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Projection Geometry

As the advantages of rear projection become more and more evident to users of video and data displays, the utility of rack and mirror systems is becoming more and more common. Yet there are still many people who shy away from mirrors because they worry that folding the projection optics will introduce unsightly distortions in the projected image. This article will seek to dispel that uneasiness by suggesting some guidelines for using mirrors so that they will always preserve a system's optimal **Projection Geometry**

Before we discuss how to use mirrors, let's recall why we use them in the first place. Put simply, mirrors let you get a big image out of a small space. In Figure 17 we have a side view of a typical video projector shooting its beam straight through a rear projection screen. The top and bottom light rays form a triangle with the screen as its base. The apex of the triangle is inside the projector and the middle line coming out of the projection lens illustrates the projection axis, the path of the light ray that bisects the screen.

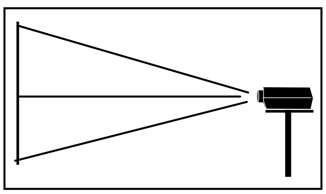
Figure 17

Figure 18 shows what happens when you take the above and fold it one time. Notice how the size of the box containing both projector and screen can now be smaller.

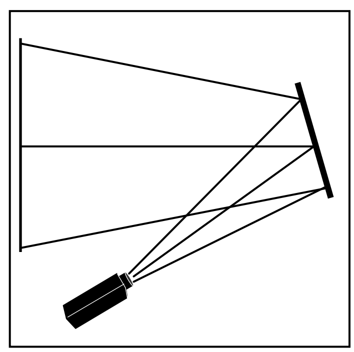
Figure 18

Figure 19 shows the same triangle folded twice, through two mirrors, and the surrounding box is smaller still. The sole purpose of mirrors is to reduce the required depth of the projection booth. When you use them, that's all you are doing and that's all you *should* be doing.

To see this clearly, if you unfold the projector from the little mirror in Figure 19, you'll get Figure 18 and if you unfold from the bigger mirror in Figure 18, you'll be back to Figure 17.

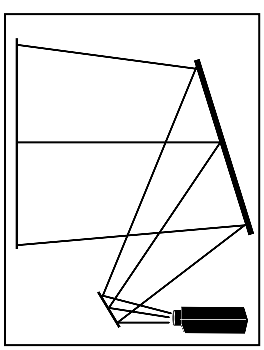
Figure 19

Another way of expressing this is to state that the angles at which all light rays pass through the screen will not be altered by the use of mirrors. No matter how many times or in how many ways you crease and fold that triangle its base will always stay pinned to the back of the screen and its apex will always be attached somewhere inside the projector.

Do you have to fold any particular triangle in one and only one way? No. In Figure 18, for instance, we could make everything work from an even smaller booth by enlarging the size of the mirror and moving it closer to the screen. We would not have to change the angle of the mirror or the position of the projector, although we could alter both. (Can you see why if we change one that we cannot escape changing the other?)

The real trick with mirrors, then, is not figuring out how to fold the triangle but determining which is the bast triangle to fold. And the very best way to make that decision is to forget about mirrors entirely and assume that instead of too little throw distance, you are suddenly given a mile of it.

Now you're free to ascertain exactly what is the optimal projection axis that is going to connect your projector to your audience. The projection axis is the path traveled by the projected light ray that passes through the center of the screen. If the projector is ceiling mounted, as in Figure 20, the path of this "principal ray" is downward, which is quite different from the direction of the same ray in Figure 17.

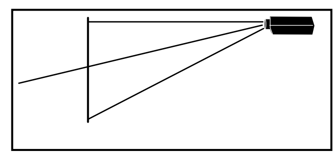

Figure 20

Video projectors don't mind these shifts in orientation because they are electronically able to correct for whatever distortions may result from their being raised or lowered from a position perfectly perpendicular to screen center. (Nothing in this article refers to shifting the projection axis horizontally because it is seldom necessary and rarely recommended.)

To determine the ideal position for the projector, start from a point approximately in the middle of the audience and extend a line straight back through the center of the screen to a point far enough behind it to satisfy the throw distance requirement. You have now located the apex of the triangle you'll want to fold.

Only occasionally will the geometry thus formed by projector and screen be an isosceles triangle (as in Figure 17). More frequently the optimal triangle will be a right triangle (Figure 20) with the projector flipped so that its base is perpendicular to the screen at the top. This, of course, is because audiences are generally arrayed below the center of a rear projection screen (if they weren't, the heads in the front row would block the bottom of the screen from the eyes in the back row).

Whatever the shape of the optimal triangle, that's the only triangle that should be folded. Whether it's folded once or twice depends on the actual depth of the available projection booth. Which angles are chosen for the mirror or mirrors and whether the projector is upside down or right side up technically doesn't matter. As long as the optimal triangle is preserved, the projected image will exhibit exactly the same geometry as it did before its optics were folded. No distortions will occur.

Everything we have said so far about mirrors is true and is particularly true for CRT projectors because they are fixed focal length devices. When it comes to using mirrors in front of LCD projectors, however, there are a couple of additional variables to be considered which, if overlooked, *can* cause distortions.

Most LCD projectors come with a button on them marked Zoom and some have an additional button marked Shift. Pressing the Zoom button telescopes the lens in or out so the image size can be changed from a fixed throw distance. The Shift function enables the user to raise or lower the image without moving the projector.

Convenient as these flexibilities are for quick setups in the front projection mode, either of them can be exasperating when undertaking a permanent installation with mirrors. In the latter case it is generally much safer to establish the Zoom and/or Shift settings before combining the projector with the mirror system than to try to adjust them afterward.

A straightforward way to do this is to begin by aiming the projector at the *front* side of the screen. Take it back the desired throw distance (the same length that you'll "fold" when you use the mirror system behind the screen) and adjust the zoom so that the image precisely fills the screen. If you also have a Shift button, you'll need to figure out what system is unfolded (that triangle again) and duplicate it while you're still out front. (It is worth noting that many LCD projectors work best when their lenses are not located exactly normal to screen center. The optimum position is often about 25% up from the bottom or down from the top.)

Once the Zoom and Shift functions have been established in the straight throw mode, treat the projector thereafter as if it were a fixed focal length device and the correct triangle will be preserved when the beam is subsequently folded.

To help with all of this, Da-Lite has created a Commercial Mirror System that accommodates virtually any projector and can be easily set up to utilize either two mirrors or one. The sled on which the projector sits pivots through 45° and the surrounding racks are expandable to hold a mirror as large as six by eight feet.

The screen manufacturer will calculate for you the correct angles and sizes for your mirror or mirrors if you give them the make and model of your projector, the size of your screen, the available depth of your projection booth and the height you wish the screen bottom to be from the floor.

It will also be helpful if you give them the angle you wish for your projection axis and, if you are using a projector with a zoom lens, what throw distance you have chosen. If you have a Shift setting as well, you'll need to specify how far from the top or bottom of the screen you want the projector's lens center to be. With these data in hand, the screen manufacturer can quickly generate a drawing indicating all appropriate dimensions and angles.

In the end there really isn't much that's obscure about mirrors and how to use them. Upon reflection it should now be clear that suitable projection geometry can always be displayed

Note: All material used in this paper is taken from the Da-Lite educational series *Angles of View, Vol. 1*

For additional questions and information you may contact your local Ford Audio-

Video sales representative or call 800-654-6744. We are available to visit your Church to analyze your needs and make recommendations to help you with training, sound mixing, and special programs.

Also, through our Web site you can contact a live person by clicking on the “Live Help” Link under Contact Us. Ask a question or give an opinion. If they can’t help they will direct you to someone who can.

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