MITSUBISHI ELECTRIC
Changes for the Better

for a greener tomorrow

LED VERSUS LASER LIGHT SOURCES FOR COMMAND AND CONTROL APPLICATIONS

It's true that lasers can be a highly efficient source of light. However, the characteristics of laser light do not necessarily make it an ideal light source for all video projection applications. The question is whether or not laser light sources are the best option for rear projection cubes used in mission critical command and control applications. LED light sources have been (and still are) the dominant technology for mission critical rear projection cube applications, but laser light sources are now becoming available in the market. There is definitely a lot of hype swirling around the laser light source, but is it really the best option? If you take a close look at the technology the hype doesn't match the reality.

Generally speaking, Laser diodes generate a narrow beam of coherent light in a very efficient manner. However, this light is hazardous and suffers from scintillation (or speckle) when being viewed on a surface such as a screen. The optical system within a laser light engine must convert the hazardous (Class4) and coherent laser light emitted from the laser diode into non-hazardous (Class2) and non-coherent (as much as possible) light that can safely illuminate the surface of the display device and be reflected to the viewing screen with minimal speckle artifacts. Although there are methods to reduce the scintillation effect, it is not always possible to eliminate completely.

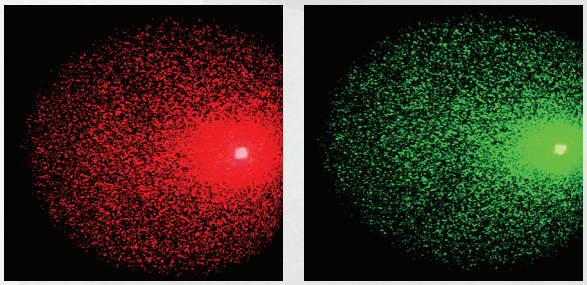
One can definitely argue that RGB Laser light sources are an ideal technology for high end cinema projectors that require extremely high lumen output. The large size and high cost of these projectors make it possible for engineers to use all available methods to reduce the scintillation effect to an acceptable level. These projectors also don't operate 24x7x365 and the light source typically has a lifetime in the 20K - 30K hour range.

You could also make an argument that Laser/Phosphor projectors are a good fit for mid to low brightness data projectors. These projectors typically only use blue lasers for the light source coupled with a phosphor wheel to create green and red. Red LED's are also sometimes used in a hybrid type of light source design. This allows for a much more cost effective design with a lifetime typically in the 20K hour range which is OK since they aren't expected to operate 24x7x365.

Light engines designed for rear projection cubes used in mission critical command and control applications do not require the higher lumen outputs that are needed in cinema and data projector applications. However, they do require stable and reliable operation running 24x7x365 over extremely long periods of time (over 10 years). They also require an image that is comfortable for the operators to view over long periods of time without causing eye strain. Not only does the specification for LED light engines meet these requirements, but LED light engines have a long standing track record in the command and control industry proving it. Laser light engines have a significantly higher initial cost, a significantly lower lifetime specification, and no track record operating in 24x7x365 mission critical environments. The only significant advantage laser engines have over LED engines is that they may have a higher peak lumen output specification; however the price you pay for that increased brightness is a significantly reduced lifetime. Considering the required display brightness for a comfortable viewing environment in a control room, the additional brightness offered by Laser is not needed and is definitely not a good trade-off for the reduction in lifetime.

Scintillation *(Laser Speckle Effect)*

Although an efficient light source, laser light is susceptible to scintillation (or speckle) which would lead to eye strain in a command and control environment where the operators are viewing the displays for long periods of time, so special precautions must be taken to reduce these effects. Due to the way the human eye processes color, scintillation (or speckle) is most severe for Green and Red lasers and countermeasures must be put into place to reduce the speckle effect to a level that viewers are willing to put up with. Below are examples of some common methods often implemented to reduce the speckle effect:



• Limited to Lower Gain Screens

High gain screens make the speckle effect more obvious. As a result, lower gain screens are typically used to reduce the speckle effect. Since higher gain screens are not typically used with laser systems, it somewhat mitigates the higher light output that can typically be achieved by laser light sources. Most laser products have much lower lifetimes at the higher brightness conditions because they need to overdrive the lasers to achieve the desired peak brightness with the low gain screens. For example, the light source lifetime of the Barco laser engine currently available on the market is only 60K hours in bright mode and 80K hours in normal mode which is significantly lower than the 100K hour lifetime in all operating modes that can be achieved with Mitsubishi's solid state LED light source. By using an LED light source Mitsubishi can also use higher gain screen options that would not be practical for RBG Laser light sources due to the increased speckle effect.

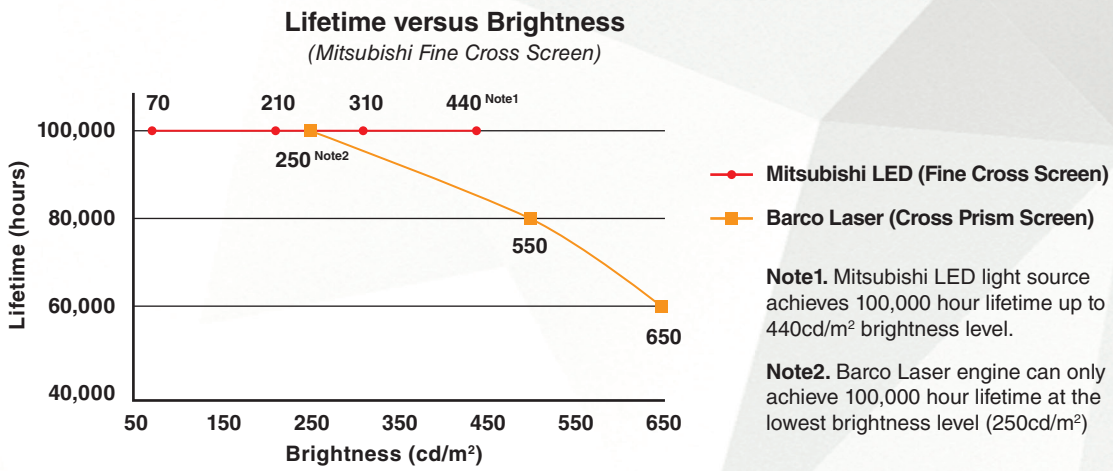


Figure1. A comparison of lifetime at different brightness levels for Mitsubishi LED cube and Barco Laser cube. Data is for 70" cubes with cross screens. Barco is brighter, but significantly sacrifices lifetime to achieve the brighter image. The Mitsubishi LED cube is 76% brighter than the Barco laser cube when considering peak brightness at 100,000 hour lifetime.

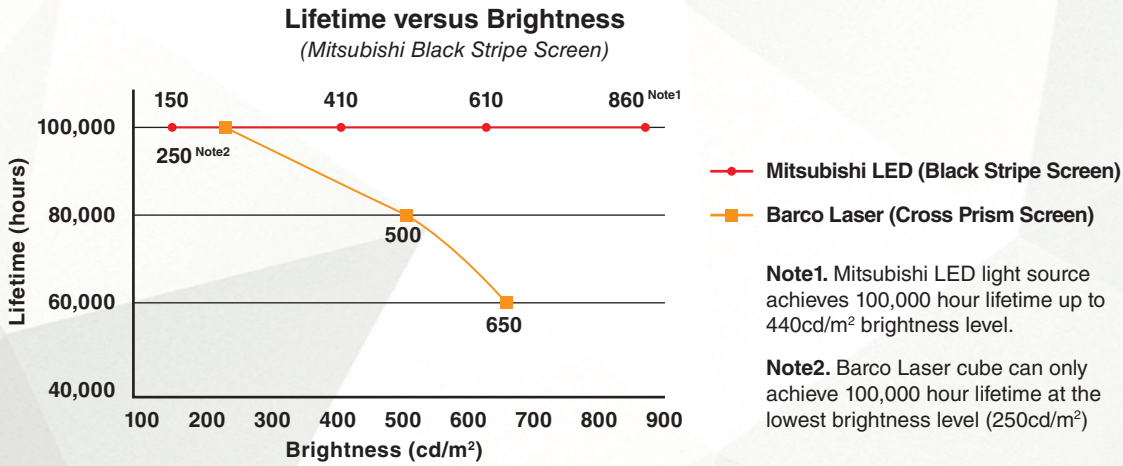
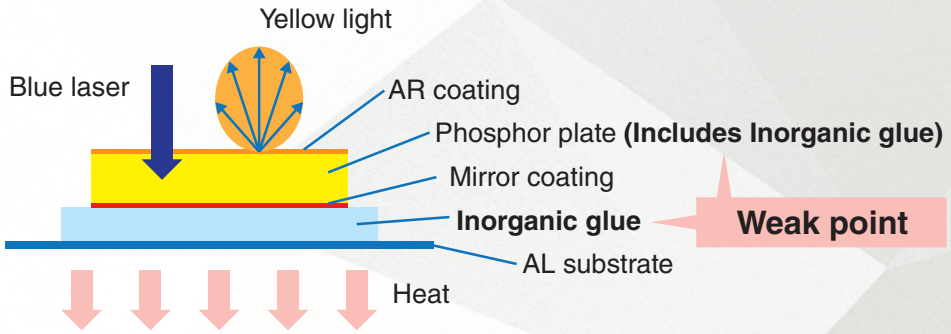


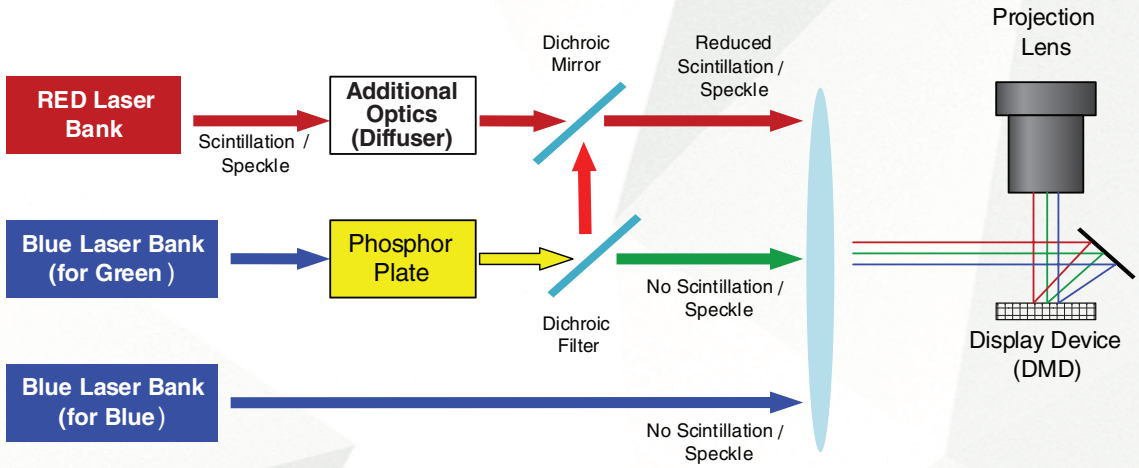
Figure2. A comparison of lifetime at different brightness levels for Mitsubishi LED cube and Barco Laser cube. Data is for 70" cubes—Mitsubishi black stripe screen and Barco CSI screen. Since the Mitsubishi LED light source does not suffer from the sever scintillation artifacts associated with laser, we can use a high gain black stripe screen to achieve significantly higher on screen brightness. The Barco higher gain screen options lead to more severe scintillation effects and are not included in the comparison.

• Use a Green Phosphor Plate Instead of an Actual Green Laser

Although manufacturers indicate their light sources are RGB laser, in most cases they do not actually use a Green laser. The main reasons are that Green lasers are not typically as efficient as Red and Blue lasers and that speckle is difficult to eliminate from Green laser light. Therefore, most (if not all) manufacturers of laser light engines with lumen outputs applicable for command and control room applications use a phosphor plate to create the green light. Blue laser light excites the phosphor plate and yellow light is emitted. Since the light emitted from the phosphor is not "Laser Light", it does not suffer from the speckle effect. Phosphor plates have longer lifetimes than phosphor wheels used in lower end front projectors, but the phosphor plate can be susceptible to long term aging effects such as binder deterioration that could lead to darkening. Using a phosphor plate also reduces the color gamut that could be achieved from a true RGB laser light source since the wavelength of light emitting from the phosphor is different than a Green laser. Although typically marketed as RGB laser, this type of configuration should technically be considered a Red/Blue Laser light source with Green Phosphor.



In an RB Laser with Green Phosphor system, you still need to deal with the speckle effect from the Red Lasers. Since the phosphor plates generate yellow light, it is possible to separate out the red component and mix that back in with the Red laser light. Because the red light component from the phosphor plate doesn't suffer from scintillation this may help reduce the amount of pure Red laser light required and may slightly reduce scintillation. Another method for reducing the speckle effect in Red is to add a spinning diffuser plate in the light path to reduce the coherency of the red laser light and therefore reduce the speckle effect. This method is somewhat effective to reduce speckle and may be used in higher end cinema projector applications, but it isn't practical to implement into light engines for command and control applications since it would negatively impact the lifetime of the light source to an unacceptable level.

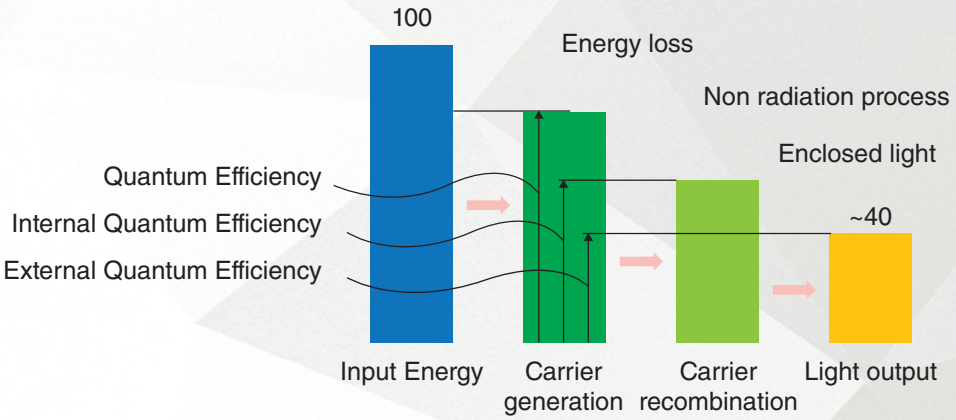


Simple block diagram of RB Laser with Phosphor plate light source

Simply reducing the Red laser light output can also be used to reduce the speckle effect of the red laser light. This can be somewhat effective, but tends to lead towards greenish whites. Manufacturers of RB Laser w/Green Phosphor light sources will typically avoid demonstrating content with a lot of red so that the speckle effect is not so easy to notice.

• Only Use Blue Laser

One way to virtually eliminate the speckle effect is to only use Blue lasers with a phosphor plate. The yellow light emitted from the phosphor plate can be separated into the Green and Red components. As previously mentioned the light emitted from the excited phosphor is not laser light and does not suffer from the speckle effect. This type of system should not be considered RGB Laser, but should be considered Blue Laser w/Phosphor. The Blue laser w/Phosphor system may sound attractive, but there are significant tradeoffs that must be taken into consideration. The power consumption for this type of system is not nearly as good as an RB w/Phosphor system. This is due to the fact that about 60% of the light energy is lost during the fluorescence process.



Around 60% energy must be lost during fluorescence process. the lost energy could change into heat.

Laser has absolutely no advantage over LED if it loses its light efficiency. Another consideration is the color gamut and color reproduction. The wavelength of the Green and Red light components emitted from the yellow phosphor plate is not equivalent to Green and Red lasers. This reduces the overall color gamut and may also make it difficult to reproduce accurate color.

Other Considerations

At this point we know that laser light sources can be very efficient at generating light and have the potential for being quite bright. However, the lifetime limitations associated with operating the laser light engine at those extremely bright levels is not acceptable and does not meet modern control room expectations of 100,000 hours that are already being achieved with LED light sources. Couple that with the fact that the laser speckle effect will be exacerbated when operating at higher brightness levels or when using higher gain screens and what you thought were advantages of the laser light source do not seem so important. Below are some other items that should be considered when deciding if LED or Laser light sources are the best option for the mission critical 24x7x365 command and control environment.

- Although there is recently a lot of hype about laser light sources in rear projection cubes, this is not a new technology and has been around for many years. Mitsubishi introduced televisions with true RGB laser light sources to the consumer market over 8 years ago. We are also a manufacturer of Red lasers. Mitsubishi is a pioneer in the display wall industry and we have done a lot of research into using laser light sources for rear projection cubes. As a manufacturer of lasers and of display products with laser light sources for the consumer market, it would make perfect sense for us to develop a Laser light engine for the command and control market. However, our research has led us to conclude that LED is without a doubt the appropriate light source for rear projection cubes in the command and control industry. If end users step back from all the laser hype that is currently proliferating through the industry and simply focus on the facts, it is clear that Mitsubishi LED light source technology is superior and the correct choice for large scale video walls in command and control environments.

- As with any light source, it is extremely important to keep either the LED's or Lasers properly cooled to insure long lifetimes required for command and control environments can be maintained. Mitsubishi uses a forced air cooling method with no toxic coolant or pumps. It may be necessary to use liquid cooling systems for some laser light source applications. Liquid cooling is not an advantage and has drawbacks that should be avoided if at all possible. This should be taken into consideration when deciding what displays you will have in your facility for the next 10~15 years.

- Mitsubishi uses a 0.96” DLP chip in our flagship LED light engine. We do this because a larger DLP chip allows you to capture more light and reduces the amount of magnification required to display the image on a large screen. This leads to best in class focus and uniformity performance. Some of our competitors have chosen to go with smaller 0.65” DLP chips on their flagship products due to the significantly lower component price. Using a smaller DMD is not an advantage and there are definitely performance tradeoffs that were made in order to use that smaller (and cheaper) device. If you need to drive your display device so hard that you’re light source lifetime is only 60% when in its brightest mode of operation that is not an advantage and should be something that is considered when deciding what displays you will have in your control room for the next 10~15 years.
- Mitsubishi has a long proven track record installing our LED light engines into mission critical environments since their first introduction in 2008 . We have continually improved our cooling system over time and have now achieved lifetimes of 100,000 hours in all operating modes for our flagship models. A laser light engine may sound exciting, but the inferior lifetime specifications and lack of proven track record must be considered when deciding what product you will have in your control room for the next 10~15 years. No product currently available in the market can touch the Mitsubishi LED light engine with regards to longevity and proven track record.
- In addition to the long term performance and reliability, cost is always a very important factor when making the significant investment required for displays in a large control room. Laser light engines come at a premium cost for the initial investment and could potentially lead to higher maintenance cost over time since the laser light source components are more expensive than LED light source components. At this point there is no way of knowing how reliable the laser light sources will be over time, but the initial investment is definitely more. Considering the points that have been made in this paper, does it really make sense to spend more money for a laser product that has no track record and offers no significant advantages over the Mitsubishi LED light engine.
- Although laser light engines are typically classified as Class-2 which is generally considered safe, there is definitely Class-4 laser light within the optical system that is extremely hazardous. Special precautions and training may be required to service a laser light source. The method for servicing the laser light source and the cost associated with that service once it is outside the initial warranty phase should be examined before making a decision to purchase a display wall with a laser light source.