is the fact that not all projection screens are able to hold or maintain the polarization of the light coming from the projector. In addition, by using a polarizing filter we essentially reduce our light output by half because it only allows light through it that is in line with its particular pattern. Therefore, our screen selection is very critical and we want to make sure we choose wisely to ensure a quality image for all viewers.

Traditionally the only screen surfaces on the market that have been able to maintain polarization have been front projection screens with a silver base to them and rear projection screens with a Fresnel/Lenticular surface. However, both of these materials were not specifically designed for 3D projection and therefore we are accepting them as the best alternative as opposed to a screen that was specifically designed for 3D. Today, there is at least one front projection screen surface and one rear projection material designed specifically for 3D projection. Those are the 3D Virtual Grey front material and the 3D Virtual Black rear projection screen from Da-Lite. Both of these surfaces were designed with polar retention in mind. Both of them maintain 99% of the polarization as the light is either transmitted or reflected. Some of the best silver screens only maintain 97% of the polarization and Fresnel/Lenticular screens are even less effective.

Regardless of whether you use a silver screen, the 3D Virtual Black or the 3D Virtual Grey materials, there are a number of considerations that need to be taken into account. The first of these is where the audience is to be seated in the room. All three of these surfaces have a fairly significant gain factor to them and somewhat narrow viewing angles. In order not to create hotspots, dark corners and/or drastic fall off, we need to make sure we match the projector with the screen and the seating area.

What we need to remember is that when it comes to projection screens with a gain higher than 1.0, we have a surface that is being more discriminate about the way it is distributing that light. A traditional 1.0 gain screen distributes light equally in all directions. (This, not surprisingly, is one of the reasons why it will not maintain polarization.) When we add reflective materials to the screen we increase its gain and reduce the viewing angle. Therefore, more light is being directed to one specific area rather than being distributed equally in all directions. Also, the angle at which the light hits the screen is even more critical since a screen with gain reflects light striking its surface based on this angle of incidence. This then begins the discussion of long versus short throw lenses.

You see, when a screen has a higher gain and a narrow viewing angle, the choice to use a short or long throw lens becomes very important. In nearly all applications a long or medium throw lens is preferred. The reason this is so has to do with the incident angles of the light rays striking the screen. If we understand that a screen with gain, will reflect the light striking it based on its angle of incidence, we can then surmise that light coming from the center of the lens will strike the center of the screen and be reflected back towards the center of the viewing area. However, if we think about the light coming from the edges and corners of the lens, that light is striking the screen at an angle that can be drastically different than those striking the center. Hence the angle of reflection from the screen can be such that the corners of the image may appear dim, if we are not towards the center of the screen. This, then, is how a hotspot is created and is an undesirable condition. Furthermore, if the screens polarization levels are dependent on the viewing angle, we could introduce ghosting or cross-talk that is also undesirable.

With this in mind, the best solution is to use a longer focal length lens for polarized 3D displays. In doing so, we will help eliminate a hotspot and increase our polar retention. Both of these are critical elements of ensuring a quality display. Just how long then should the focal length be? Well, based on testing done at the Da-Lite Tech Center in Cincinnati, OH, we have determined that a focal length greater than 1.6 is preferred for use with our polar retaining screen surfaces. By using this as a minimum we are ensuring that the light rays at the corner are striking the screen at an angle that is much more similar to those at the center of the screen.

Now, let us say that you are placing the screen in a rear projection setting and you do not have enough room for a 1.6 focal length lens. Well, here too, there are answers. What can be done is that a mirror system can be utilized to make better use of the space behind the screen and eliminate the need for a short focal length lens. What typically happens is that a CAD design of the room is created to include the light path and projector. Then the light path is folded until it is able to fit into a nice tight package. Sure, this type of system is more labor intensive to install, but the end result is a great looking picture with very good contrast, high levels of polar retention and no hotspot. By most standards, this is the best a display can get.

The last thing we need to consider when we choose a screen to be utilized in a 3D display is where the audience will be seated. If we are using a screen that has a narrow viewing angle, placement of our viewers is very critical. First of all, we need to remember how viewing angles are determined and what they tell us. By the SMPTE (The Society of Motion Picture Television Engineers) standard, the viewing angle of a projection screen is determined by taking a light source and pointing it at the center, both horizontally and vertically, of a given screen surface. A measurement is taken at that center point and recorded. Then the measuring device is moved from the center in an arc like manner and measurements are taken at every degree in that arc. The reason an arc is used is so that the distance from the screen surface and the measuring device is constant. From here we are able to determine how much the intensity of the light falls of as we go towards larger and larger angles. The point along that arc at which we have half of what we did at the center is considered the “half angle” and this is normally synonymous with the viewing angle. However, the key element we are forgetting is that the same is true on the other side of the center point giving us a viewing cone. As an example if we determined, through testing, that a screen surface had a half angle of 20 degrees, the viewing cone would be 40 degrees. That equates to 20 degrees from left of center and 20 degrees from right of center. Armed with that information, we are better equipped to choose a projection screen surface and place our audience.

Ideally, we want to make sure that our audience is seated within the viewing cone of the screen surface. However, we must remember that we need to consider this not from the center of the screen but from the sides of the screen. Furthermore, we must also take into consideration the angle of incidence of that light coming from the projector and striking our screen. This is how we will determine if our audience is in the right place.

In conclusion, when considering a 3D display there are a number of items to consider. However, the task is not insurmountable. First, we must determine what 3D technology we are going to utilize. This in itself is not a small undertaking. Cost, availability and physical constraints all need to be considered during this step. Once this decision is made, the next step to consider is the screen choice. This is done by determining if we need a polarization preserving screen or not. Then we need to determine where the audience will be seated and make changes in either the seating or the technology and screen choice made. If you follow these items through in an organized manner, you too can have an impressive 3D display and view the Final Frontier.

-- Blake Brubaker

ANGLES OF REFLECTION

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It is considered by many to be the single most important parameter in a projection screen's specifications, and so it should come as no surprise that gain has been covered many times in many ways. Given its position in the minds of those interested in screens, it is important that the concept of gain is well understood. What is it? What does it do? How can it be used to enhance a display? Let's review and perhaps learn a bit more about:

Gain Again

Quite simply put, gain is a number that tells us how bright a projection screen is. Higher numbers indicate screens that are brighter than those with lower numbers.

Defined a bit less simply, gain allows us to predict how bright a screen of a given size will be when used with a projector of a given light output. The output of the projector, typically indicated by the manufacturer in lumens, can be divided by the square footage of the screen to determine what amount of light energy will fall on one square foot of its surface. This number, multiplied by the gain, will reveal the amount of light that is reflected from that square foot of material, and is measured in foot lamberts. A movie theater screen will typically reflect around 16 foot lamberts, while for most commercial applications, 30 foot lamberts or more will be appropriate.

$$\text{Foot Lamberts} = \frac{\text{Light Output}}{\text{Image Area}} \bullet \text{Gain}$$

Figure 1 – Formula for determining the amount of light reflected from a surface (in Foot Lamberts)

Finally, in more technical terms, a screen's gain is measured as a comparison between the amount of light the screen reflects and what would be reflected by a reference standard under identical conditions. That reference is typically magnesium carbonate ($MgCO_3$), a chalk-white substance which absorbs virtually no incoming light, diffuses it in a fairly even pattern, and represents a gain of 1.0.

Under our current system, the gain measurement you find on most screen specifications represents the light measured returning from a screen at the perpendicular angle expressed as a multiple of what was measured from the reference standard. If more light is returning compared to the reference, it will have a value greater than one, and if it is less, then it will be less than one. A 2.5 gain screen will reflect 2.5 times the light of magnesium carbonate at this angle, and a 0.6 screen will return only 0.6 times as much. As a result, these different surfaces will generally appear either brighter or darker than $MgCO_3$, respectively. I say *generally*, because the way gain is manipulated into becoming greater or less than one is not quite as simple as it might at first seem.

To achieve a low gain, some amount of gray pigmentation is added to the screen material so that it will absorb a portion of the incoming light rather than reflect all of it. This will make black appear darker, and will, therefore, improve the contrast ratio that the screen is capable of producing. Naturally, the entire image will be darker, and not just black, but a change in black level is the most important factor in determining contrast. For more on this, please consult "Contrast", the fifth article in Angles of View.

As for a higher gain screen, these are often used to help brighten an image from an inadequately bright projector for a given screen size. Recalling that the light falling on a square foot of material will be the total output of the projector divided by the square footage of the screen, it is possible for the light to be spread out over too large an area to see a bright enough image. Increasing the gain will allow this light to be multiplied by a number larger than 1.0, and will increase the foot lamberts we'll see reflected.

To do this, the screen will use a reflective coating to create a sort of directionality in how the light is reflected, focusing a good portion of it along a single axis. This, in turn, reduces the amount of light that is sent in all other directions. The screen cannot create more light energy, but it can focus it in one direction at the expense of the others, and in most cases, the higher the gain the more light is aimed in one direction. In the absence of directionality, such as with a Matte White screen or $MgCO_3$, light is diffused in a more even pattern. This means that the measure of light returned at one angle will be almost exactly the same as at every other angle. No one angle is increased, and no angle is forced to decrease its light emission to allow for an increase.

What complicates this process is that it is possible and even commonplace to combine pigmentation and directionality to create a gray screen with a gain close to or even greater than 1.0. Doing this will both darken and brighten the image to some degree, allowing both contrast and brightness to be enhanced. Being simultaneously darker and lighter does not invalidate our foot Lambert formula described above for determining how much light to expect from a screen, but it does reveal an important distinction between gain and what we've been referring to as *directionality*. Two screens with the same white or gray base, and even two screens with the same listed gain measurement cannot be assumed to behave in the same way under projection, and the reason for this is that they may have a difference in their directionality.

To show this difference, most manufacturers take additional gain measurements and graph the results. We measure at 5° increments around the center of the screen, and this is a fairly common approach. A non-directional screen will diffuse light fairly evenly, whether its gain is 1.0 or less, and will show a graph with a very gentle curve. What this means in the real world is that anyone seated anywhere in front of an evenly lit screen will see an evenly reflected image of uniform brightness. With a directional screen, as the angle away from perpendicular increases, we will soon exit the area of directionality's influence and the amount of light being measured will usually decrease. At a certain angle, the measure of light reflected from the screen will be one half of what it was at perpendicular, and this is referred to as the half angle.

Far from being a trivial or arbitrary consideration, this angle is significant not only because it will provide a clue as to a screen's directionality (being significantly directional will create a narrow half angle, regardless of the actual gain), but also because when the light reflected measures half of what it was at the center, the screen will become unmistakably dimmer. If enough of a brightness change is visible simultaneously across the screen, it can be perceived as a hot spot.

This distracting artifact is the primary reason why we avoid creating outlandishly high gain screens to allow for dim projectors, or recommend using them in situations where the audience will be seated in a wide area around the screen. The significant directionality in high gain screens will result in a very acute half angle, and a large portion of the audience will likely be seated outside of it. Even in the case of a screen intended for a single viewer who promises not to move away from the seat centered in front of the screen, at large enough screen sizes and short enough throw distances, it is possible for a hot spot to appear if light from the projector is traveling to the corners of the screen at such severe angles that they will be essentially directed away from the viewer.

An exception to this rule may be expected from the retro-reflective materials you may have seen in highly reflective paints, road signs, and in Glass Beaded projection screens. The important difference between these and the far more typical angular reflective screens is that retro-reflective materials reflect light primarily back towards its source. This means that while the directionality of an angular reflective screen would cause it to behave like a mirror, aiming light at an angle equal but opposite to the light source, a retro-reflective material will be aiming light back towards the incoming light.

In practical terms, this means that although there will be a conspicuous change in brightness from one viewer to the next, what each viewer sees from his set perspective will be more uniform than one might otherwise expect. This is because the majority of each light ray is reflected back towards the origin at each point on the screen instead of away from it at the edges. A hot spot may still be seen by a viewer far enough away from the origin (ie, the projector), but retro-reflectivity allows for large screens with high gain that will be fairly uniform if viewed from inside the boundary of the half angle.

Interestingly, looking at the gain measurements taken from angles outside the influence of directionality will reveal that many screens will show a flat curve out towards the most oblique angles. This may not be particularly significant in terms of the screen's use, as the uniformity experienced by a presenter or someone standing in the wings is not a prime concern. However, knowing the gain at the angle where the curve flattens out can potentially reveal the shade of the screen's base in a way that is more accurate than making this judgment based solely on a photograph of it.

Figure 2 is an example of the sort of gain chart many manufacturers provide, but with a slight difference. As you can see, the Y axis is not vertical as it is in most charts, but angled around a single point both to reflect the relative positions from which each measurement was taken, and also to present a shape that should ease in the visualization of each material's reflectance pattern.

Looking at the Matte White material's curve, it very closely follows the 1.0 line around the center axis which means it is diffusing light evenly in all directions with very little directionality. The most obvious example of a directional screen would be in the Glass Beaded material which peaks at 2.5, and then dips sharply before settling into a gentle curve starting at 25°. From this point on, it looks very similar to Matte White's curve, but centered around the 0.9 line instead of 1.0. As a result, the image will begin to appear uniform as the viewing angles increase beyond this point, but the picture will not be nearly as bright as it was at the center, or as bright as it would be on a Matte White screen.

The High Contrast material, which touches 1.1 before quickly descending below 1.0, is a clear example of how the curve beyond the influence of directionality can be a clue to the grayness of the base material. Finding 1.1 gain on a screen would understandably seem to indicate a white base and some directionality, but looking at the actual curve tells a different story. The gain on a Matte White screen would not fall very far below 1.0 at any angle, but the measured gain on this material reaches below 0.8. At around 40°, the slope at which gain decreases evens out, and it begins to act more like a darker version of Matte White. This is more or less what the High Contrast material is beneath the reflective coating. Placing a sample of this particular High Contrast material next to a Matte White screen will prove that it is basically darker, but as far as incident light from a projector or light meter is concerned, its coating more than overcomes the absorption of the pigmentation. A simple gain measurement might not reveal this to be the case, and it would be difficult to know that a 0.8 gain material with no directional coating is practically just as gray as a 1.1 gain material with that coating.

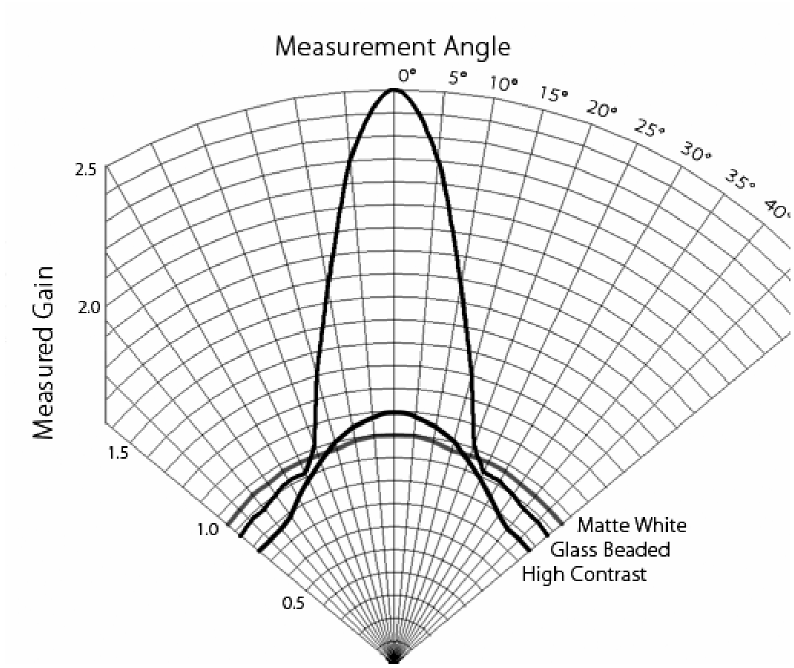

Figure 2 – Gain measurements of three screen materials plotted around a central point to represent the measurement angles more directly

Because of this, please look at both the gain and the half angle to get an idea of how the screen will behave. From this, guide the arrangement of the room so that the audience is inside that half angle and able to enjoy the benefit of increased gain. In addition to these considerations, the measurements the manufacturer provides will give some insight into the possible uniformity of the projected image. The details of this have been covered by Kim Milliken in “Uniformity”, the first article of Angles of View, and also in “Uniformity – Revisited” by Blake Brubaker in the fifth issue of Angles of Reflection. Their comprehensive work will be an excellent next step in exploring these matters regardless of your level of expertise.

-- Adam Teevan

ANGLES OF REFLECTION

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Different people look for different things in a big display but it is probably safe to assume that "big" is a priority. Aside from budget or environmental limitations, how can anyone determine what size is big enough? On the other hand, what if a small screen is needed? Where is the minimum limit on size? The short answer is that it is all a matter of perspective but there are still absolutes that can lead us to find:

The Right-Sized Screen

If you have ever stood on a railway platform and looked across the tracks at a billboard-sized advertisement on the opposite wall, then you have an idea of what it means to see content that is designed to be viewed from a distance. The text is large enough to be legible, the images are big enough to be identifiable and, while physically large, it is far enough away that the entire sign is visible at once. To step up to the big screen experience, simply turn around and stand in front of the large ad on your own side of the tracks.

You will probably find that being so immersed in advertising makes it impossible to take in all of the information on this board as quickly as you could with the other. While large enough to command the entirety of your vision, you are only able to process a fraction of what is being taken in at any given moment. The rest is in your peripheral vision and while still a part of what you see, it does not contribute significantly to what you comprehend. Assuming you are moving your eyes as you read even this text, it should be fairly easy to confirm that this is true.

Should that huge image on the wall become a display with moving video, or graphics with several lines of text, it would quickly become tiresome and ultimately impossible to understand all of what is being shown as you move both your head and your eyes to keep the important parts of the screen in the more useful center of your vision rather than the periphery. This is to say nothing of the angular distortions and the insufficient resolution of the images that would further impede your ability to digest what is being served.

Because of this, it is inadvisable to specify a screen that would be too big for the intended viewing distance. The absolute dimensions are not at issue here but it is the viewer's proximity to the screen that makes all the difference. Just as it is possible to make a coin appear to be the same size as the moon by bringing the coin closer to your eyes, it is practically trivial that a fifty inch screen is actually smaller than a sixty foot billboard so long as you are a certain distance from both.

Figure 1 is an approximation of this phenomenon. From the top, the three horizontal lines in Part A represent a large object, a smaller object and the bottom line shows the amount of area on the viewer's retina those objects occupy. This retinal area is commonly discussed in terms of

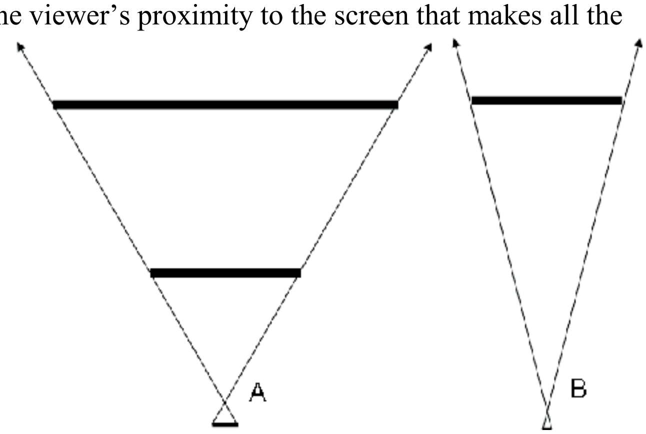


Figure 1: Illustration of the relationship between an object's linear dimensions and perceived size based on angular size

angular degrees and it is the case that when the angular distance from one side to the other on two objects is the same, even if they really are different sizes, they will use the same amount of the retina. In terms of the moon and coin example, the small coin can eclipse the much larger moon so long as the angular size of the coin is the same or greater than the moon's.

Of course, there are a number of other visual cues which indicate that one object is actually smaller than the other, regardless of what else is going on in your eyes but this can be manipulated to some extent as well. This specific application of perspective is not necessarily within the scope of this document but through some Escher-esque engineering, it should be possible to use the perception of scale to create the effect of a drive-in theater in one's own home using models of various scales.

Returning to the illustration, Part B uses a similar concept to A but now the smaller item has moved away from the eye to the space where the larger object was positioned. This results in a narrowing of the angle between the left and right edges and causes the object to appear smaller than it did before.

When it comes to small screens, probably the smallest and most common of these is the one on your cell phone. It is smaller than any projection screen you are likely ever going to see but it is still legible and, therefore, able to serve a useful purpose. The reason for this is, again, the distance between the screen and the viewer and the resultant angular size. Rarely will the screen ever be more than an arm's length away and keeping it close enough to be visible should not be difficult. As an added benefit, the number of people looking at the screen will almost always be one.

Under these conditions, it is fairly simple to justify using a very small screen but that all changes once you begin to introduce additional people to the audience. What still may be a perfect image for the one person in the one ideal position will be useless to everyone else from their varying distances and viewing angles. The options at this point are to give each individual their own screen, which is a great choice for certain venues, or provide one big screen that everyone in the room can see clearly. This is typically a far more efficient method.

Of course, now the problem is to define what size is small enough and large enough to be quickly and comfortably understood. We know that the distance between the viewer and the screen is important but we need to find the actual limits between size and distance.

Both Kim Milliken and Blake Brubaker have written comprehensively on the mathematics behind this relationship, and I would direct you to *Sizing* in <u>Angles of View</u> and *Too Close for Comfort?* in <u>Angles of Reflection</u> for the precise details. To summarize the results of their trigonometry, the closest audience member should be around 1.5 times the height of the screen and the most distant should be within around 6 screen heights for comfortable reading and viewing. Seating the last row a bit closer (4x height) may be necessary for some applications where finely detailed images must be inspected. For entertainment, it can be a matter of personal preference where the best seats will be located but these rules remain valid guidelines.

To get an idea of your own personal preferences, be prepared to estimate how large various screens appear by measuring them against something you always carry with you. For me, that means holding up one hand with thumb and pinky finger extended vertically as much as possible and held at arm's length to check a screen's relative height. It's not a perfect system but comparing the size of the screen to my own hand lets me keep an accurate enough idea of what looks good without much effort. Conversely, holding your arm out as though weakly attempting to greet some invisible surfer may make you look somewhat foolish, so please find a system that you are comfortable using.

Once we have figured out how large or small the screen should be based on the distances from which it will be viewed, the next thing to consider is the size of the content that will fill that screen and the resolution at which it will be displayed. The same rules of angular size apply in this case but the particular angles will be quite different.

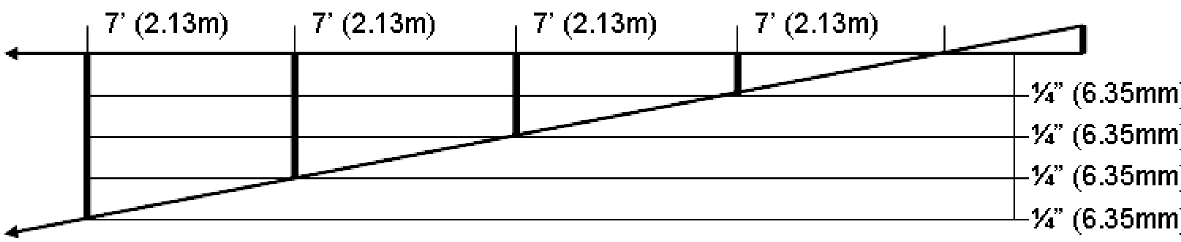


Figure 2

Figure 2 illustrates the rule we use for determining font height. The minimum legible size of text described by Milliken is such that the smallest character subtends no less than 10 arc minutes of a degree. This is the same as saying 1/6° and although the above chart is not at all to scale, it does show how the font size must change at a fixed rate with the distance from the viewer in order to maintain a constant size on the retina. Allowing ¼″ in character height for every 7′ of viewing distance is a fairly accurate ratio which will ensure that virtually anyone will be able to read what is on the screen.

Beyond this rule, any size at any distance can be determined by considering the distance from the viewer to the screen as one leg of a triangle and the height of each character as the other leg. Given that the tangent of an angle is equal to the length of the leg opposite to that angle divided by the adjacent leg, minimum character height can be found through: tan(1/6°) * Distance. The maximum distance for a given character height results from Height / tan(1/6°).

Please note that this angle is given in degrees and must be used in radians for the equation to work. Conversion to radians is accomplished by multiplying the number of degrees by pi and dividing by 180. For the sake of simplicity, the usable tangent of 1/6° is roughly 0.00291. Thus, seven feet (84 inches) times 0.00291 is equal to 0.244 inches, or in practical terms, one quarter of an inch. For metric, consider using 3mm for every 1m.

The actual point size of the font used will be dependant on the resolution of the display. This information is usually given as the number of pixels that make up the width of the screen and the number of pixels that compose the height. The current standards for televisions are 480, 720, and 1080 pixel heights. Common computer resolutions have been along the lines of 640x480 or 1280x800, both of which denote the screen width and height in pixels.

An increase in resolution essentially means that the height and width of the screen is divided into more pixels. If the dimensions of the screen remain constant, then each pixel must be reduced in size to accomplish this. This is why we have been discussing font height in terms of actual linear height instead of the number of pixels or points from which it is comprised. A 12pt font might work for the printed page but on a high resolution screen it may need to be 24pt to remain legible from similar distances.

To estimate the size of a pixel in a given display, simply divide the linear length of one dimension by the number of pixels in that same dimension. A screen that is conveniently 4.8m high and with a vertical resolution of 480 will have pixels that are around 1cm tall. There is some distance, or pitch, between each pixel and this is the reason why we cannot assume the pixel to be exactly one centimeter high. Fortunately, for the purposes of determining font legibility, it is generally safe to ignore the pitch.

The maximum character height for a 12pt font on this screen would be around 12cm high, and would, therefore, be visible from about 40m away (1m distance for every 3mm character height). We are more interested in the minimum character height to determine the threshold of legibility however, and this is going to be somewhat less than 12cm. Exactly how much less is dependant on the individual font. Suffice it to say, sizing the font a few points higher than what would be needed for maximum height will probably be in order.

I have found through experimentation that the short lowercase letters in some common fonts will be about 60% the height of the uppercase letters. This means that "X" is about 1.66 times taller than "x" and so if you can determine the minimum character height and the number of pixels it would take to render that character, multiplying by 1.66 should let you know roughly what size font to actually select. In this example, a 20pt font will yield characters no less than 12cm high.

To tie everything together, assuming this 4.8m screen at 640x480 pixels, the first row of seating should be 7.2m back (4.8m*1.5) and the last row will be within 6 screen heights, or 28.8m. Multiplying this distance by 3 will give us 86.4, the minimum legible font size in millimeters. Since dividing the screen height by the number of pixels in the vertical resolution gives us 1cm per pixel, the smallest character will be 8.64 pixels high. Multiplying this by 1.66 lets us know that we need a font at least 14pts to be seen by the back row. Imperial measurements will work the same way, with the exception of using ¼″ character height for 7′ distance.

By using these rules together in this way will help ensure that the screen and everything on it is able to be understood by anyone in the room, regardless of their point of view.

-- Adam Teevan

ANGLES OF REFLECTION

December, 2009 ©Da-Lite Screen Company Volume 2 Issue 4

Our traditional myths have survived for millennia and continue to resonate as insights into the very nature of humanity. Other myths, unfortunately, are related to AV. While they have the potential to be just as enduring, their contributions to the human race are often negligible and rarely positive. This article will investigate just three of these, all related to light in an AV system. Let's put an end to their proliferation and so hasten:

The Twilight of the AV Myth: Light

Myth 1: Moving the projector closer to the screen will brighten the projected image.

Frankly, the idea that the distance between projector and screen will influence brightness makes quite a bit of sense. Most people will be familiar enough with a candle, flashlight or torch to know that there is a certain range where the illumination from those sources is most useful. All of them are more than adequate for the close work of navigating an otherwise dark room or staying on a path through the forest, yet they generally fail to light up distant objects very effectively.

Projectors give off light much like flashlights do, so it stands to reason that they would follow a similar pattern. However, there is a critical difference that contradicts this expectation. To preface this difference, I think it is worthwhile to look at the way light is measured.

The diagram below shows a flashlight with a familiar looking cone of light being emitted from it. The top and bottom of the beam are obviously not parallel and we can say that the light is coming out at a measurable angle. Since the light is emitted in a three dimensional, conical shape, rather than the two dimensional wedge shown in the illustration, the angle we measure will describe the edges of the beam all around the cone, not just the top and bottom.

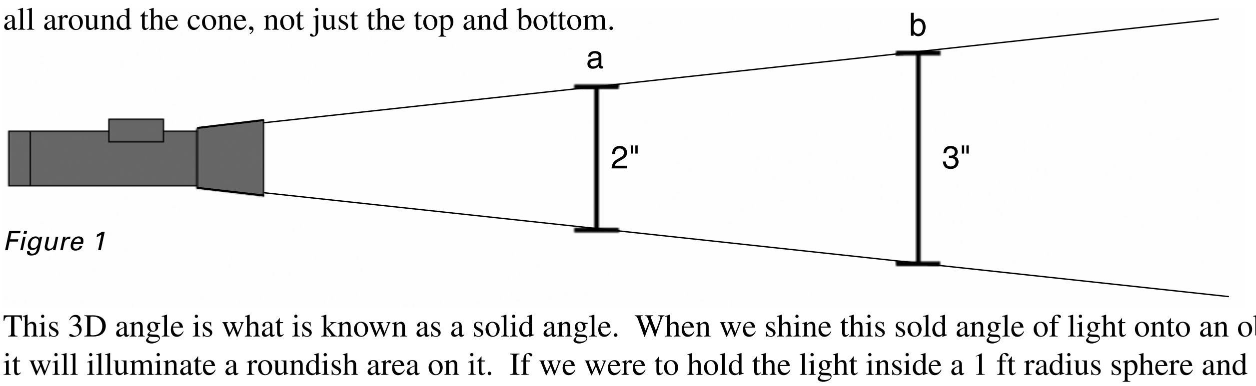


Figure 1

This 3D angle is what is known as a solid angle. When we shine this sold angle of light onto an object, it will illuminate a roundish area on it. If we were to hold the light inside a 1 ft radius sphere and light up a 1 ft² area while the light is originating from the center of the sphere, then we could say that we are shining a unit solid angle (in SI units: 1 Steradian).

The amount of light energy that is being emitted inside that unit solid angle is measured in a unit called "lumens". An increase in energy will mean an increase in lumens and we will see this as a brighter light. Alternatively, leaving the lumen output constant and enlarging the sphere will decrease the brightness of any 1 ft² relative to what it was at the smaller size.

To find the reasons for this, let's leave the sphere and return to the flashlight in Figure 1. Line segments *a* and *b* signify two planes onto which the beam of light might shine. At *a*, the diameter of the beam is 2 inches, and at *b*, the diameter is 3 inches. Figure 2 shows how this minor increase in diameter will more than double the surface area that the beam covers. The same number of lumens in *a* will be essentially spread out more thinly on a larger area in *b*. As you might suspect, the brightness of each square inch at *b* will be reduced because of this.

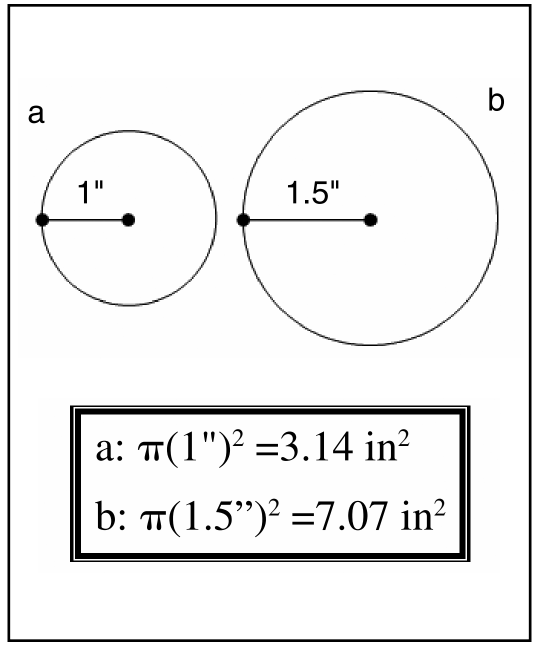


Figure 2

Another way to look at this is to leave line *a* at 2 inches high and move it towards *b*. It would grow dimmer to match *b's* brightness as it approached *b's* position. This is so because as *a* moves away from the light, each 1 in² occupies less and less of the total area of the beam and so uses fewer and fewer of the available lumens. Moving the line back towards the light will cause it to regain its brightness.

The careful reader will now recall that the original question was whether or not moving the projector closer to the screen will increase the brightness and it would seem that we have just confirmed that it will. At last, however, we come to the important difference that separates a projector and a flashlight.

To compensate for changes in distance between projector and screen, the projector is designed to alter the size of the beam it emits and focus the same number of lumens into a wider or narrower solid angle. This can allow an identical number of lumens to fall on a 1 ft² area from a distance of 1 ft as on 1 ft² from 10 ft. It is still possible for the projector to act more like a flashlight and give a brighter image at a shorter distance, but only if the image is allowed to decrease in size along with the distance.

As soon as the lens is adjusted and the image returns to its original size, it will be almost exactly as bright as it was before. All other things being equal, the important factor for overall brightness, in other words, is the size of the image on the screen.

Myth 2: Light sources between the projector and screen will directly interfere with the projected light.

Instead of light, think of the projector as sending out a jet of water in roughly the same conical shape as the beam of light it actually does emit. For the sake of the analogy, imagine that the water pressure is sufficient that the water reaches a screen several feet away without succumbing to gravity. Between the projector and the screen, add in some light fixtures which will act like waterfalls, each dumping a dense volume of water directly through the projector's stream.

Needless to say, the projector would have to send water out with enough force to penetrate the waterfalls or else there would be little more than a fine mist reaching the screen. If we went further and added colored dye to the projector to simulate the different colored wavelengths in the light beam, there would surely be some dye lost amid the falling water on its way to the screen. Does a real projector need to be bright enough to pierce through the lights in the room? Does mixing the projected light with the other lights dilute the color saturation of the image?

Well, not really. Ambient light absolutely can compete with the projected light in ways that could suggest that the kind of interference described above is occurring. This does not, however, take place when the streams are crossed.

The color dilution question should be easy enough to demonstrate by using two flashlights, a colored filter and a dark room. By shining one light through the filter, note the color of the light where it hits a solid surface (a screen, perhaps). With the second flashlight, intercept the red beam at an angle near perpendicular so that the second light is not falling in the same place as the red light (the wall will suffice). So arranged, these lights should effectively show that whether the white light is on or off it will have little bearing on the color of the red beam.

Admittedly, it is possible for there to be some desaturation of the colored beam in this experiment but this leads us back to the acknowledgement that ambient light does have an impact. The important distinction here is that the impact is *indirect*. When the white light shines through the red light, both beams continue on without direct interaction. However, the white light will eventually reach a solid object and when it does, some of that light will be absorbed, reflected and diffused. The light that is not absorbed will travel away from the object and some of it could possibly fall on the same area onto which the red beam is shining. When that happens, the white light is essentially added to the red light and what reaches your eyes is a combination of these, giving the appearance of a somewhat diluted red light.

This is the real justification for wanting to control ambient light. The issue is not that it blocks or washes out the light from the projector directly but that it finds its way onto the screen. Keeping these additional lights under control is, therefore, important and the source of another myth.

Myth 3: A completely light-controlled environment is a completely darkened environment.

It is generally the case that an illuminated display will look better in the absence of competing sources of illumination. As mentioned in the previous section, any light that falls on the screen and makes its way back to the eyes of a viewer will degrade the image to some extent.

The safest thing to do, therefore, would be to avoid this possibility by eliminating all light sources other than the projector. This does not actually eliminate the issue and, of course, there are situations where doing this is simply not practical. Some light may be needed for safety or note taking or simply to be able to see who is speaking in a lecture hall or meeting room.

Fortunately, it is possible to leave these lights on and still maintain a light-controlled environment. The key here is to keep the light from shining on the screen directly and to keep the intensity of the light low enough that very little is shining on the screen indirectly.

Restricting direct light simply means ensuring that whatever light sources are lit inside the room do not send rays at the screen. This can generally be accomplished by covering the windows and by not installing lights close to the front of the screen. Placing them several feet away from the screen, to the sides or, when possible, even behind the screen may be perfectly acceptable. The goal here is to keep the screen surface dark when the projector is off.

The indirect light is a bit trickier to control and, frankly, it is virtually impossible to stop it entirely. There is, after all, a large screen bouncing light from a projector back towards the audience and that light will continue to bounce off of other objects in the room. Again, we don't need to stop it; we just need to control it. In most cases, dark colored walls and surfaces that are not reflective or glossy will help minimize these secondary reflections. Installing a dimmer for the room lights to keep them relatively low while the projector is in use is also very effective.

As far as the screen itself is concerned, adding contrast will work to negate some of ambient light's effects. The darker surface material will appear blacker than a pure white screen will in environments where some additional light is reaching the screen. Another approach is to use retro-reflective materials for their ability to reflect light back towards the source of illumination. When those sources are the walls or table tops, the majority of the light those objects reflect will be returned to them and not to the audience.

So long as the majority of the light the audience sees is coming from the projector and it is possible to allow only a minimal amount to come from other sources, we can say that the ambient light is controlled.

We can also say that one more AV myth has fallen.

-- Adam Teevan

Angles of Reflection VOLUME III – 2010

ANGLES OF REFLECTION

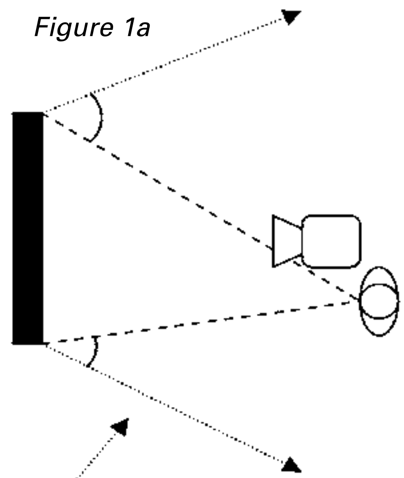
January, 2010 ©Da-Lite Screen Company Volume 3 Issue 1

If you have been around projected displays for very long, you have probably at least heard of the possibility that one area of a screen might be visibly brighter than the rest of it. That brighter area is a "hot spot" and while it is usually fairly easy to detect, it is not always so easy to predict. There are some very useful guidelines that will help in assessing the risk of a hot spot appearing but only if they are properly understood and applied. What does it take to determine if the audience will see a:

Hot Spot or Not?

As you may suspect, the answer to this question is going to involve looking at a gain chart and measuring some angles. We have talked about half gain angles on several occasions before and how important they are for brightness perception so it stands to reason that they will be involved as well. In addition to these points, I would like to focus on two important components of uniformity issues that have received a little less exposure: bend angles and reflectivity.

Figure 1a



Bend angles, in this context, are simply the angles between a single ray of light and a corresponding line between the viewer's eye and the origin of that ray. The rays we are interested in do not originate at the projector, as might be expected, but rather at each point on the screen where a projected ray is reflected.

Figure 1's top down views illustrate these elements, here selecting two points on the edges of the screens visible to the viewer where two rays are reflected and thus showing two bend angles for each. The dashed lines represent the path from those points to the viewer's eyes and the dotted lines are the rays of light reflected by the screen at those points. Please note that, in the interest of keeping the illustrations free from extraneous information, the lines showing the projected rays are not included.

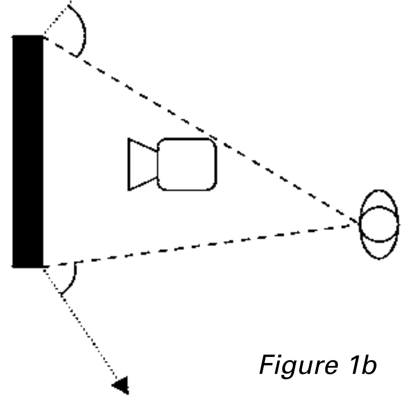


Figure 1b

Of course, a real display will have nearly infinite angles and the lines will be drawn through space in three dimensions instead of only two. The corner opposite the viewer will usually represent the widest angle in reality but for the purpose of demonstration, we can assume that the edges at the horizontal level of the viewer's eyes will be the maximum.

Now that we have this picture of bend angles in mind, let's look at what they mean in practical terms, specifically, as they relate to gain measurements.

When we measure gain, we typically aim the light source directly at the center of the screen and do the same with the light meter. The essential reason for this is not because the center of the screen is special or that other considerations necessarily need to be made based on the center of the screen. Rather, it is to control as many variables as possible thus simplifying the measuring process.

When the light is directly in front of the center of the screen, the rays that are incident to the screen's center will measure 0° perpendicular to the surface and the reflections will be the same. This means that by keeping the light source stationary and the meter trained on the screen center while moving it in 5° increments in an arc around the center, we can be as sure as possible that each measurement is taken at the intended bend angle. If we put the light somewhere else and aimed the meter at a point other than the center, we would need to do a few extra calculations to determine at what angle the gain is being read. It would, however, be possible to measure this way.

Incidentally, this is a handy lesson in why bend angles are so important. That gain chart showing the relative brightness of the screen from all of those different angles is going to tell you roughly how bright the screen will appear at any point, not just the center we usually measure, so long as the bend angle can be determined for those points.

In almost all cases, the brightest area of the screen is going to be at 0° from which point the brightness will descend at some rate as the angles increase. The more rapidly the gain falls the more likely it is that a hot spot will be visible. The general rule states that the hot spot is most likely to appear inside the half gain angles, that is, the angles where the gain drops to half of what it was at the highest point.

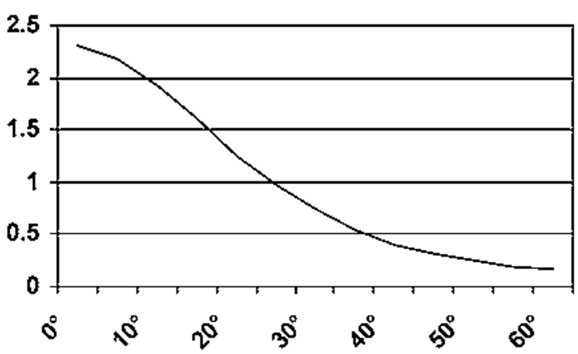


Figure 2

What does it mean to be "inside the half gain angles", exactly? The angles we are interested in are, naturally, the bend angles. In order to find them, we need to take the location of each viewer into account relative to the surface of the screen and we also need to know where the projector is positioned. Assuming a projector mounted directly in front of the very topmost edge of the screen and a viewer seated in front of the bottom edge at the center, let's look at what we might expect that viewer to see.

First, we need to know the smallest angle visible to him relative to the projector. This will be the one ray that goes from the projector to the screen and directly into the eye of the viewer, giving us a 0° bend angle. From some seating positions, this ray will not be visible but for this particular example, we can be fairly sure that the ray being reflected at about the center of the screen will give us the bend angle we're looking for. The angle of incidence at that spot will, as always, be equal and opposite to the angle of reflection. Given that the projector and the viewer are on opposite edges of the screen, the angle from the projector to the screen's center will match the angle from the center to the viewer's eyes.

If the smallest angle is where the reflected ray and the viewer's sightlines converge, the largest angles will be where the ray and the sightline are most divergent. Generally speaking, these will be the points located at the corners of the screen. Different projector and viewer positions will yield somewhat different solutions than this, but again, this example will have the largest bend angles at the corners. Without entering into the specific trigonometry involved, let's say that the bend angles at the corners will be a fairly reasonable 40°.

When the largest and smallest bend angles are known, we can turn to the gain chart for the intended screen, such as the one in *Figure 2*. The smallest angle in our example was 0° which means that our peak gain is 2.30, according to the chart. The largest angle might be somewhere in the 40° area. This gives us the lowest gain of 0.41. Since the lowest gain is less than half of the peak gain, the chances of there being a hot spot are quite good.

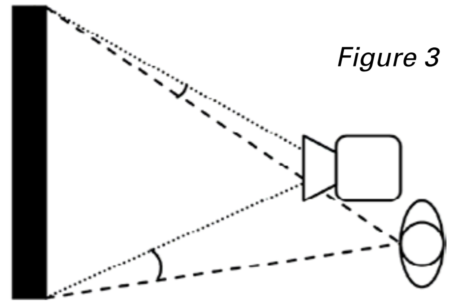


Figure 3

This is not a guarantee, however. It is possible to use a dimmer projector in order to minimize the visibility of a hot spot in situations where one is likely to occur. Occasionally, someone may attempt to specify a bright projector with a high gain screen in hopes of creating a singularly bright display. The result is usually a blinding hot spot that can be alleviated by simply reducing the light output of the projector.

Another option is to increase the throw distance of the projector. Compare the arrangements in *Figure 1a* and *Figure 1b* to see how moving the projector closer to the screen can increase the maximum bend angles while setting it farther back will reduce them. If we used a long throw lens to turn the 40° bend angles at the corners of the screen in our previous example to less than 25°, the resulting minimum gain might not drop below half of the peak. In this case, a hot spot might be avoided without making any other changes to the system.

A further alternative is to use screen materials that reflect light a little differently. This brings us to the second important yet often overlooked component of uniformity issues: reflectivity. Retro reflective materials reflect light primarily back towards the source instead of at an angle away from it. *Figure 3* uses a similar arrangement of projector, screen and viewer as *Figure 1a* but introduces a retro reflective surface. As you can see, the bend angles become notably more acute as the rays trace back towards the lens instead of away from it.

In other words, the bend angles at even the corners of the screen will not be nearly as wide as with the screen in the previous example because the reflected rays will not be nearly as divergent from the sightlines of the viewer.

With these relatively narrow angles we can safely increase the gain of the screen quite a bit without introducing the same uniformity issues that would make an angular-reflective screen hot spot unrepentantly. As you might suspect, this is exactly what we do.

Figure 4 is a 3D representation of a gain chart for a retro reflective surface with a 2.8 gain. The chart is presented in this fashion to accentuate the point that the bend angles apply in all directions and not just the two dimensions often illustrated.

As you may gather from the mountainous curve, the half angle on this screen is relatively narrow and again, with an angular-reflective screen, this would mean the same hot spot likelihood as in *Figure 2*.

Because it is retro reflective, however, acceptable levels of brightness uniformity can be observed from a variety of seating positions, especially those that are as close to the projector as possible, thanks to the relatively small bend angles afforded by its reflective properties.

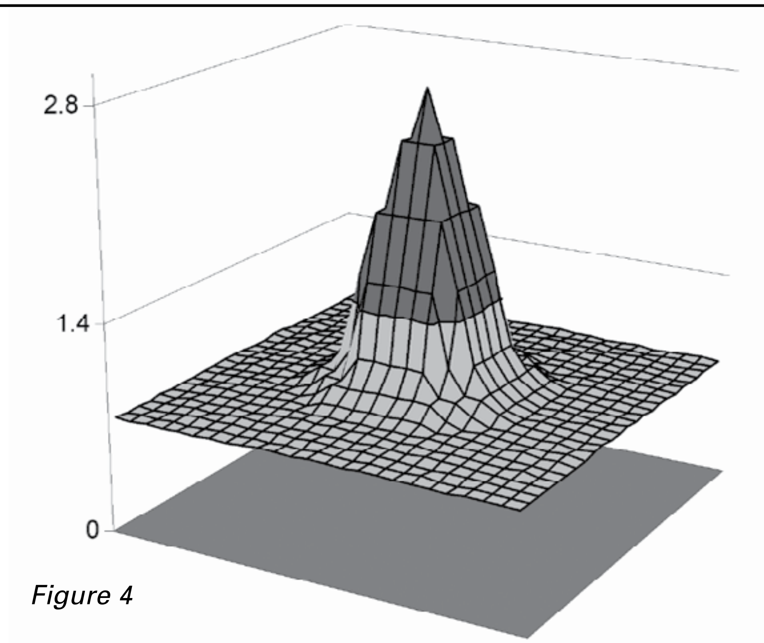


Figure 4

A gain chart for this screen is, therefore, somewhat misleading. It is not inaccurate and does not somehow result from faulty measuring techniques but it is important to understand that the chart is meant to be used with bend angles and not simply the angle between the viewer and the center or edges of the screen. Furthermore, bend angles will be calculated differently for retro reflective screens because the light is reflected differently. Instead of the angle of reflection being equal and opposite to the angle of incidence, both angles will be exactly the same.

As an aside, it is possible to see a hot spot on a retro reflective screen even despite the considerable improvement in brightness uniformity that it allows. Granted, the absolute worst seating positions are somewhat impractical for normal viewing and the shadow cast by the viewer's head will eclipse the bright center of the hot spot anyway. More subtle uniformity differences may be seen from otherwise reasonable seats, however, so it is wise to remember that the same rules apply as before with the maximum and minimum simultaneously visible bend angles determining the peak and lowest gain for each viewer.

The surest ways to avoid hot spots, in general, are to position the projector as far back from the screen as possible, to use a projector that is not too bright for its intended use and to use a material whose gain does not drop off too quickly or is retro reflective. A somewhat more detailed model may be derived by more sophisticated methods utilizing some fairly tedious calculations. Be sure to visit www.da-lite.com in the future for some computer aided illustrations of what these calculations can do.

-- Adam Teevan

ANGLES OF REFLECTION

February, 2010 ©Da-Lite Screen Company Volume 3 Issue 2

Of all the astonishing developments made in the field of 3D display technology in recent years, there is perhaps no single aspect quite as unexpected as the backlash against it. For every article or comment in praise of the technology, there seem to be two more in which the only enthusiasm to be found is for its anticipated failure. In response to this malaise, I have split the most frequently heard complaints into three categories, each beginning with the letter "D". By identifying and responding to these, I hope we can spread realistic optimism and stand…

Against the Three D's

1. Disinterest

Anyone who believes that 3D is a fad, especially one who recounts the cyclical nature of the technology's previous lives, can probably be said to be disinterested. They may have seen a few 3D movies in the past but can hardly be bothered to give it another try.

I suspect that a good portion of this group is comprised of those for whom the term "3D" still carries some synaptic link to "blue and red cardboard glasses". If this is the case, then I absolutely can empathize with the yawning indifference they draw upon to greet the idea now. Fortunately, this is the simplest issue to address since, barring a few exceptions, what we're using for stereoscopy today has absolutely nothing to do with colored lenses.

The three primary methods for creating moving 3D images are referred to as active, passive and autostereoscopic. They all accomplish the same task. That is, they all display two distinct images simultaneously (or nearly simultaneously) to both eyes individually so as to create the illusion of three dimensional space. Their methods for doing this, however, are quite different.

Active 3D systems use shuttered glasses, synchronized to open and close the right and left lenses in time with the display which alternates between showing right eye and left eye frames sequentially. This approach has the benefit of considerable flexibility in the kinds of devices that can employ it. Computer

Stereoscopy

At its root, stereoscopy is about seeing with two eyes. Because our eyes are spaced a few centimeters apart from one another, they both have a slightly different point of view into the world. By taking advantage of these different viewpoints, the brain is able to judge depth.

2D images usually represent a monocular view. While they do contain some clues as to the depth of what they depict, the lack of a second perspective makes it impossible for the viewer to derive the same caliber of 3D information from them.

To produce the illusion of 3D, the content needs to present both of the viewer's eyes with a slightly different image, corresponding to their different points of view. The trick is to produce both images at virtually the same time for both eyes while making sure that the right eye only sees what is intended for it and the left eye does the same.

monitors, televisions and projectors capable of showing at least twice as many frames per second as would be necessary for 2D will, theoretically, be compatible.

That same flexibility also carries over into the kind of projection screens that would be appropriate for use. In essence, whatever would be good for a 2D system will work for active 3D as well. Whether the installation is for a classroom, home theater or boardroom, this method of projection does not necessitate the application of different or special rules for screen selection.

Passive 3D is so named for its use of inert filters to keep the left eye and right eye images separate. These can be either polarizing filters designed to pass light based on the orientation of its oscillation or color filters which allow only certain wavelengths of light to pass through. This article will assume the use of polarizing filters, as the use of color filters is not at all recommended for good displays.

There are actually two sets of lenses in a passive system: the first are in front of the projector lens (or lenses if using two projectors) and the second are the ones in the glasses worn by the viewers. Compared to active glasses, the cost of passive glasses is sufficiently low to justify their use, with even large audiences. The typical commercial theater showing the most recent 3D films is almost assuredly using this technique.

There are some special considerations that need to be made in choosing the projection screen; arguably, the third lens in a passive system. Just as it is important to use good filters to polarize the light from the projector and good filters to only allow one orientation of light to enter the viewer's eyes through the glasses, it is critical that the screen onto which all of this is being projected maintain that polarization.

A traditional projection screen is designed to scatter light with fairly high efficiency in order to meet the needs of the traditional projection environment. When polarized light is involved, the priorities change somewhat, making it necessary to emphasize the reflectivity of the screen rather than its dispersion abilities. This is why silver screens have often been used in 3D projection in the past and why we developed 3D Virtual Black and 3D Virtual Grey as more sophisticated alternatives.

Autostereoscopic displays are those that achieve the differentiation of right and left eye images without requiring the viewer to wear special glasses. This should not be construed to mean that there are no special lenses or optics at work in this solution, only that these are a part of the display itself; usually in the form of a lenticular lens.

Arguably, autostereoscopy represents the ultimate goal of three dimensional imaging: it creates the necessary illusion without requiring the audience to wear additional equipment. The current incarnations of the technology are limited by their number of "zones" from which the viewer is able to see a 3D picture. Based on what we've seen so far, some unforeseen breakthrough in the technology is likely necessary to raise this method from promising to practical for many applications.

In other words, to categorize 3D as doomed to fail because of some notion of its unending cycle of death and rebirth is to fail to recognize that forward progress is being made in the technology itself. This is not merely a reincarnation of its predecessor and it can, therefore, not be expected to share its fate.

2. Distrust

These individuals might see the appeal of the technology but simply do not trust it to continue along its present course. They look at 3D as another format war, with active, passive and autostereoscopic gear offering different paths towards the same end and worry that they'll adopt the wrong one. They might even doubt that there will ever be enough content to make the hardware investment pay off. Like the disinterested consumer, they also fear that this will all wind up being just another fad.

Fortunately, what the different 3D technologies provide is diverse enough to allow them to coexist without any of them necessarily being abandoned by the industry. After all, the television and the projector are both still in heavy circulation, even after decades of rivalry. What separates those devices is, to some extent, analogous to what separates these 3D techniques.

For large-scale presentations to large audiences, there is currently no solution more cost-effective and efficient than two piece projection. When 3D is involved, the use of polarized filters and a screen capable of maintaining that polarization are absolutely recommended. In cases where a much smaller audience is involved or a direct view device is required, an active system can be the best choice. There is ample room for both approaches to thrive.

Autostereoscopy is, in its current form, most likely to compete directly with active 3D rather than passive, so long as passive projection systems remain the mainstay of large venues. Given that it is universally unwise to make specific, long-term predictions about any technology, I will make no further claim on this subject greater than this: the methods of recording and transmitting 3D images will likely be sufficiently robust as to allow for either technology, be it natively or through signal processing.

This leaves the question of whether or not there will be enough content to make a 3D-capable system worth the investment. Judging by the faith indicated by the investments being made to drive the technology forward, there is little reason to believe that the creation of new content is soon to cease. Both the film and television industry are making a concerted effort to capitalize on the technology and, more importantly, they appear to be succeeding. Even if no other factor is considered, the revenue that 3D has the ability to generate is a hopeful sign that it will continue as a form of entertainment for some time. There are other factors, of course, which will follow in the final section.

3. Dissatisfaction

This group hates wearing 3D glasses of any kind, dismisses the state of the art and believes that the effects are mere distractions. In short, they condemn the technology as pointless and uncomfortable.

Much of this attitude seems to result from what ultimately amounts to a branding issue. The problem, as I see it, is that a cursory look through the technology's history can easily reveal it to be the stuff of trifling bemusement. It has regularly been presented as a diversion for people in unusual glasses who reflexively throw their popcorn into the air as clawed hands reach into the theater. With such a limited and, to be honest, damaging perception, it can be difficult to envision it as having any weightier applications.

It should come as some relief, then, that there are an abundance of instances where 3D not only enhances the experience of the participant but also offers important contributions that would be virtually impossible to attain otherwise. The use of the word "participant" rather than "viewer" is intentional as the most compelling arguments in favor of 3D are those cases where some manner of interaction is involved.

Any field that has traditionally used numerous 2D “slices” as a means to peek inside solid matter stands to benefit from 3D equipment. Be they geologists, doctors or engineers, what can be gathered from a cohesive model in three dimensions instead of various flat samples is considerable. For students in these fields, being able to visualize the subject as it is rather than how it must awkwardly be represented would be similar to having the ability to read texts in their original languages without resorting to translations.

Training simulations of any kind, particularly those in military and aeronautics, are able to take an important step forward when the hypothetical situations they present mimic the physical world even more closely.

This is to say nothing of the legitimate uses for the technology that the entertainment industry is already implementing. That mental image of the monstrous appendage bursting into the theater is largely an artifact of outmoded attitudes towards how the technology is best used to entertain. The role of 3D has been given almost entirely over to extending the scenes outward behind the plane of the screen rather than in front of it. This tends to yield an improved experience, not only because it puts a stop to the gimmicks that many dislike, but also because it is actually more comfortable for the viewer. Because the sightlines of both eyes are able to converge in a more relaxed state when looking at distant objects, allowing the scene to extend beyond the screen puts less strain on the eyes.

Extending the scene in sports programming offers an appreciable improvement over traditional broadcasts, though depth perception in this sphere is perhaps something many people have not specifically regretted missing out on. Regardless, it is an excellent convergence of the benefits of watching televised sports (the camera is always close to the action) and the sense of being present at the event. The effect of being able to actually look down the field through the screen is both subtle and impactful. It must not be dismissed as an empty gimmick without a fair trial.

Interactive entertainment, specifically video games, gained quite a bit when they migrated from being based primarily on two dimensional assets to 3D models. So long as the images are rendered on a flat surface, however, they also lost something rather important in that it became much more difficult to judge distances as a result. Allowing that lost information to be recovered in a stereoscopic 3D display provides not only the aesthetic improvements of the other applications but, as in the training simulators, can actually be a contributing factor in the difference between success and failure.

In the end, the success or failure of 3D itself is largely dependant on the attitudes of the people using, selling and creating the content and equipment. If all they see are the Three D’s, then we may as well give up now and save ourselves the trouble of giving up later. But if we can see beyond those concerns into what 3D really has to offer, there is no reason to feel anything less than a sense of interest, trust and satisfaction.

-- Adam Teevan

ANGLES OF REFLECTION

May, 2010 ©Da-Lite Screen Company Volume 3 Issue 3

Contrast is listed in the specifications for virtually every kind of modern display device, touted with remarkable frequency in their advertisements and is even included as an adjustable feature in most display's settings. It is obviously an important factor in the performance of the equipment but how does it contribute to the overall quality of the system? Does the fact that it is a ratio instead of an absolute value imply that it is governed by variable or relative forces? Though potentially daunting at first, we would be utterly lost without it and so I say…

Vive la Contrast

Universal Fundamentals

By looking up into the sky on a moonless night from a vantage point far from city lights, one may be compelled to marvel at the incalculable number of stars which appear to envelop our humble Earth. One may, perhaps, even comment on how many more stars there are when seen from such a place, forgetting for a moment that the stars are always there, burning with roughly the same intensity, regardless of a viewer's location or whether it is night or day. The crucial difference is that our hypothetical star-gazing spot is underneath a sky so dark that even dim points of light are visible. At other times and from other locations, the stars would be lost among the competing sources which illuminate the atmosphere.

This relationship between light and dark which permits us to glimpse the enormity and splendor of the universe also, though perhaps not as impressively, makes it possible to read the words in this document. The dark letters surrounded by the significantly lighter paper or screen creates good contrast, which allows for effortless differentiation between the shape of the text and the medium on which it appears. Should we attempt to use white text on a light gray background or black text on dark gray, we would diminish the contrast, causing the text to all but disappear into the surrounding space. *Figure 1* illustrates this point.

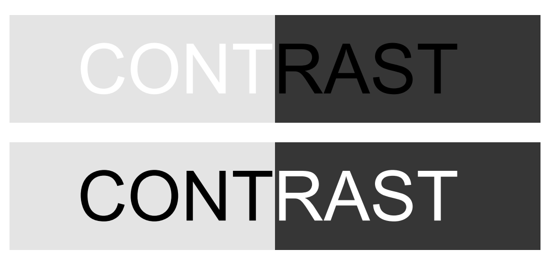


***Figure 1**: The word "CONTRAST" appears in both the top and bottom boxes but will be easier to read in the box where the text and the surrounding space are not similar shades.*

The fact that the difference between light and dark allows objects to clearly appear distinct from one another is, essentially, why contrast is so important. It is a critical aspect of vision in total, beyond the fairly simple contexts already mentioned and, naturally, that includes displays of all kinds.

Ratio and Relativity

For displays, we often talk about contrast as a ratio between the brightest and darkest elements the display is capable of representing, ideally, at the same time. Expressed as a figure such as 2,000:1, (read: *two thousand to one*) the ratio indicates how many times brighter the brightest area of the picture will be compared to the darkest area. Brightness, in this context, refers to the measure of light energy taken in lumens, nits, foot lamberts, or other appropriate units for luminance or illuminance. The darkest area, often called the black level, is also measured by one of the same units of brightness, with the ultimate goal being to have the reading be as close to zero as possible.

As with any ratio, adjusting the lower quantity has a more dramatic effect overall than a similar adjustment to the larger one. Assuming a display that is able to produce 20 units of brightness at its peak and .01 at its darkest, we can divide the high value by the low and find a ratio of 2000:1, as in *Figure 2*. If we were to increase the brightness by 0.005 units and make no change to the black level, we would need to round up even to make the ratio increase to 2001:1. If we lower the level of black by the same amount, however, the ratio leaps to 4000:1.

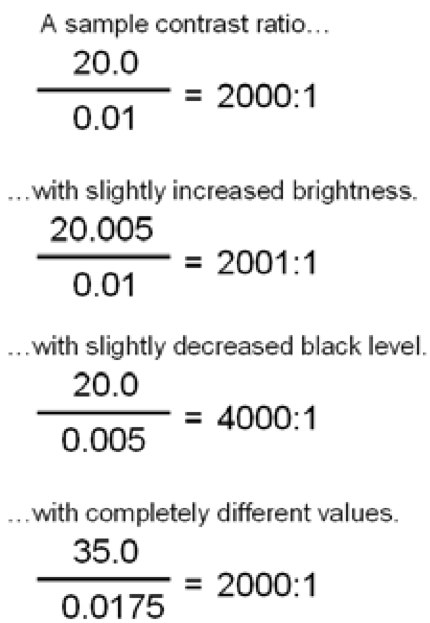


Figure 2: How contrast is affected by various readings for white and black

Clearly, black level is a vitally important factor for good contrast. However, it is not always necessary to demand that it approach zero. As the final example in *Figure 2* shows, an increased black level can actually leave the overall ratio unchanged, so long as the peak white value increases at an appropriate rate. In other words, the relatively flexible ratio is generally more important than the exact measurements taken for white and black as far as establishing good contrast is concerned.

To illustrate the reason for this, consider a time when you have needed to pause for a moment to let your eyes adjust to an environment either suddenly brighter or darker than before. You may have also stopped to consider that what we commonly define as “bright” and “dark” are more about relative comparisons than fixed definitions. What can be blindingly bright in one context may seem dim to the point of being dark in another, thanks to the human eye’s ability to adjust to accommodate a variety of different light levels.

As a result, brightly lit environments often require a higher peak level in a display which would be overpowered otherwise. Should the black level climb upwards at an appropriate rate relative to the brightness as a result, there is no reason to automatically assume that the picture will suffer. It could be possible to note a black level increase with a meter but to a sensory organ as variable as the human eye, it may be that no change is noticed.

In no way does this mean that the ratio is the only thing that matters or that the absolute measures of black and white never make an appreciable difference. Before we look at why this is, we should investigate how white and black are actually created in a display. This topic can and has filled far more than the few pages here, so this investigation will be brief and topical.

Level Absolutes

Most current illuminated displays will contain either a light source which emits white light or some number of red, green and blue sources. The light from these is then filtered, blocked, redirected, combined or otherwise altered in order to create every permutation of hue, saturation and brightness the particular technology will allow.

The creation of white is a matter of either combining or transmitting virtually unaltered the light from the source(s) so that the light leaving the display is what we would call white. Many factors combine to determine the efficiency with which this is carried out and so “white” may, realistically, arrive in different intensities and colors.

Black is created by preventing light from leaving the display. This is accomplished in various ways with varying degrees of success across many platforms but the fundamental requirement for black is always the absence of light reaching the viewer. It is important to note that some devices are not as capable of stopping light compared to others, resulting in black levels that range from excellent to poor depending on the amount of light that unintentionally “leaks” out.

The contrast ratio allows us to compare equipment by their relative ability to block and pass light to the viewer without needing to be concerned with exactly how bright or how dark those limits are. Since it is often necessary to adjust the intensity of light from a display depending on the environment, it is logical to speak in these relative terms.

However, almost no display in use today relies on a simple binary of black and white and there is no reason to expect all content to be similarly limited. While it is true that the overall ratio depends on the minimum and maximum brightness levels measured, there is endless content which will include tremendous amounts of visual data which will fall somewhere in the millions of places between pure white and pitch black.

As a result, the maximum brightness the system can provide may not always be utilized. In cases where the system is producing very dim images or the brightest areas occupy a minimal portion of the screen, the viewers’ eyes will adjust to the lower light level. In turn, the relative threshold of what is perceived as black will change and any failure in the absolute black level can become alarmingly apparent.

Making it Work

While bright environments and bright displays can make it easier to forgive inefficient black levels, they also nearly always raise the level of black further by spilling ambient light where no light should be.

Just as the contrast ratio can be improved by even a slight decrease in black level, the ratio can be injured by a small increase and perfectly devastated by a large one. A screen is said to be “washed out” when the black level has reached a point where it is too bright to be seen as black. The white text on a gray background in *Figure 1* is a good example of how a thoroughly washed out screen may appear.

Although it would be theoretically possible to increase the brightness of the display in order to outshine the ambience and maintain a decent ratio, there is an upper limit to this approach. At some point the brightness would become unreasonable or even dangerous to produce or view.

When absolute brightness can no longer reasonably increase, the remaining option for improving contrast would be to lower the black level. This can be achieved by either controlling the problematic ambient light directly or through the use of a display that is able to do so indirectly.

For its part, a projection screen has the ability to contribute to improving contrast in two ways. The first is by using increased gain. This not only makes the display appear brighter but also has the potential to redirect a portion of ambient light. Any light that is directed away from the viewers will have its detrimental impact on black levels reduced accordingly. The second option is to use a gray material instead of pure white to absorb some of the ambient light and bring the blacks down to a more acceptable level.

A gray screen can also be useful in a darkened environment when paired with a projector that is overly bright, "leaking" light or is in some way washing out what should be black. Such a screen can help alleviate the problem of poor black levels, particularly in images that do not have the needed peak brightness to keep the viewers from noticing how light the black actually is.

For similar reasons, it is a good idea to keep a little bit of controlled light on in the viewing environment rather than committing to complete darkness. This way, even if the image is dark, the light in the room will set a limit to how much the viewers' eyes will naturally adjust, making it easer to keep black relatively dark.

The idea of light helping make black appear darker may seem counterintuitive in the context of projection screens where ambient light is so often seen as its undeniable enemy. Even the visibility of the night sky can be threatened by no more than a streetlight, after all. So long as the radiance from these "bias lights" are neither falling on the screen nor shining into the viewers' eyes directly, the benefits to the perceived black level will outpace the theoretical detriment they would pose.

There is much more to say about bias lighting beyond their contribution to contrast and, unfortunately, beyond the scope of this article. For our current purposes, they, along with the specifics of the display and the viewing environment they occupy all contribute to keeping blacks dark and whites bright. This difference is, after all, crucial to stellar viewing.

-- Adam Teevan

ANGLES OF REFLECTION

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Once characterized by beeping soundtracks, blocky graphics and simplistic interfaces, video games have grown to include multi-channel audio, high-definition visuals and increasingly sophisticated controls. The medium is vast and varied, representing numerous genres and concepts that can provide experiences wholly impossible to find elsewhere. The industry today is booming and in real need of people who understand what it is and what it needs.

Designing for Video Games

What Are Video Games?

As a medium for entertainment, "video game" is an enormously broad label. Asking if someone plays video games is fundamentally identical to asking if that person watches movies. On average, there is a decent chance that the answer to either question will be some version of "yes" but the amount of specific, valuable information gained from the answer will be, on average, virtually zero.

Even by restricting our definition to only include games that are played on a console or computer (see sidebar for brief descriptions of both and others), we are hardly narrowing the field. The use of the word *game* itself is somewhat restrictive as it implies that fun is the main goal. Not all video games are intended to be fun any more than all movies are intended to be serious. Neither media can be reduced to a singular concept; rather, they provide a way to experience virtually anything.

Video games can be a method for telling a story, a way to make music and even act as an exercise machine. Some games are ambitiously realistic, while others strive to be more cinematic, cartoony or artistic and everything in between. Even games that, on the surface, are quite similar in many respects can still be wildly different in their complexity, methods of interaction and countless other particulars.

Game Hardware Varieties

Computer – Generally employ a mouse and keyboard for input; a flat surface for both is recommended. Although output has traditionally gone to the computer's monitor and attached speakers, integrating with a capable AV system offers a simple enhancement to the experience.

Console – Proprietary systems originally designed for play on the family television, though contemporary output options are fairly robust. Input is most often performed through a handheld controller, though alternative approaches are many and under continuous development.

Others

Arcade – A self-contained game and AV system created for public use. They can take many forms but are almost all alike in that their games are designed to be played for shorter amounts of time than most console or computer games.

Handheld – Essentially a miniaturized console with an integrated display and loudspeakers. Some are capable of communicating with computers and consoles and of outputting to an external display device.

In short, video games cannot collectively be thought of as a single product created for a single audience, requiring a single approach for proper integration. It would be incorrect to assume that all games will be played while seated or while standing; while alone or in a group or with the lights on or off. There is no perfect and infinitely applicable solution to any design challenge, of course, but the variables involved with video games are exceptionally many.

What do they need?

Basically, they need a way to see and hear what is going on in the game and, obviously, a place to play. Quite often, the AV tasks are still being performed by workstation monitors and standard definition televisions. Even so, it would be rare to find anyone oblivious to the appeal of a bigger screen and a more powerful sound system. As far as accurate components and proper calibrations are concerned, some work is still needed to elevate these matters in perceived importance.

As for the room, it is rare to see one dedicated solely to the purpose of playing video games but there are still a few precepts which can lead to an environment more conducive to the activity.

Room Design

The archetypal home theater benefits greatly from the existence of the commercial cinema in that the latter serves as an obvious model on which to base the design of the former. The average home theater user is likely already familiar with the model and would, therefore, have some notion of what to expect from it as a part of the home.

Without an analogous relationship to a larger venue for video games, it can be difficult for users and designers to know exactly what form their rooms should take. It may be tempting to envision a *home arcade* which mimics the midway-style of the typical video game arcade on a smaller scale. While this could strongly appeal to a certain niche, it would utterly fail to provide the average user with a system that takes full advantage of the console and computer games that are in far broader circulation.

A very logical starting point for the design of such a room is, actually, some multi-purpose version of the home theater. There is a reasonable amount of overlap in their intended uses – one or more people in a room and experiencing content via a display and loudspeakers – but they are not identical in every way. Games, after all, are played actively rather than watched passively, so their controls take on a significantly more important role than the control system in a theater.

At one time it was fairly safe to assume that a game would be manipulated by a mouse and keyboard or via a standard handheld controller of some kind but this is no longer the case. Those methods still exist and are often used but they have been joined by such as guitars, wands, skateboards, and even the player's entire body. With so many possible ways for players to interact, it is critical that the video game room be flexible enough to allow for players to sit, stand or move around freely.

While seated, it is advisable to give at least four seats to those in the front row or its equivalent. Rarely will a game support more than four simultaneous players sharing the same display and, as with any other type of game, few people want to play from the second row.

Housing the Hardware – New and Old

Just like any technology, the obsolescence of video game hardware is absolutely inevitable. Console generations last some variable number of years, generally five or more, after which completely new hardware is released. Computers, on the other hand, may be upgraded in stages by replacing individual components over the life of the machine instead of starting over with an entirely new system.

Outdated hardware becomes obsolete in that it ceases to be a platform for new software but its complete disappearance from use is rather unlikely. Old systems have a way of maintaining some relevance among players long after they have been abandoned by developers and manufacturers. This is especially true among many of the most serious hobbyists who treat their aged collections with the same respect that music enthusiasts might reserve for their analog recordings and tube amplifiers.

It would be wise, then, to approach designs meant to accommodate video game hardware with an expectation for simultaneous permanence and impermanence. The devices installed today are permanent in that they may remain installed for the rest of their lives and should be protected. Newer devices will be added, however, so the system's configuration overall is impermanent and must have room to expand.

Naturally, when a broad sampling of gear from multiple decades attempts to share the same display, signal management can easily become something of a challenge. Virtually every consumer-level AV connection method ever devised is likely to be utilized by some piece or another. Even where only one or two new systems are installed and the input needs are not as great, being able to switch between them easily is a point worth emphasizing.

Also important is being sure to use the best output method available for any given video game system. Most will have the capability to output digitally in the current generation but analog is still in use. Composite cables are included as a part of almost every system, though many will also work with S-Video and Component. Unfortunately, it is common practice to use a proprietary adapter on one end of an otherwise normal cable, so the possibility of upgrading is going to depend on the availability of the part from the manufacturer.

The management of the cables requires some additional consideration, especially as it relates to those cables that run between the controller and the console. Wireless equipment has only recently become the norm, meaning that the interaction between players and their legacy machines is very often going to be conducted via an input device tethered by a two or three meter cable. Where these systems can be installed, then, is wherever they can be within a few meters of the most distant player.

Calibration

The central promise of each successive hardware generation is that it will support software which looks and sounds better than what preceded it. The video game player is conditioned to expect these improvements but might not understand what proper calibration can do to maximize their potential. Of course, every calibrator is probably familiar with this kind of thinking already. That nobody seems to care whether magenta is really magenta is not unique to video game players but a badly calibrated display can have more than an aesthetic impact in this arena.

When the black level or white point of a display is wrong enough to make it impossible to discern certain details in a game, progressing can easily become a frustrating proposition. Game designers expect players to be able to see bright and dark objects and to differentiate one color from another. Likewise, important dialogue and sound cues can come from any direction and need to be intelligible. Failing at these tasks because of hardware inadequacy is, in essence, to play the game incorrectly.

Even when the system is performing adequately, some fine tuning can be instrumental to creating the ideal experience. Many games now include the option to adjust the picture – usually black level or gamma – within the software itself instead of through the player's display hardware. While this certainly simplifies the task of ensuring that the images in any particular game are not lost, the fact that they are being individually calibrated at all hints at a deficiency in the industry's display standards.

This represents a fairly significant challenge, I think. Granted, not every professional video or audio recording is conducted with the greatest adherence to their respective standards but there is little evidence to suggest that there are similar standards for video games at all. This is not an indictment of the video games industry but I do hope that as the AV industry gets to know it a little better, they get to know us, too. I hope this has been a good step in that direction.

-- Adam Teevan

Angles of Reflection

July, 2010 ©Da-Lite Screen Company Volume 3 Issue 5

There are plenty of very practical reasons to be excited about the capabilities and efficiencies of digital signage, even without considering how adept they are at attracting viewers' interest. The battle for this kind of attention is forever escalating, however, and as the once novel digital messages become commonplace, standing out will require new approaches. One such approach that carries an undeniable allure is to use…

A Semi-Transparent "Holo" Screen

The simplest reason to take this route is that it offers a set of capabilities similar to yet quite separate from the established digital signage equipment. Before we get to what this screen can do, we should establish what it is and what it is not.

The Holo Screen is a passive display device comprised of a special diffusion coating applied to an acrylic substrate. This is the same basic definition as any of our other rigid rear projection screens and, indeed, they are comparable in most respects. As with any rear projection screen, the diffusion coating is designed to transmit and scatter light from a projector in order to render a bright, visible image. Likewise, the substrate's primary function is to provide a rigid structure to support the diffuser.

Where the Holo Screen diverges from other rear projection materials is in the aforementioned "special diffusion coating". This coating is formulated with a particular emphasis on transmitting more incoming light and diffusing less than what is typically done. To get a better idea of what that means, we should take a close look at a common diffuse surface and a transmissive medium: a thin sheet of white paper and a window.

Most paper of this kind does a good job of evenly diffusing light that falls on it. It provides a uniform, matte surface that is free of mirror like reflections, absorbs very little light and is largely – but not completely – opaque. Holding the paper up to a light source will demonstrate this and probably also reveal obvious imperfections in its transmissive uniformity. Light and dark patches will intertwine in unpredictable patterns corresponding with minor fluctuations in the density of the paper. The thinner portions allow more light to pass through and, thus, appear brighter than the darker, denser portions.

If we could refine the sheet to be the same density throughout and, in doing so, improve its uniformity when backlit, we would wind up with a decent version of a diffusion coating. By affixing this makeshift coating to the interior side of a windowpane on a bright day, a rudimentary rear projection screen would be created. In fact, many other screens of this sort are created using similar methods but there will be more to say on this topic later.

At this point, it should be easy to distinguish the paper from the surrounding glass window by virtue of the way these objects affect the light pouring in from outside. Whereas the window simply lets most of the daylight into the room without much noticeable interference, the paper is scattering the light in all directions. This difference is what makes the paper appear to be glowing white while the window is virtually invisible. We have already established that the paper on the window is analogous to a rear projection screen, so the next step will be to turn it into a faux Holo Screen.

This will require making some changes to the paper so that it retains some of the diffusion properties it already has while adopting the transmission characteristics of the window. An easy way to accomplish this is to dampen the paper with water or oil. Once done, the paper will allow a more significant portion of incident light to pass without interference than before. If the sheet is sufficiently thin, it should even be possible to see objects on the other side of the window through the paper.

Despite this change, the sheet would not be as transparent as the window and would still look very slightly white. This is so because it would continue to diffuse some incident light, just as it did when it was a normal piece of paper. Regardless, the transparency would be unmistakable and its balance of scattering and transmitting light would be roughly similar to that of a Holo Screen. Of course, the actual coating on the Holo Screen is a lot more complicated than an oily sheet of paper.

Without digressing too far into the details, our diffusion coatings are sprayed onto substrates in a carefully controlled process not unlike powder coating or spray painting metal. While the reasons for doing this are fairly practical and mundane, the benefits are much more interesting. First, this method makes it impossible for the diffusion layer to peel away from the substrate, bubble or otherwise interfere with the image by way of losing adhesion.   Second, we are able to use a much thinner diffuser than many alternative methods, which improves the sharpness of the images it displays.

Now that we know what the Holo Screen is, we can explore how to take advantage of its properties. The most compelling way to do this will be to utilize it in ways that would be impossible for a standard flat panel or projection display. In short: make use of the transparency.

There are endless ways to do this. Indeed, there would be far more than I could write down or even think of. That is exactly why this is a valuable tool for digital signage: the possibilities have only begun to be explored. Whether using a dim image to create a ghostly effect or bright text around a dark background to give the appearance of words floating in space, the techniques for engaging a viewer in unexpected ways are, to be sure, still unexpected.

The important thing to keep in mind when devising content for a Holo Screen is that anything that appears black in the image will become transparent in the display. This can be advantageous, as in the example of the white text in front of black mentioned above, but it can also be dangerous if not given proper consideration. Whereas good, high contrast images are perfect for showing off the capabilities of most display systems in a variety of environments, that contrast is created when a part of the image is very dark. A nice, deep black on a regular screen will become whatever happens to be behind a Holo Screen. The options for accommodating this fact are to use bright images without dark areas, to use a dark background behind the screen so that black stays black or limit the use of black and dark gray to only areas that are intended to be transparent.

No matter how the screen is used, however, there will certainly be a projector involved. As you might expect, the fact that the screen passes light nearly as easily as a window does will mean that the projector's position will need some careful thought. Keeping the lens from shining light directly into the eyes of viewers will be an important factor, as will controlling where that transmitted light falls.

Both of these conditions can be met by setting the projector either above or below the edges of the screen and aiming the lens down or up, respectively. As a rule of thumb, we recommend placing the projector 18-35° either above or below the screen, though any position will be possible, so long as the projector is able to perform keystone correction and provide adequate heat ventilation when not laying flat. Since most people do not carry a protractor with their projector installation equipment but do carry a tape measure, please refer to *Figure 1* for the methods for determining where the projector should go.

Vertical Offset

$$TD \cdot \sin(PA)$$

Horizontal Offset

$$TD \cdot \cos(PA)$$

TD = Throw Distance
PA = Projection Angle

Figure 1

The throw distance for the intended image size and appropriate lens should be calculated as indicated by the projector manufacturer. Once the throw is known, simply multiply that distance by the sine of the projection angle (remember to use radians, not degrees) to find how much higher the projector should be placed. For example, to project at 30° above normal from five meters away, multiply 5 by sin(30°) to get 2.5m.

	V Offset	H Offset
18º	0.309	0.951
20º	0.342	0.940
25º	0.423	0.906
30º	0.500	0.866
35º	0.574	0.819

Figure 2

For the horizontal axis, multiply the throw distance again, only this time with the cosine of the projection angle. Using the formula: 5*cos(30°) = 4.3301m†. If our projector were intended to be set up directly behind the top edge of a normal screen, five meters away, we would want the projector to be 2.5m above the top of the screen, and only about 4.33m from its surface. This will give us the desired projection angle of 30°.

Incidentally, 30° is a good angle to choose. We have taken Holo Screen gain measurements from a variety of vertical angles, beyond the standard 0° in use for all other materials. Because so much light is going directly through the screen, its on-axis, peak gain measurement is somewhere around 400. This is an astonishing number but virtually useless since anyone looking at a 400 gain

† Because calculating trigonometric functions is not always easy to do, consider using the chart in *Figure 2* as a guide to make the process a bit simpler. The V Offset and H Offset values approximate the results for sin(PA) and cos(PA) respectively for the given projection angles.

screen will quickly look away. Measurements taken from even a few degrees away from the center, thankfully, allow the gain to drop by a significant amount. By the time we reach 30°, the screen is showing a much more reasonable 0.4 gain.

Admittedly, 0.4 sounds like a low number – and it is. While experience may suggest that such a gain is the result of absorption by gray pigmentation in the screen, the real cause is loss due to transmission. Any screen that passes a large portion of light energy in one direction does so at the expense of all other directions. When the area of peak gain is directed away from the viewer, what that viewer sees is the light that is scattered in those other directions. The quantity that remains to be scattered is relatively small, hence the low gain.

In practice, this gain will make it necessary to use a projector capable of generating approximately 2.5 times the lumen output needed for a comparable Matte White screen. Other solutions are possible because as the projection angle increases or decreases, the lumen output must do the same. The 30° angle we have been using until now is a good balance between keeping the peak gain out of the viewer's eyes and maintaining a reasonable brightness requirement.

With brightness accounted for, the next concern should be uniformity. Fortunately, an enormous peak gain does not prevent all remaining light from being scattered in a uniform pattern. What this means for the Holo Screen is that, while a lot of light is lost, what is left over is surprisingly uniform, thanks to the fact that the light is projected and viewed at an angle. Specifically, the effective half angle is around 45° when the projector is set at 30°. For reference, this is comparable to the half angle of a front projection surface with a gain of 1.3. This does not change the fact that a bright projector is definitely called for to make a bright image on a Holo Screen but as far as uniformity is concerned, there should be no problem.

Actually, if there were a single phrase I would use to describe using a Holo Screen, it would be "no problem". Granted, there are some major differences between these screens and traditional displays and several of these differences require a little extra thought, preparation and design effort. When the work is done right and there is well-designed content on the screen, though, the benefits are perfectly clear.

-- Adam Teevan

ANGLES OF REFLECTION

August, 2010 ©Da-Lite Screen Company Volume 3 Issue 6

A green plant is, ideally, one that is healthy and thriving, taking in just enough resources to survive and grow. It has the flexibility and means to maximize its useful production in a way that is neither wasteful nor unsustainable. If that description sounds like the opposite of a typical for-profit corporation, then read the last two sentences again with the phrase "green plant" replaced by "green business". The key linking the two is efficiency and the outcomes can be both...

Green and Profitable

The idea that profitability and environmental responsibility are complimentary rather than contrary concepts may not be exactly intuitive. Profit is often perceived to come at the expense of the environment or, at least, to be made with little regard for any environmental impact. Environmental responsibility, on the other hand, has a way of evoking a sense that some restrictive sacrifices will be required without anything being added to the bottom line.

It is possible to chase both goals simultaneously, however, by focusing on the pursuit of efficiency. This will place value on the exploitation of resources in the sense that they must be used wisely. Sacrifices will be necessary but the primary target will be mere waste. An efficient operation is bound by its very nature to trend towards profitability and to have at least a tinge of green.

By now, green initiatives are widespread enough that adopting some sort of environmental policy is an almost obligatory way to keep up with the competition. At the same time, a little ingenuity can help a business surpass the baseline responsibilities and give them a competitive edge. Taking the first step towards turning a business green can be intimidating, especially if it is not clear where to start or where to end up.

Pick the Low Hanging Fruit

A great starting point is to just take a good look around and try to identify the most obvious ways that some kind of efficiency improvement could be made. Are there things being thrown away that could be reused or recycled? Is paper circulating for tasks that could be done electronically†? Would alternative energy be a viable option for all or some of the organization?

† If you would like to receive an electronic copy of Angles of Reflection instead of print, please email me at the address on the last page of this document.

By identifying and then answering these sorts of questions, you not only begin the process of working more efficiently but you also start to look at your surroundings in a different way. Minor issues that have received temporary patches and workarounds will begin to reveal themselves as prime opportunities to take decisive action and to make permanent solutions.

Furthermore, conditioning yourself to track these micro changes on a macro scale is a valuable skill. It can be difficult to appreciate the benefit of fixing something in a way that will save a tiny amount of money periodically unless discussed in terms of months and years. By becoming accustomed to taking this longer view, better long-term decisions will follow more easily.

As an example, when we added outdoor lighting to our parking lot, we made the decision to use a system that would prove to be rather efficient. Some time later, while looking for the low hanging fruit that could be improved, we found that the light fixtures were efficient enough that an upgrade was not necessary. By making a good decision early on, energy consumption has been lower than it would have been since the beginning and the cost of upgrading was completely circumvented. This is a benefit for our desire to be green by virtue of the lower energy use and by making the discarding of equipment unnecessary. As far as the bottom line is concerned, energy unused and bulbs not purchased are both expenses avoided.

Establish a Committee

Once the easiest problems are on their way to being solved, the remaining tasks tend to get a bit more difficult to find and address. Even the most well-meaning and self-motivated people in the world can find themselves overwhelmed and unsure of what to do next when working on a big project alone. Aside from the possibility of dead ends and overwork, just taking on a job's regular responsibilities can make it difficult to see beyond one's own desk into other departments. In a large enough organization, that means there can be enormous areas of the business that remain largely obscure. For a company-wide project to really progress, a group of company-wide representatives would certainly help.

This is why a committee is an important part of this sort of project. Organizing will make it easier to see what needs to be done because there will be that many more eyes at work. A committee can also be a great source of accountability. Going green is a lot like making a New Year's resolution: the more people who know about it, the harder it is to give up early.

Our committee turned up an efficiency issue that would have been fairly difficult to tackle alone. At the front of the Da-Lite campus is a water tower that has been a landmark in town for over fifty years. Although there are numerous valid reasons for a manufacturing facility to have a water tower, we had exhausted virtually all of them and were left with a monument to old inefficiencies.

What really made the tower stand out as an obvious problem was the fact that it required the heat to be turned on earlier in the year than any other part of the facility. Our winters tend to be fairly cold, so while we may not find it practical or advisable to eliminate artificial heating entirely, it is good to limit its use whenever possible. Of course, being something of a landmark, we did not feel that it was a good idea to do away with the tower entirely.

Today, the tower is still standing right where it was in the ‘50s without any change that would be obvious just by looking at it. Inside, however, it has been completely and permanently drained for the first time since it was built. This has allowed us to delay running the heat until later in the year and, over time, that amounts to a significant savings.

This serves as another good example of how an efficiency decision can have multiple benefits but the real point of this case is to show that it is possible to eliminate a problem without needing to eliminate the place where the problem resides. Waste is the real target for elimination and it can be done in such a way that preserves the waste producer, should it happen to have some intangible value.

Learn the Standards

Once the easy fixes have been made and there is a committee organized to watch the place, the next big step is to look outward for help. There is already an impressive body of work that outlines what businesses of any size or purpose can do to improve themselves. The ISO, EPA, LEED, STEP and any number of local or regional equivalents have guides that run from general to specific to make it easier to know what to do and how to do it.

Besides the internal benefits that conforming to an external standard can bring, what is particularly excellent is that doing so usually yields a visible acknowledgement that everyone can see. Being able to add *LEED* to the end of your name, or *ISO 14001 Compliant* to your company profile helps consumers know that they are supporting efficient companies rather than wasteful ones. The more you can do to improve your company by working with these organizations, the more attractive your marketing can become.

Continue to Grow

The logical limit to efficiency improvement is probably when zero labor produces infinite product or work with zero waste. Assuming that this goal will remain out of immediate reach for the foreseeable future, it should be safe to say that there is always something more to be done. This is where your internal committee and the outside organizations become very important.

This is an exciting time for green. There is enough already accomplished that the concept is immediately useful for a newcomer while still new enough to benefit immensely from refinements and additions to it. Information sharing is an important part of growing as a green company. The odds of your business being exactly the same as any other are fairly low but there is bound to be enough overlap that sharing your challenges and successes can serve as a valuable contribution.

Reap the Benefits

The bottom line for all of this is, well, the literal bottom line. When the goal to improve efficiency is being met – when more is being done with less – the usual outcome is a more profitable operation. Add in the bonus marketing opportunities and the fact that customers are growing to expect some evidence of green in what they buy and it really makes good business sense to be environmentally conscious, even if under the guise of pure efficiency.

The most achievable and justifiable path to take is not to give up what you are doing but to give up the wasteful part of what you are doing. The goal is to minimize the negative impact your business makes on its own environment – your financial environment, labor environment and the other spheres that affect you and are influenced by you. A common byproduct of doing so is a better global environment.

-- Adam Teevan
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I owe special thanks to Rich Lundin, Kris Barone, LEED® AP, Rhen Taylor, CTS, and Rachael Conley, CSCP, CTS, from whom the content of this article has been 95% recycled.

ANGLES OF REFLECTION

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One of the many benefits projection screens offer compared to other types of displays is their flexibility in design. Granted, most screens in the world take the form of some variety of rectangle but there is no reason why they need to be restricted to that one basic shape. All sorts of shapes are possible and one popular variation on the standard is a curved screen.

Curved Screens

As a specialty product, a curved screen is rather interesting. It is automatically a more eye-catching design compared to most displays, simply because it is different from the more typical televisions, billboards, posters, monitors and any other flat rectangle we might happen to see virtually everywhere we look.

For digital signage, this differentiation of form can be a real boon. Enticing people to look at the content of an advertisement by delivering it through unconventional means is a great way to get the message across to consumers. Beyond the novelty, a curved screen can add a very practical benefit in that it is easier to see at least some portion of the screen from a variety of angles, rather than just from a range of positions in front of the screen.

Curved screens can also be put to good use in the field of simulation. Whether for avionics, military, or even for medical use or in museums of any kind, the ability of a curved screen to envelop the viewer can be quite valuable. In fact, it is possible to extend a curve into a complete circle to create an entire 360° panorama for a completely immersive environment.

In light of these applications for a curved screen, it may be tempting to use them in other areas as well. It certainly may be possible to do so in some cases but there are a few points of caution worth mentioning.

The first point to consider is the matter of the projection geometry. On a flat screen, it is a fairly simple matter of using a projector's zoom function and the physical location of both the projector and screen to arrive at an image that fills the screen and terminates in nice, square edges. A curved screen, on the other hand, presents an unusual challenge because not all portions of the screen are the same distance from the projector.

The reason this is a problem is that the size of an image on a screen will increase just as the distance between the screen and projector increases. A pixel on the edge of the screen will not be the same size as one in the center of the screen's curve. This is most noticeable at the very top and bottom of the image, which will bow outwards like a pincushion instead of running parallel to each other and perpendicular to the vertical edges. Fortunately, image warping software and special lenses can bring the image back into square, though these solutions do contribute to the overall cost.

A more subtle artifact of a non-flat projection surface is that the shape of a pixel will no longer be square. This is another expression of the correlation between distance and size, outlined above, but on a much smaller scale. Admittedly, non-square pixels would probably go completely unnoticed in most cases, save for a home theater or any other environment where perfect performance is expected.

Another potential difficulty is that of uniform focus. The degree to which this is objectionable will depend on the precise nature of the projector's optical system. Basically, when a projector is "in focus", there is often a bit of room in front of and behind the screen that would also qualify as being so. This range is commonly known as *depth of field* and a curved screen will certainly benefit from a lens system that is relatively deep in this respect.

Beyond these video considerations, the introduction of any curved surface to a room can present a significant challenge to proper acoustics. The basic problem is that this sort of shape is excellent at focusing sound waves in ways that flat surfaces cannot. In practical terms, this means that any source of sound in front of the screen – rear channel speakers, especially – is in danger of sounding inordinately loud from certain positions.

Not all is lost for curved screens, however, despite the stipulations outlined above. Integration of any piece of equipment requires some level of compromise, after all. The important thing is to understand what the restrictions and benefits are for each piece of equipment so that the overall system can perform as expected.

While it is true that curved screens need a little extra thought and possibly some extra hardware or software to really shine, none of the challenges they present are insurmountable. The key, again, is weighing the costs against the benefits to arrive at a solution that serves the user's needs without going "around the bend".

-- Adam Teevan

series of articles examining the various issues related to the concept and nature of information.

Angles of Reflection VOLUME IV - 2011

ANGLES OF REFLECTION

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The start of a new year is as good a time as any to look inward to question the assumptions we seldom take the time to challenge. In our case, that means pulling back for a moment to cover a few projection screen basics that we often take for granted, regardless of whether or not the actual information has ever been provided. Even if you think you know the answer already, I think it is relevant to stop and ask:

What is a Projection Screen, Anyway?

The fundamental purpose of a projection screen is to support the viewing of projected images. This is not the full answer, obviously, but it is at the root of every discussion we are likely to have on the topic of screens. Expanding on this foundation, the following questions and answers in this document will help us reach a more complete answer.

Are projection screens necessary?

If we define "necessary", in this context, to mean that the screen is an essential part of a projection system and that every system would fail every time without a screen in place, then the answer would probably be "no". This may sound like a cutely provocative answer (and it is, so stay with me here) but the reality is that humanity has filled the world with walls and other surfaces readily available to act as screen alternatives. In light of this, we may categorize the projection screen as being merely optional.

There is a catch, of course, in that screens are optional for projection in the same sense that roads are optional for driving. It is absolutely the case that some vehicles are driven without roads just as some projectors are never paired with a screen. For the majority of users of both, however, their respective complimentary items are absolutely necessary for the realization of peak performance and for simple convenience.

That convenience factor is often the most compelling argument in favor of using a projection screen. Most walls are incapable of rolling up when not in use, often fail at being portable and are quite prone to attracting picture frames, wall hangings, and other obstructions that interfere with projection. This is to say nothing of the fact that screens are designed to accommodate the shortcomings of projectors and environments (as will be discussed in the following section) in ways that a common wall cannot reliably be called upon to emulate.

Beyond the convenience is the need for a screen that allows the sophistication of the projector to shine through, as it were. This is important to professional users in such fields as film and photography, who rely on their projectors and screens to provide an unerringly accurate picture. It also applies to anyone who uses a projector and screen to display polarized 3D images and, to some extent, anyone who uses a projector at all.

Why are there so many different screen surfaces?

There are numerous obstacles which interfere with the screen's ability to display projected images and so there are numerous screen types designed to overcome them. Generally, these obstacles can be collectively understood as arising when the projector is not able to adequately illuminate a screen in order to provide usable images in a given environment.

The influential factors here are the:

- Light output of the projector
- Light levels ambient in the viewing environment
- Size of the screen
- Properties of the screen material

As a screen manufacturer, we have no control over how bright anyone's projector happens to be. We likewise have little power to affect the amount of light in the viewing environment. It is possible for us to alter the size of a screen, however, and that does let us influence the performance of the system somewhat. If the projector is too dim or the room is too bright, a smaller screen can actually make the image brighter and, therefore, easier to see. It also makes the image smaller and more difficult to see, which is why we produce a variety of surface *types* in addition to the different sizes.

These types are based on an assortment of properties that influence how the screen reflects, diffuses, and even absorbs light. Through various combinations of these properties, it is possible to do such things as brighten an image, increase contrast and even deflect ambient light. In other words, projection screens are designed to accommodate an array of requirements and limitations that arise in putting together an actual projection system.

Can anyone even tell the difference between one screen and another during normal use?

Honestly, if all screen materials looked the same under projection, we probably would not bother to make so many different kinds. Aside from the characteristics we have briefly touched upon already, there are still more variations in screen surfaces that depend upon the materials and techniques used in their construction.

While it is true that the human eye is remarkably adept at overlooking a variety of irregularities and shortcomings in displays of all kinds, it is also true that it is absolutely possible to distinguish one screen from another, due to these variations. It is part of what not only sets one brand apart from another but also makes it important to select the right screen for the situation.

-- Adam Teevan

ANGLES OF REFLECTION

March, 2011 ©Da-Lite Screen Company Volume 4 Issue 2

The front side of a projection screen is, arguably, the most important side. It diffuses the light from the projector, it is the side the audience actually looks at and is, as a result, the side that carries all the important characteristics like gain and half-angle. The reverse side of a front projection screen is also important, though much less is said about its properties and it garners little attention. Let's look at what goes on…

Behind the Screens

If you look at the back of a projection screen, you will probably see one of three things. Either the back will look almost the same as the front surface, it will look like an untreated or uncoated version of the front or it will have a black coating. For the purposes of this discussion, the two screen variations without the black coating will collectively be called non-backed and the screens with the coating will be called black backed. Compared to the numerous permutations found on the front side of projection screens, these few options for the back are not exactly robust. I would argue that only one choice is really needed but we will get to that in due course.

First, we should establish a distinction between useful and unwanted light. In essence, the projector will be responsible for supplying all of the useful light to the display system. Any other light involved will be considered unwanted, at least as far as the display of a projected image is concerned. The screen's role is to make use of the projected light while minimizing the detrimental effects of the unwanted light. Previous articles have shown how the front surface of a projection screen is able to contribute to this effort but what of the reverse side?

For that, we often use a black backing, intended to help control unwanted light by absorbing any that would otherwise be transmitted through the screen. While we do not recommend doing so, the obvious instances where black backing would be the most useful would be when the screen is installed in front of a window or some other source of illumination. The logical question that would follow from this is:

What if there is no light source behind the screen?

Plenty of screens are installed directly in front of such things as walls, chalkboards and whiteboards, none of which count as particularly luminous surfaces. In these circumstances, it would appear that a black backing may be, at best, superfluous. Of course, that is assuming that no light is being reflected by whatever happens to be behind the screen. Perhaps we could negate this possibility by ensuring that the projector is the only light source in the room but then, perhaps not.

Earlier, we established the basic assumption that the projector is the source of useful light for our purposes. That remains true but it should not be implied that all projected light is useful. Specifically, projected light that is allowed to pass through the screen and away from the audience can hardly be called useful and is, actually, in serious danger of becoming unwanted.

Any portion of that light that is reflected by an object behind the screen and then is allowed to pass back through its surface a second time is now very likely to interfere with the projected image. The interference will most likely take the form of a drop in contrast as the display's black level will rise towards gray as a result of the additional light.

Does the backing have to be black?

If the main reason for the backing is to block light from being transmitted through the fabric, then it stands to reason that any adequately thick or dense material would serve that purpose regardless of its color. While arguably true, it is important to remember that projection screens are usually designed to be as light and flexible as possible. Increased density and the resultant rigidity and heaviness are not positive features for a screen. Granted, some rigidity is needed to help the material to lie flat, especially in non-tensioned screens but too much would prevent a screen from being able to roll up easily. Similarly, extra weight in the fabric puts stress on the roller or framework that supports it, making it increasingly difficult to maintain a flat surface, even if the screen is not intended to be rolled.

As a result, there is a limit to how thick or dense a screen surface can be before additional considerations are needed in its overall construction. The alternative to blocking light via density is to absorb it using a dark color and, obviously, that is where black backing comes in. It is able to absorb a good amount of light without significantly adding to the weight of the screen. It is simply an efficient method of controlling unwanted light.

How much transmitted light is too much?

The safest thing to do is not to let any light through the screen at all. A black backing all but ensures this in so many applications that it seems worth the effort of putting it there in the first place. To answer the question at hand: the bare minimum contrast needed for an acceptable display is 10:1. No one will mistake "acceptable" for "excellent" but as has been covered in this series earlier, this is the cut-off point beyond which lies disaster.

To connect this contrast requirement to the issue of light transmission is a little difficult because of the number of variables involved. Is the light from behind the screen the result of direct or indirect sunlight? Is there a reflective surface behind the screen or a diffuse one? How much light will that surface return towards the screen? It would be possible to make some educated predictions for specific cases but, again, the easiest solution to all of these issues is to eliminate them with a black backing.

-- Adam Teevan

ANGLES OF REFLECTION

ANGLES OF REFLECTION

June, 2011 ©Da-Lite Screen Company Volume 4 Issue 3

Leave it to human ingenuity to take the hassle out of long distance communication. It used to be that if, for example, you needed to send word of Greece's victory in battle back to Athens, it involved sending someone out to run a marathon. I would guess that messenger had plenty of time along the way to reflect on how nice it would be to talk to someone miles away without needing to travel every one of those miles first. If so, he would be thrilled to know that we have spent the last few millennia finding all sorts of ways to communicate across even greater distances and with ever-increasing levels of sophistication. While none of these methods quite fully capture the experience of the original and still popular face to face conversation, we do come very close with…

Large Format Videoconferencing

What we mean by "large format" is any videoconferencing system in which the images being transmitted between users end up on a display that is big enough to be approximately life-sized. This is significant because much of the point of using videoconferencing at all is for the way it allows the nuance of communicating directly and in person to be replicated between remote locations. Body language, facial expressions and everything else we express nonverbally while speaking are all available with videoconferencing but only if presented at a scale that can be easily seen by others. When your conversation partners have been significantly miniaturized by a small screen, the benefits of the conversation's visual component are in danger of shrinking as well.

None of this should be taken to mean that so-called small format videoconferencing is in any way invalid. This approach has its own unique advantages, especially in that it offers a level of portability that is all but impossible to emulate in a larger format. A couple of flat panel displays on a mobile equipment cart can be moved between rooms with an ease that leaves large format displays quite literally behind. In permanent installations with sufficient space, however, large format is definitely recommended for its potential to make better use of the immersive nature of video.

"Immersive" may be a word not often found outside the context of entertainment or simulation but I think it is relevant here because videoconferencing really should be thought of as a branch of simulation. Mundane though it may sound, it acts as a sort of meeting simulator that quite handily removes the need to actually meet in order to collaborate. Since collaboration is at its best when everyone is focused on the task at hand, videoconferencing equipment should mimic reality as closely as possible and not introduce distractions and limitations.

One obstacle on the path of reaching this goal is the proper use of lighting. At a minimum, the faces of the participants and anything else that needs to be seen clearly across the video feed must be well lit. The typical lighting scheme in most offices is great at illuminating horizontal surfaces like desktops but is not always sufficient to make a group of people look presentable on camera. Complicated stage lighting is not really necessary but additional diffused light sources aimed to keep faces lit instead of the tops of heads will make an appreciable contribution towards enhancing the system overall.

Lighting matters become more complicated when there are significant competing light sources visible to the camera. The issue here is that most cameras automatically adjust exposure to keep the overall light level in the scene from being either too dark or too light. Any bright window or light fixture in the shot can skew that level to the point where the camera's compensation causes everything else in the room to look rather dark by comparison. Either these sources need to be avoided by the camera, treated in some way or, again, additional lighting is needed to ensure that everyone is adequately lit.

At this point, it may begin to seem as though using two piece projection for this sort of application would fail because of the considerable light requirements for videoconferencing and the diminished performance of projection in bright environments. The key to making the two work together is to keep all of this lighting under control.

As in any projection application, controlling light does not have to mean eliminating it altogether. Simply increasing the amount of light for the sake of being able to see the people speaking will not necessarily ruin the image on the screen, so long as those lights are not too close to the screen and, more importantly, are not aimed towards it.

In addition to the care necessary to keep light from hitting the screen directly, secondary reflections will need to be considered as well. This indirect light will not be as intense as direct light but can still become objectionable unless adequately controlled. Often the most reasonable way of doing this is to use a dark color palette for the walls and furniture and to avoid glossy or reflective surfaces as much as possible. The goal here is for the objects and coverings in the projection environment to absorb light that would otherwise continue to be reflected within the room and potentially reach the screen.

Even having taken these measures, the amount of ambient light present with videoconferencing is likely to exceed what would be found under ideal circumstances for projection. To further combat this, a "high contrast" projection screen that includes some gray pigmentation can further improve the image by absorbing a portion of that extraneous light. This absorption lowers the black level on the screen which yields a higher contrast image. The end result improves the appearance of the video and goes a long way towards guaranteeing that the message gets through.

Our Greek friend may have needed to go an even longer way to achieve similar goals but then, that's the sort of difference a few thousand years can make. Fortunately, it has not taken nearly as long to make dramatic progress in videoconferencing and the infrastructure it relies upon. As these – and as projectors and screens – continue to improve, the quality of the experience will as well. At the very least, it will be a lot easier to gather everyone to collaborate on it than ever before.

-- Adam Teevan

Angles of Reflection

December, 2011 ©Da-Lite Screen Company Volume 4 Issue 4

Properly specifying a projection screen is a bit like finishing a crossword puzzle. Both are done through the systematic use of interrelated clues to arrive at the best solution, but with "Projector Brightness" taking the place of hints like "Erstwhile Acorns". Although some careful forethought is always recommended regardless of the task, rigid rear projection screens require special care because, as when using a pen to fill in the squares, errors can be especially difficult to correct. In the interest of avoiding costly mistakes, let's take a quick look at what goes into…

Rear Projection Planning

To begin, assume a twentieth floor conference room located in a building surrounded by a bustling city. An integrator (we'll call him Dale Eitscrene) has been asked to install an in-wall rear projection screen. The owner wants the screen to be as big as the room will allow, envisioning an image that will span from floor to ceiling. Dale wisely notes the fact that they are standing on floor twenty in an office building with doorways, elevators and stairwells that would struggle to accommodate an 8-foot high piece of nearly inflexible acrylic. Add to that the fact that most screens are better off standing roughly 48" from the floor and it is clear that the owner will need to modify his expectations.

To get a better sense of an appropriate size for the screen, Dale measures the room height and the distance to the farthest seat, following the recommendations made previously in this very same series of articles. He also measures the small projection room behind the conference room and finds that the projector intended for the display needs more space than is available to fill the necessary image area. One option is to reduce the size of the screen to match the projector's capabilities but that may result in a display too small to be seen comfortably by everyone in the room.

A better option is to use a mirror system to effectively fold the projected light's path, allowing a short space to accommodate a longer throw distance. To ensure that he specifies the right mirror, Dale's next step should be to fill out a mirror request form, which collects the sorts of measurements he has already taken so that we can design the most efficient mirror system and projector cradle (collectively referred to as a Rear Projection Module) to suit his needs. This will ask for the model of the projector, the thickness of the wall holding the screen, the distance from the bottom of the screen to the floor, etc. The more information he can provide, the better the results will be.

This information will also allow us to recommend an appropriate surface type for the screen. The process for doing this is largely similar to the one used to find the right front projection screen with the gain and half angles being the most important factors. However, it is important to note that these two measurements do not necessarily relate to each other the same way in both front and rear projection.

Case in point: DA-100, a coating that has the same 1.0 gain as a Matte White screen but does not share the same half angles. This is because, while the composition of this particular coating does allow it to transmit an equivalent volume of light compared to what Matte White reflects, it does not diffuse it in exactly the same pattern. In other words, this and most other rear projection screens allow off-axis light to fall off more quickly compared to front projection screens with a similar gain. In response to this phenomenon, we have developed a line of wide angle coatings that more closely match their front projection counterparts. Their wider half angles allow for relatively large screens with good uniformity, even when there is not much room to accommodate a long throw distance.

Since Dale is working with a limited throw for his screen, he would definitely benefit from a wide angle coating. Also, since bright, affordable projectors are now widely available, it may be advisable for him to look for a coating with a gain below 1.0. Generally speaking, the lower the gain, the more uniform the image. While it is possible for a screen to be too dim or too bright, it can never be too uniform. The same formula for converting lumens to foot lamberts applies in rear projection. As long as the projector is bright enough to give good results, a good low gain coating will almost always look best.

Besides gain and half angles, the other relationships worth understanding are those between a rear projection screen's viewing area, its panel size, and its overall dimensions. There is no single answer to how these factors will relate, since these will depend greatly on how the screen is going to be installed. If using one of Da-Lite's frames, approximately one half inch on each of the four sides of the screen is needed for the frame to grip the acrylic panel. This adds an inch to both the width and height of the actual panel beyond the viewing area.

The frame itself will determine the real overall dimensions and the size of the opening needed to hold the screen. Different styles will give different results, so it is generally advisable to confirm the size before making a decision. In cases where a frame is not needed or wanted, it is also a good idea to detail how the screen will be supported. After all, not every rear projection screen is going to be placed in a wall; some are the walls, as is the case with flight simulators, or are the top of an interactive work surface, just to name a couple of alternative options. In these instances, we can offer our advice on how to make the best use of a projection screen to suit.

That is our goal with any projection screen, actually. Nobody likes to make mistakes and even when they can be fixed, they can cost time, money, and confidence. They are better avoided in the first place, which is what makes planning so important. Adequate planning helps to ensure that Dale will have installed a great rear projection screen just as surely as erstwhile acorns have become oaks.

-- Adam Teevan

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