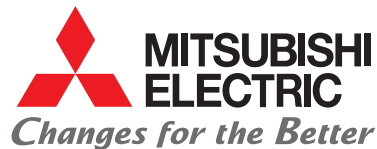


# Rear Projection DLP™ Cubes with LED Light Source vs. Slim-Bezel LCD in Control Rooms

---

*By Mitsubishi Electric US Visual & Imaging Systems Division  
and Mitsubishi Electric Sales Canada*



The primary purpose of display systems in command and control applications is to provide domain experts (operators) with a large, clear, high-resolution common operating picture for critical real-time situational awareness. This allows them to simultaneously monitor information from various sources and assets (application data and graphics, vehicles, personnel, power, environment, etc.) and provides them with the appropriate tools for intelligent decision-making in response to operational emergency situations. The display wall permits sharing of real-time critical information and operational efficiencies with stakeholders.

When selecting the technology for a specific application, emphasis should be placed on the following:

- Total cost of ownership with a potential for high return on-investment (ROI)
- Smallest seams (screen-to-screen gap) to provide a visually seamless and high quality image
- The need for true 24x7 operation
- High reliability and minimum downtime with reduction in points of failure
- Long-life expectancy of the system with ability to upgrade to future technologies

The two most commonly deployed control room technologies today are:

- Thin bezel LCD display wall systems
- Rear-projection DLP display wall systems with long-life LED light source

This document compares the technologies and highlights pros and cons of each to help customers make an informed choice for their investment in display technology.

## Thin-Bezel LCD

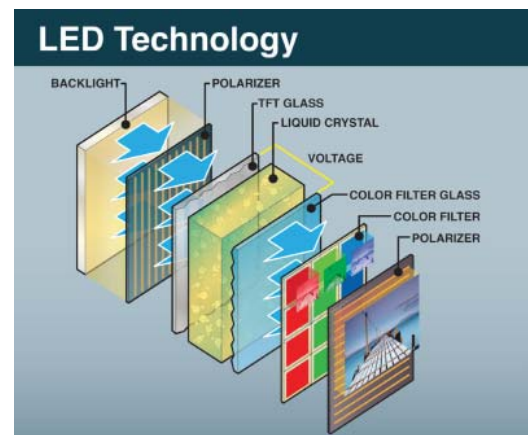
### About the Technology

Liquid crystal display (LCD) is a digital display technology that produces images on a surface by shining light through liquid crystals and colored filters.

The term "liquid crystal" describes a substance in a state between liquid and solid but which exhibits the properties of both. Molecules in liquid crystals tend to arrange themselves until they all point in the same specific direction. This arrangement of molecules allows the medium to flow as a liquid. Depending on the temperature and particular nature of a substance, liquid crystals can exist in one of several distinct phases. Liquid crystals in a nematic phase, in which there is no spatial ordering of the molecules, for example, are used in LCD technology.

A particular sort of nematic liquid crystal called twisted nematic (TN) is naturally twisted. Applying an electric current to these liquids will untwist them to varying degrees, depending on the current's voltage. LCDs use these liquid crystals because they react predictably to electric current in such a way as to control the passage of light.<sup>1</sup>

In a color LCD panel, each pixel is made up of three liquid crystals and each of these cells is fronted by a red, green or blue filter. Light passing through the filtered cells creates colors seen on the LCD.



Occasionally, the mechanism that sends the electrical current to one or more pixels fails; in those instances, the bad pixel is dark.

As light (energy) passes through the multi-layered LCD panel, the heat generated can cause the panel to heat or burn unless properly cooled. This is often expressed as panel degradation due to heat and is excluded by panel manufacturers in LCD warranties.

Liquid crystals have a naturally relaxed state. When a voltage is applied, the crystals rearrange themselves to block certain light waves. If left with the same voltage for an extended period of time (e.g. borders of camera images displayed on LCD screens, static portions of image, etc.), the liquid crystals can remain in one position, which can throw off the requested color, causing the image to look like the traditional "burn-in" on plasma displays. In fact, the root cause of LCD image persistence is the same as phosphor burn-in on CRTs: non-uniform usage of the display's pixels.

This could be due to several factors, including 1) accumulation of ionic impurities inside the LCD, 2) electric charge building up near the electrodes, 3) parasitic capacitance, or 4) a DC voltage component that occurs unavoidably in some display pixels owing to anisotropy (direction dependence) in the dielectric constant of the liquid crystal.

Image persistence, while usually temporary, can also become permanent. Consequently, all major LCD manufacturers exclude image persistence from their warranties. Allowing the liquid crystals to return to their relaxed state can usually reverse image persistence. In other words, turning off an LCD display for several hours or days could relax the crystals and reduce / eliminate the risk of image retention. The use of a screensaver that has a constantly changing image can also help. Another approach is to create a solid white image and displaying the image as a screen saver covering the entire display area for an extended period of time.

In the event of bad pixels, panel degradation and image persistence (all three excluded from LCD manufacturers' warranties), the only remedy is to replace the faulty LCD panel, because repair of LCD panels is cost prohibitive. These panels must be carefully disposed when they fail or reach end of life.

Due to ever-changing advancement and development of LCD technology, unless sufficient spare panels are maintained by the customer for the project, it is highly unlikely to find a matching replacement panel in a relatively short time and over the anticipated lifetime of the display wall array.

Thin-bezel LCDs were introduced in 2010 and have rapidly evolved. There are currently two sizes available for control room applications: 46" and 55" diagonal.

## Application

Display wall systems using thin-bezel LCDs have been increasingly used in applications where space and budget are limited and the system is not used in true 24x7 operations – especially with static data or graphics displayed for extended periods of time.

Organizations have justified the use of thin-bezel LCD technology due to:

- The perceived lower cost of the hardware compared to the procurement costs of a DLP display wall system
- The savings of real estate in the control room

Thin-bezel LCDs possess a significant screen-to-screen gap (as much as 5.7mm), which can affect operations and content. While it may be satisfactory in a security operations center with numerous camera images arranged so that the seams do not affect

the image, when a specific camera image is expanded over multiple panels, the resulting image can be disturbing as well as in SCADA or GIS applications.

It is also important to note that LCD technology is not recommended or warranted by the manufacturers for use in 24/7 applications, especially with static images or static portions of an image, such as borders of security camera images. Ideally, LCD panels are used from dawn to dusk (about 12 hours per day). Some thin-bezel LCDs may also be used for as long as 20 hours per day without significant effect on image quality.

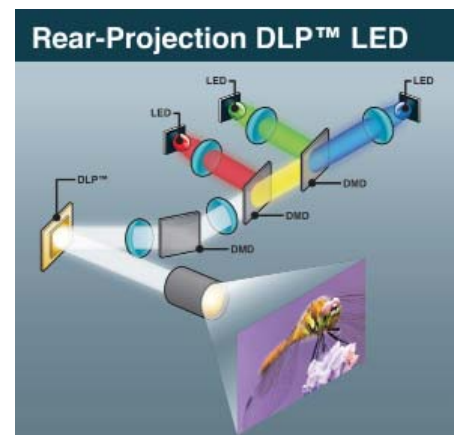
Pros	Cons
<ul style="list-style-type: none"> <li>• <b>Low initial cost of deployment</b></li> <li>• <b>Small footprint</b></li> </ul>	<ul style="list-style-type: none"> <li>• If wall mounted, the supporting wall must be fortified to support the weight of the display wall. If not wall mounted, the supporting structure takes up more space in the control room and must be designed not to tip.</li> <li>• Potential for "dead" pixels. <i>Not covered by manufacturers' warranties.</i></li> <li>• Potential for accelerated panel degradation when used continuously for extended operations. <i>Not covered by manufacturers' warranties.</i></li> <li>• Potential for image retention with static images or portions of image. <i>Not covered by manufacturers' warranties.</i></li> <li>• Large seams / screen-to-screen gaps. Usually 5.7 mm and can be very distracting during operations</li> <li>• Shorter lifespan (less than 50,000 hours / 5.6 years). Lifespan is even shorter when used in continuous operation.</li> <li>• Higher power consumption and greater heat dissipation increases ongoing operational costs.</li> <li>• Unreliable color calibration.</li> <li>• Cannot be repaired in the field, failed panels must be replaced.</li> <li>• New model released every 2 to 3 years. This often makes it difficult to find a replacement panel soon after installation is completed.</li> </ul>

## Rear-Projection DLP-LED Cubes (DLP Cubes with Long-Life LED Light Source)

### About the Technology

Rear projection is a display technology that produces images on a screen surface via a projector, more commonly referred to as a light engine. There are several types of rear projection, such as "straight-shot" or "custom mirror bounce," but rear-projection "cubes" are the most common. Cubes create standard screen diagonals (from 50" to 80"), with a wide variety of resolutions (XGA, SXGA+, HD, WUXGA), and aspect ratios (4:3, 16:9, 16:10), making design, installation, and serviceability of a display wall easier than ever before. A light engine placed within a cabinet projects an image upward to a mirror where it is bounced toward a screen to produce a visible image.

The light engine employs Digital Light Processing™ (DLP). DLP is a type of projection technology trademarked by Texas Instruments that uses a semiconductor chip known as a digital micromirror device (DMD). Millions of tiny



mirrors on the DMD move thousands of times per second to create a digital image. Each mirror represents one or more pixels in the projected image. The number of mirrors corresponds to the resolution of the projected image. These mirrors can be repositioned rapidly to reflect light through the lens. DLP then needs a light source for illumination.

Prior to 2010, single or dual (for redundancy) UHP lamps were used; UHP lamps require annual replacement, more power and a color wheel.

In 2010, LED was introduced as the new light source for DLP cubes, with a 60,000 to 100,000 hour (6.8 to 11.4 year) life expectancy on the LED light source, depending on the manufacturer. The color wheel and filter also became obsolete with the LED light source.

## Application

Rear projection (be it CRT or DLP) has been the primary technology used in the command and control room space since large overview display walls started to be deployed within the operation center. This is due to its high reliability, no image retention, long life, and minimal seams. Consequently, rear-projection LED has been the technology of choice for true mission-critical applications in utilities, defense, transportation, emergency management, emergency operations, etc.

Rear-projection DLP cubes with LED light source require a depth of 20" to 40" for installation, which must be accounted for during system design. The technology is rated for 24/7/365 use with no effect on image quality.

Pros	Cons
<ul style="list-style-type: none"> <li>• <b>Long life expectancy</b> <ul style="list-style-type: none"> <li>• Mean time between failures (MTBF) of the DLP technology is 650,000 hours.</li> <li>• MTBF of the LED light source is 60,000 to 80,000 hours (depending on manufacturer)</li> <li>• MTBF of the cooling system is 50,000 to 100,000 hours (depending on manufacturer)</li> <li>• The LED light source and the cooling system are easily replaced in the event of failure (modular system).</li> <li>• Anticipated life of the DLP cube with LED light source is 18+ years (a user's potential need for higher resolution would be the only primary reason for replacement of the display wall prior to the technology reaching end of life).</li> </ul> </li> <li>• <b>Stand-alone structure</b> <ul style="list-style-type: none"> <li>• Display Walls with DLP cubes are stand-alone structures, which do not need fortification of supporting walls like LCD display wall systems do.</li> </ul> </li> <li>• <b>Designed for true 24x7x365 operation</b> <ul style="list-style-type: none"> <li>• DLP technology is a "reflective" technology (not transmissive technology such as LCD) and is rated for true 24x7x365 applications, even with static information displayed for extended hours of operation.</li> </ul> </li> <li>• <b>Lower power consumption</b> <ul style="list-style-type: none"> <li>• DLP cubes with LED light source require less power than other technologies.</li> <li>• Some manufacturers offer multiple operating modes that allow users to reduce energy consumption.</li> </ul> </li> <li>• <b>Low heat dissipation</b> <ul style="list-style-type: none"> <li>• DLP cubes with LED light source generate less heat (BTUs) than other technologies (with multiple operating modes of operation, this can be further controlled).</li> <li>• Low heat dissipation translates to savings in cost of HVAC systems and power requirements for these systems.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Footprint</b> DLP cubes require 20" to 40" footprint compared to approximately 8" to 10" required by thin-bezel LCD display walls (with mounting brackets).</li> <li>• <b>Initial Cost of Deployment</b> Unit price of DLP cubes is about two to three times that of thin-bezel LCD display wall panels (depends on cube size).</li> </ul>

Pros	Cons
<ul style="list-style-type: none"> <li>• <b>Modular design and upgradeability</b> <ul style="list-style-type: none"> <li>• With modular design and construction of the DLP = display wall cube with LED light source, individual components such as power supplies, mother boards, LED modules, etc. can be replaced quickly on site without the need to replace the complete engine.</li> <li>• Mean-time-to-repair (MTTR) is less than 15 minutes with on-site spares, compared to LCD panels, which must be replaced.</li> <li>• With cube technology, upgrade paths are available to improve resolution, change light sources, and add additional features, etc., as technology changes.</li> </ul> </li> <li>• <b>Lowest cost of ownership</b> <ul style="list-style-type: none"> <li>• DLP display wall cubes with LED light source offer the lowest cost of ownership in the control room space due to:                             <ul style="list-style-type: none"> <li>• Low power consumption</li> <li>• Low heat dissipation</li> <li>• Anticipated lifespan of 18+ years</li> <li>• Virtually no major maintenance required for over 9 years of continuous 24x7x365 operation</li> <li>• Modular construction for quick replacement of any component parts in the field.</li> </ul> </li> <li>• Cost of ownership varies depending on manufacturer.</li> </ul> </li> <li>• <b>Seams / screen-to-screen gap</b> <ul style="list-style-type: none"> <li>• With a screen-to-screen gap of 0.2 ~ 1.5 mm and no bezel/seam, display wall cubes can be used to create large, visually seamless displays.</li> <li>• Large, visually seamless display walls help provide a large common operating picture and true situational awareness for control room operators.</li> </ul> </li> <li>• <b>Various sizes and resolutions available</b> <p>DLP display wall cubes with LED light source are available in a variety of sizes and resolutions:</p> <ul style="list-style-type: none"> <li>• Sizes: from 50" to 80" diagonal</li> <li>• Resolutions: from XGA to WUXGA and</li> <li>• Aspect Ratios: 4:3, 16:9, 16:10</li> </ul> </li> </ul>	

## A Direct Comparison

### LCD Display Wall Panels v/s DLP™ Display Wall Cubes with LED Light Source

#### Burn-in or Image Retention

Although LCD technology is less prone to burn-in than CRT or plasma technology, it is not free of a similar occurrence. While burn-in is more prevalent on older CRT monitors, a phenomenon with a similar visual effect occurs with LCDs. Referred to as image retention or image sticking, the appearance is visually similar to burn-in. LCD manufacturers do not warranty their panels against image retention when used in a 24/7 environment. LCD panels are rated for no more than 20/7 operations.

#### Disposable Technology vs. Refreshable – Rear-Projection LED is a Long-Term Investment

Thin-bezel LCD technology is essentially disposable. It cannot be upgraded, and once image retention occurs, it cannot be repaired. When a panel is in disposed condition, an identical model may not be available for replacement. Consequently, the entire wall may have to be replaced.

Rear-projection DLP cubes with LED light source are refreshable. Therefore, cubes may be upgraded to a higher resolution engine or an alternative light source. The engine can be replaced within the same cabinet and screen structure without disturbing millwork around the display wall. The upgrade is quick with little or no downtime and no additional construction costs.

With a service life of 10 to 11 years requiring no consumables, DLP cubes can be repaired on site in less than 15 minutes using on-site spares, with little or no disruption to normal operating activities.

### Repairs – Cubes are Repairable On-Site

LCD display wall panels cannot be repaired on site – they must be replaced. Since there are no new LCD display wall panels, the replacement would either be a used, repaired, or refurbished unit, with no way to tell its condition. The backlights lose brightness over time just as lamps do, so at 50,000 hours, the panel will be half as bright. Rear-projection DLP cubes with LED light source can be repaired easily and quickly with on-site spare parts, without disturbing the display wall.

### Screen-to-Screen Gap / Mullion – Mullions are Smaller with Cubes

LCD display wall panels for control room applications have a screen-to-screen gap of 5.7mm or 0.22 inches. (Some new digital signage models have a smaller screen-to-screen gap, but are not suitable for the demands of control room applications).

Mitsubishi Electric DLP Rear Projection Display Wall Cubes, have screen-to-screen gaps from 0.2 mm ~ 1.5 mm (0.007” ~ 0.05”) depending on the screen size, array size and whether the cubes are rear or front serviceable. This is more than 70 percent smaller than the screen-to-screen gap of LCD display wall systems.

### Brightness and Color Balance – Cubes Maintain both Brightness and Color Uniformity over Time

Currently, brightness level of control room LCD display wall panels is 500 cd/m<sup>2</sup> maximum (normal mode) or 700 cd/m<sup>2</sup> maximum (bright mode) typical.

In comparison, rear-projection DLP cubes with LED light source are much brighter than similarly sized screens.

	<b>Bright Mode (max.)</b>	<b>Normal Mode (typ.)</b>	<b>Eco Mode</b>	<b>Adv. Eco Mode</b>
<b>55” LCD Display Wall Panel</b>	700 cd/m <sup>2</sup>	500 cd/m <sup>2</sup>	350 cd/m <sup>2</sup>	N/A
<b>60” DLP Display Wall Cube with LED Light Source</b>	1,100 cd/m <sup>2</sup>	810 cd/m <sup>2</sup>	700 cd/m <sup>2</sup> (more than LCD panel in normal mode)	410 cd/m <sup>2</sup>

*In advanced eco mode, power consumption is reduced to 96W with thermal dissipation 82.6 kcal→/h (328 BTU/h).*

Although some of the newer LCD display wall panels offer an “optional” color calibration solution to ensure color uniformity across individual and multiple screens, this system is typically employed during installation on a one-time basis. The system makes no provision for color or brightness uniformity over extended periods of operation.

Mitsubishi Electric Rear-Projection DLP Display Wall Cubes with LED light source employ unique circuits built into each display wall cube to ensure brightness and color uniformity across the entire display wall image, including digital color space control, dynamic brightness balancing with three built-in sensors (R,G,B), dynamic gradation circuit, etc. These technologies allow the display wall cubes to talk to each other over the array and continuously maintain uniformity of color and brightness across the display wall image over the entire lifetime of the light source (80,000 hours / 9+ years). Even when the light source is changed,

the system can adjust itself by downloading color information from the new light source and comparing it with the luminosity and colorimetry stored in the display wall from the previous light source. Colors are then automatically adjusted to accurately match the various cubes in the array.

### Active Display Area – Cubes Provide a Larger Display Area

Generally, display wall cubes offer a larger image area for the same resolution. Below is a comparison of a similar configuration of LCD display wall panels and DLP display wall cubes providing the same resolution and with similarly sized screens.

	<b>3 Wide x 2 High Array of 55" LCD display wall panels</b>	<b>3 Wide x 2 High Array of 60" DLP display wall cubes</b>
<b>Individual Screen Size</b>	47.9" W x 27.0" H	52.3" W x 29.4" H
<b>Total Resolution</b>	5,760 x 2,160 (12.4 million pixels)	
<b>Total Display Wall Image</b>	12.0' W x 4.5' H (53.9 sq. ft.)	13.1' W x 4.9' H (64.1 sq. ft.) (18% larger image)
<b>Optimal Visual Acuity</b>	7.1 feet	7.8 feet

### Resolution – rear-projection DLP display wall cubes can be upgraded

Currently, the resolution of the LCD display wall panel is fixed (HD: 1920 x 1080) with an LED backlight. This is standard and cannot be upgraded without replacing the entire array of displays when newer resolutions or light sources become available.

Rear-projection DLP display wall cubes can be upgraded from XGA (1024x768) to SXGA+ (1400 x 1050) resolutions within the same cabinet and screen structure, by simply replacing the engine. Similarly, lamp-based cubes (single or double lamp) can be upgraded to the latest LED light source within the same cabinet and screen structure. The same would be true for any future 16:9 or 16:10 aspect ratio resolution.

### Duty Cycle – DLP Display Wall Cubes Have a Longer Anticipated Life

LCD display wall panels are rated with up to 60,000 hours backlight life. However, there is no system MTBF published for the entire device, which is a better indication of how long the unit is likely to last.

Rear-projection DLP cubes with LED light source clearly list anticipated life of all major components.

For example, in Mitsubishi Electric display wall cubes:

- Fans are designed with an anticipated life of 100,000 hours (11+ years).
- LED modules are designed with an anticipated life of 80,000 hours (9+ years) in normal operations

A comprehensive list of parts and sub-assemblies with MTBFs is available, which gives a true indication of the display wall system's anticipated lifespan.

### Response time – Cubes Have a Significantly Faster Response Time

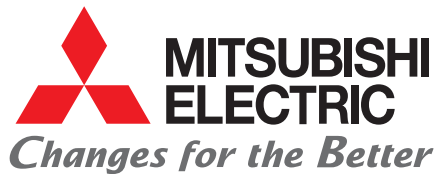
Response time or latency indicates how fast the monitor can display moving images. If a display's response time is too slow, the display's pixels can't keep up with the information sent from the computer's graphics card, resulting in digital noise and/or ghosting.



The response time of LCD display wall panels is rated at 8 milliseconds. DLP technology has a response time of approximately eight microseconds or 1,000 times faster than the LCD response time.

#### Power consumption – Cubes Have Lower Power Consumption and BTU's

DLP display wall cubes have a lower power consumption and lower heat dissipation when compared to similar sized LCD display wall panels. This translates into reduced on-going operational costs throughout the life of the control room.



*This report has been created by Mitsubishi Electric US Visual & Imaging Systems Division ([www.me-vis.com](http://www.me-vis.com)) and Mitsubishi Electric Sales Canada ([www.mitsubishielectric.ca](http://www.mitsubishielectric.ca)).*

*Mitsubishi Electric, one of the core companies that comprise the \$40 billion multi-national Mitsubishi Group, is the global leader for command and control display wall products, with a wide variety of rearprojection DLP display wall cubes and LCD display wall panels. This report has been created agnostically to compare the two technologies and for certain specifications, is based on Mitsubishi Electric products.*

#### Sources

1. Fujitsu Microelectronics America, Inc. "Fundamentals of Liquid Crystal Displays- How They Work and What They Do." 2006
2. "How Digital Light Processing Works". THRE3D.com. Retrieved 3 February 2014.

*DLP is a registered trademark of Texas Instruments.*