My Heuristic Projection Calculator

Rev 4.3 | 08-10-16

Mine is not your typical throw-ratio calculator. No, that's too easy. This is a story of discovery and problem solving that many have wished for, but few have found.

This adventure starts about ten years ago. It was then that a customer complained that a new projection system I specified was not "bright enough". He asked how I determined what projector to use. Remember, this was back at a time when cost-effective LCD projectors were just beginning to reach above about 3,000 ANSI lumens. My answer to him was weak. I really didn't calculate anything, I just specified the brightest XGA projector they could afford.

When I saw the image for the first time, I had to agree with him. It was washed out, with poor contrast. Ultimately, the problem was resolved when our service manager found a bad connection on one of the extender cables that had been installed. Once the termination was repaired, the image came to life and was acceptable to all.

That event sent me on a mission to figure out a better way to objectively quantify my projection designs. I figured this would be fairly easy to do. Surely, the leading projector or screen manufacturers would have calculators on their websites, or at least have some specific information relating to "industry standards" for brightness and contrast. Oh my, was I wrong.

There are many details to factor when calculating for brightness and contrast. They include screen size, available projector lumens, usable projector lumens, aspect ratio, screen gain, black level, front vs. rear projection, throw distance, and ambient light.

It took about a year of research to cobble together what were fragments of information, which came from all corners of the industry. I was looking for consistent ideas and direction, target values and formulas. I couldn't find much. I took a little from each of the major projector and screen manufacturers, from standards organizations such as ANSI and SMPTE, and anything else I could find. Actual guidelines and formulas were few and far between.

As I came to learn, the two key elements are Ft. Lamberts (FL) and Contrast Ratio (CR). FL being the amount of light that is reflected off a screen and to the viewers eyes. CR is the ratio between the brightest color (white) and the darkest color (black) that a system is capable of producing. I now knew what to look for, but I couldn't find any published data describing how much of each was needed.

So, what are the objective goals for FL and CR? Based on my research and experience, a combination of 50 FL or more, AND a CR of 15 or greater, will deliver an excellent image, under most ambient lighting conditions. If you have a reasonably sufficient budget, these goals aren't too hard to achieve with today's technology.

There are two obvious exceptions to the 50/15 goals: First is a darkened theater. There the CR will easily and significantly exceed the necessary FL. The FL goal may only be about 20, while the CR can and should easily exceed 100.

Second is a scenario with significant ambient light directly behind and around the screen. Think large windows. When this situation occurs, human eyes can't voluntarily isolate on the projected image. In general, if the background light is equal or brighter than the projected image, the pupil constricts, allowing less light in. The viewing experience is significantly degraded. If faced with this scenario, arrange for an in situ demo, and advise the customer they will either have to install and close blinds or drapes, or throw an excessive amount of money at the problem.

I've had a long standing love affair with spreadsheets. To me they blend art and science; here math meets graphic design in a most elegant way. And so, I began to heuristically connect the dots, plugging various formulas into my first projection spreadsheet. The goal was to figure out a way to incorporate all the factors, as I understood them at the time, into an interactive tool that was flexible enough to get quick, reliable results.

Over the years, new insights and experiences have pushed me to update the workbook a few times. My FL & CR Projection Calculator (v4.1) is the latest and greatest version of these efforts. It's also the one that best incorporates a sub-component I didn't fully understand and appreciate until quite recently - lens dimming factor (LDF).

LDF is a subtle but important component in the final FL and CR calculations. Simply put, LDF is a reduction in projected lumens caused by the lens. The light loss is not due to throw distance, but rather the internal optics of all zoom lenses.

All zoom lenses have (or should have) two published throw ratios. The smaller number is the widest (short throw) end of the zoom, the larger number is the tightest (long throw) end. Ratios such as 1.6 - 2.3 are often representative of a projector's "standard" lens.

In addition, each zoom lens has a speed range, which is given as two "f" numbers. At the widest end of the zoom range the f number is smallest. It's largest at the long-throw end. A projector's standard lens usually has the fastest range of optics. Fixed, short zoom, and longer zoom lenses almost always have a higher range of f numbers than do the standard lenses.

Lens theory tells us that more light passes through a projection lens at the short-throw end of the range, less light passes through at the long-throw end, thus reducing the usable light being produced by the lamp(s).

Manufacturers are not consistent nor standardized with their testing methods. The most reliable metric is found when ANSI lumens are derived using their standard lens, set mid-way between the throw-ratio extremes. However, some manufacturers test their projectors using the best case scenario in their lens lineup; their fastest, widest option. This usually appears at the wide end of their "standard" zoom lens. The only way to tell which method was used is to call the company and ask.

The LDF algorithm I created attempts to calculate the "usable" lumens that can be delivered to the screen, based on the distance between the projector and screen, the required throw ratio, and the various lens options. Plugging in the appropriate speed values would be much easier if the manufacturer's actually published the f number for each of their lenses. Few do. Hitachi and NEC were the most forthcoming I could find online.

It's interesting to note, even today, none of the major projector manufacturers address the two key elements (FL and CR) in their projection calculators. They're all happy to help with basic projection geometry, but that's the easiest part of the designer's work. Hopefully, you'll find that my application delivers the rest of the necessary information.

Why does this matter? The main reason is this. It gives the designer and customer confidence that the specified projection system is nether too much nor too little for the desired application. Said another way, it helps the customer trust they aren't spending too much or too little to get a high-quality image. I think this is the goal of all concerned, and the true value of this application tool. Click here to download the .xlsx spreadsheet.

There are a minimum of eight cells that must be used to properly calculate for FL and CR, and a few more that provide even more accuracy. To help guide you through the process, there are many informative and instructive fly-offs embedded in the spreadsheet. You'll see the notes when you hover your mouse over the various cells. Please take the time to read each at least once.

Disclaimer: There are no perfect, interactive algorithms for calculating FL and CR values. My spreadsheet application should be used as a practical planning guide with these tolerances in mind. Best case - +/- 5%. Worst case - +/- 10%