How to design your cinema auditorium for higher contrast

by Tom Bert, Senior Product Manager, Barco

The topic of high dynamic range (HDR) has been heavily debated in cinema over the past months. We won't go into detail about all forces at hand in the discussion; but we will take on a more solution-oriented approach, stepping away from technology.

As presented by Barco and others at several SMPTE Technical conferences (and other events), the room design is of key importance (see here for our 2015 SMPTE paper) when trying to do higher dynamic range in cinema. Auditorium properties like ambient lighting and reflections go hand in hand with the projector technology to create the perceived on-screen contrast and image quality.

The research in this domain has been analytical and descriptive so far: how big is the effect? How do room parameters and projector specs impact image contrast for a typical room?

Optimizing the viewing experience by using a higher dynamic range of colors, contrast and brightness

As part of a funded research project, Barco has now taken this one step further. The project with code-name HD²R (Highly Delightful Dynamic Range for Next Generation Digital Cinema and Television), researched ways to optimize the viewing experience by using a higher dynamic range of colors, contrast and brightness. To that end, the project carried out pioneering experiments to achieve the **optimal and reliable visual quality, conversion and color correction of HDR images**. Running from October 2015 to September 2017, HD²R studied all aspects of the imaging chain, from the camera that shot the content to the screening in the cinema or in the living room. Lead by Barco's Dirk Maes, the research was done in collaboration with six industry and academic partners.

Click here for the project results.

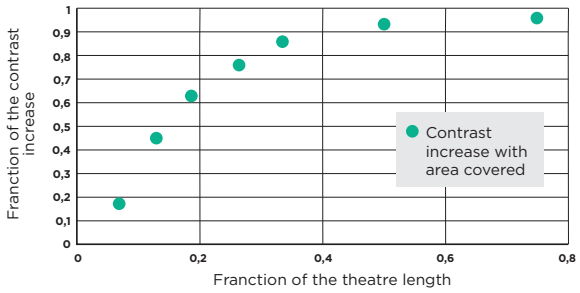
How to optimize your auditorium design for higher contrast?

The research conducted by Barco zoomed in on cinema auditorium design and how to optimize it for higher contrast. Of all the parameters in the mix, what should an exhibitor focus on first? What's not worth spending money on? To quantify and validate the advised actions, **four different approaches** were used. A **mathematical model** combined scattering, reflections and ambient light into one formula to predict on-screen effect. **Measurements and tests were done in real cinema auditoriums** to check if the numbers and outcomes matched the practicalities of the field. Thirdly, an **auditorium scale model** was built that allowed the research team to quickly and flexibly play around with the room properties by adding or removing seats; putting a different color on the walls; changing the seating inclination angle etc. And finally, a full 3D (so-called ray-tracing) model was designed that helped match theory with practice.

Design guidelines

Some of the recommendations coming out of the project are listed below. These are actual design guidelines that exhibitors who want to optimize their auditorium for higher contrast images can implement:

1. Focus on the **area closest to the screen**: by – only – putting dark or black material on the floor area just in front of the screen, the perceived on-screen contrast ratio can be enhanced by more than 40%.
2. When optimizing your **seats**, focus on those **closest to the screen**: putting dark seating in the front 1/3 of the auditorium is 25% more efficient than putting them in the back.
3. When optimizing your **walls**, again focus on the area **closest to the screen**: the first 25% of the wall (measured from the screen) gives 75% of the impact on perceived contrast (see graph below).



4. **Steep stadium seating is not good for higher contrast**: increasing the inclination from 15° to 30° decreases the contrast by 16%; increasing the inclination to 45° decreases the contrast by 27%.

There are other, non-quantified recommendations in the report that sound straightforward but are not consistently applied in the field. The most important one is on the **impact of recessed exit- and stair-lighting**. It is perfectly possible to give visibility and safety to the audience, without having to shine directly onto the screen. Doing that latter, is detrimental for the perceived contrast. Another one is on the importance of a **dust-free porthole window**, at the right angle, made out of the right material. Those reflections cause light to go in the wrong direction; which deteriorates the perceived contrast.

Closest to the screen = biggest impact

As a general conclusion for the quantified metrics in the list, it was found that the elements closest to the screen have the biggest impact. Elements further away have reduced impact, and because this is true in both horizontal and vertical direction, the impact is quadratic with distance. To extend the dynamic range it is advisable to focus on reducing the reflectivity of the interior elements within a distance closer to the screen than one times the screen height. For that same reason also, the impact of the reflectivity of the audience is not as big as originally feared.

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About the author

Tom Bert is a senior member of the Product Management team in Barco's Entertainment division; he is responsible for the digital cinema servers and projectors. Tom joined Barco in 2006 as Research Engineer for Barco's Technology Center. In 2009, he joined the Product Management team in the Digital Cinema division. Since 2015, Tom has been actively working on digital cinema servers and projectors and he has been promoted to Sr. Product Manager. Based in Belgium, Tom has international experience in display technology. He holds a PhD degree in Engineering from Ghent University.