The Technology War: LCD vs. DLP

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Introduction

If you are new to the world of digital projectors, you won't have to shop around long before discovering that the terms LCD and DLP refer to two different kinds of projectors. They are in fact two different kinds of micro display imaging technology. You might not even know what LCD and DLP are before asking the obvious question "which one is better?"

The answer is simple--neither one is better than the other. They both have advantages over the other, and they both have limitations. Both technologies are much better than they used to be. The purpose of this article is to discuss how they differ today, so you can determine whether the imaging technology itself is a relevant factor in your choice of a projector.

It is important to note there is a third significant light engine technology called LCoS (liquid crystal on silicon). It is developed and marketed by several vendors, most notably Canon, JVC, and Sony. Many excellent projectors have been made with LCoS technology, including several outstanding home theater projectors that can, in the opinion of many observers, surpass the value proposition of both LCD and DLP offerings. The discussion of LCoS technology is beyond the scope of this article, and will be addressed separately in an upcoming article.

Is it 3LCD or LCD?

You may have already seen the term 3LCD on websites and in projector literature and press releases. Several makers of LCD projectors have adopted 3LCD as a marketing brand name. It is intended to distinguish the specific implementation of LCD technology found in digital projectors from the more common direct view LCD displays found in a wide variety of consumer products. In LCD projectors there are always three LCD panels, and they are always light transmissive devices rather than reflective or direct view displays. Within the projector industry, there is no technical difference between 3LCD and LCD, and the terms can be used interchangeably.

Which Technology Leads the Market?

Well, the answer to this question depends on your definition of the word "lead." As of this writing, DLP technology has a significant lead in terms of the number of models currently in production. As of this date, July 28, 2009, our database lists 704 different DLP-based models in production, as compared to 430 LCD models. Thus, DLP holds a commanding lead in the number and variety of models being produced.
However, this is not the whole story. Many of the best selling projectors these days are LCD models. As an example, at the moment, six of the Top 10 Most Popular 1080p home theater projectors on this site are LCD's, two are DLP and two are LCoS. In fact, despite the clear advantage DLP has in the number of models in production, Pacific Media Associates reports that LCD projectors held a 51% market share by unit volume in 2008. Clearly both technologies have a huge market presence, and neither one is about to emerge as the dominant player.

The Technical Differences between 3LCD and DLP

**LCD (liquid crystal display)** projectors contain three separate LCD glass panels, one each for the red, green, and blue components of the video signal. Each LCD panel contains thousands (or millions) of liquid crystals that can be aligned in either open, closed, or partially closed positions to allow light to pass through. Each liquid crystal behaves in essence like a shutter or blind, and each represents a single pixel ("picture element"). As red, green, and blue light passes through the respective LCD panels, the liquid crystals open and close based on how much of each color is needed for that pixel at that moment in time. This activity modulates the light and produces the image that is projected onto the screen.

**DLP ("Digital Light Processing")** is a proprietary technology developed by Texas Instruments. It works quite differently than LCD. Instead of having glass panels through which light is passed, the DLP chip is a reflective surface made up of thousands (or millions) of tiny mirrors. Each mirror represents a single pixel.

In a DLP projector, light from the projector's lamp is directed onto the surface of the DLP chip. The mirrors tilt back and forth, directing light either into the lens path to turn the pixel on, or away from the lens path to turn it off.

In the most expensive DLP projectors, there are three separate DLP chips, one each for the red, green, and blue channels. However, in most DLP projectors under $10,000 there is only one chip. To define color, a color wheel is used that contains (at minimum) a red, green, and blue filter. This wheel spins in the light path between the lamp and the DLP chip and alternates the color of the light hitting the chip from red to green to blue. The mirrors tilt away from or into the lens path based upon how much of each color is required for each pixel at any given moment in time. This activity modulates the light and produces the image that is projected onto the screen.

(Note: In addition to red, green, and blue filters, most color wheels contain other segments as well. A "white" or clear filter used to boost brightness is common in business/commercial projectors, and many color wheels have filters for colors other than the primaries, such as dark green, cyan, magenta, or yellow.)

The Advantages of DLP

We will look at the advantages and limitations of both DLP and LCD in turn. The most important advantages of DLP technology include the following:
**Sealed imaging chip.** Most DLP projectors have sealed DLP chips that eliminate the possibility of a dust particle alighting on the imaging plane, which could create a dust spot on the projected image. LCD projectors do not have sealed panels, and the possibility of getting a dust spot exists. This is especially true when air filters are not cleaned periodically as per operator manual instructions.

**Filter-free.** DLP projectors that have sealed DLP chips can operate without air filters. Thus maintenance is reduced since there is no need to periodically clean or replace filters. Some vendors represent their DLP products as maintenance free, other than the occasional lamp change and dusting of the case and lens. Others don't go quite that far, and recommend a periodic vacuuming of the air vents to limit the amount of dust getting into the unit. The vast majority of DLP projectors on the market do not have air filters, but some of the most expensive high performance 3-chip DLP models do, as do a few earlier generation DLP models that may still be in use.

Whether filter-free design is a true advantage to the user is a matter of competitive debate and controversy. In most DLP projectors, components other than the imaging chip itself are not sealed and can be adversely affected by a build-up of dust. In particular, dust on the color wheel may affect color and image quality. Dust particles can burn or melt when coming into contact with the lamp surface, thereby accelerating the degradation of lumen output over the life of the lamp. The degree to which a filter-free projector might be adversely affected depends on how much dust there is in the operating environment. Texas Instruments maintains that the amount of dust found in a normal room environment will not adversely affect the operation of a filter-free projector. Those who advocate the use of filters maintain that air filters will prevent an accelerated degradation of the lamp's lumen output, even in normal room conditions.

Recognizing dust as a potential problem, Mitsubishi has taken extra steps to combat dust contamination in their latest filter-free DLP projectors, the XD3200 and WD3300. They have sealed the color wheel to prevent dust from reaching it. They have also made design improvements to the light pipe and airflow channels which reduce the amount of dust that can reach the lamp. These changes are intended to help maintain the lamp's lumen output potential over its lifespan.

Those who advocate using air filters on projectors maintain that dust is never good inside a projector, and that the user is better off with a filtered design that prevents dust from entering the projector to begin with. All LCD projectors use air filters, as do some of the higher end 3-chip DLP models from vendors such as Runco and Digital Projection.

Those who support filter-free designs point out that many users of filtered projectors do not follow recommendations for cleaning or replacing air filters. If an air filter gets clogged over time, it can inhibit airflow, increase internal operating temperatures, and adversely affect the life of the LCD panels.

**No convergence problems.** All projectors using three imaging devices, whether they are LCD, DLP, or LCoS, must have all three devices aligned perfectly so that the red, green, and blue information for each pixel is in convergence. Over time, these three device systems can slip out
of alignment. On occasion they can come out of the box, brand new, with slight convergence errors. Convergence errors can soften the projector's image and create color artifacts where there shouldn't be any.

The single-chip DLP design has a unique advantage over all three-chip or three-panel systems: since there is only one imaging chip, convergence problems don't exist. There is simply nothing to go out of alignment.

**Contrast advantages.** Most business class DLP projectors (those intended for portable presentation or conference room use) have much higher Full On/Off contrast ratings than comparably priced LCD models. ANSI contrast figures are rarely published in the projector industry, but our measurements indicate DLP projectors usually have an edge over the LCD competition in ANSI contrast as well. However, with the introduction of inorganic LCD panels that are now used in most LCD 1080p home theater products, DLP's traditional advantage in contrast within the home theater market niche has been neutralized to a large extent.

**No image persistence.** If one displays a static image for an extended period of time, an LCD projector with organic LCD panels may have a tendency to retain a subtle ghost of that image even after the subject matter is switched to another image. This does not occur on a DLP projector. Nor does it occur on LCD projectors that use inorganic panels.

Some of the advertising hyperbole has blown the seriousness of this issue out of proportion. Anti-LCD ads have claimed that LCD projectors are subject to "burn-in." Strictly speaking, this is not really true. Burn-in, in traditional usage, refers to permanent damage that can be suffered by CRT or plasma phosphor-based displays. Once a static image has been etched into a phosphor display through long term exposure, it cannot be removed. This is a different phenomenon than we see on LCDs. On organic LCD displays, when image persistence occurs, it is temporary and can normally be erased by displaying a white screen for a period of time.

Nevertheless, the point is that image persistence does not occur on either DLP projectors or inorganic LCD projectors. So on these products there is never any need to take steps to erase a persisting image.

**No degradation of image quality over time.** There is usually no degradation of image quality on DLP projectors when used over long periods of time, other than that which might result from excessive internal dust build-up. But in any event, the DLP chips themselves will not degrade. Conversely, LCD panels and polarizers can degrade with time, causing color shifts, unevenness of illumination, and reduction of contrast. The degree to which LCD degradation is a problem on current products is somewhat of a mystery since those who know the most about it (the LCD manufacturers) don't discuss it publicly. This issue will be discussed further below.

**Somewhat less pixelation/screendoor effect on low resolution products.** One of the historical advantages of DLP over LCD has been a reduced level of pixelation in the image. Pixels tend to have sharper definition on an LCD projector, and this can produce a more visible pixel structure in the image. This is often called the screendoor effect, since the picture on low resolution projectors can look like it is being viewed through a screendoor.
However, the differences between LCD and DLP in this regard are not as great as they used to be for two reasons. First, LCD makers have achieved smaller interpixel gaps, making the screen-door effect much less visible. Second, the average native resolution of projectors being sold today has increased dramatically over what it was several years ago. With increases in resolution come smaller pixels and a less noticeable pixilation across the board. Nevertheless, on low resolution products like SVGA and even standard XGA, DLP projectors still have an advantage in manifesting somewhat less visible pixel structure than LCD projectors. (Note: There is a disadvantage to having less distinct pixel structure, which is reduced image sharpness. We will discuss this further below.)

**DLP leads in miniaturization.** The single-chip light engine affords the opportunity for extreme miniaturization that LCD cannot quite match. At the moment there are 15 DLP projectors on the market that weigh less than 3 lbs and put out more than 1000 lumens. By comparison, the lightest 3LCD projector on the market weighs 3.5 lbs and most are 4 lbs or more.

**Weaknesses and limitations of DLP**

**Color wheels can produce rainbow artifacts.** The problem people point to most frequently as a weakness in DLP is its tendency to produce "rainbow artifacts." Rainbow artifacts (sometimes referred to as color separation artifacts) are momentary flashes of banded color that look like rainbows. They occur at random, and they only last for an instant. But for people who are sensitive to them, they can be quite distracting. If you are engrossed in a film or video, they can take you entirely out of the video experience.

Rainbow artifacts are a problem only on single-chip DLP products, and for the most part, only those using slower speed color wheels. They can also occur on LED-based models due to the sequential strobing of red, green, and blue LEDs. Typically the problem manifests itself when the viewer is watching movies or video. When viewing static images such as presentation charts or photographs, people generally do not experience the problem.

The rainbows occur because of the sequential color updating from the wheel or LED. As the color wheel spins or the LEDs change, the image on the screen is either red, green, or blue at any given instant in time. The technology relies upon your eyes not being able to detect the changes from one to the other. However, when your eye moves rapidly in response to some movement in the picture, you can get a red, green, and blue update on three different points on your retina, thus producing the impression of a rainbow. Not everyone perceives rainbows the same way. Many people have less sensitive eyes and cannot detect rainbow artifacts at all. Others see them quite readily. There is no way to know whether you are among those who can or cannot see them except by watching a DLP projector yourself.

Since LCD projectors and 3-chip DLP projectors always deliver a constant red, green, and blue image simultaneously, they do not create rainbow artifacts.

On DLP projectors with color wheels, rainbow artifacts are reduced by increasing the speed of the wheel. The first generation DLP projectors incorporated a color wheel that rotated sixty times per second, or 3600 RPM. With one red, green, and blue filter in the color wheel, updates on
each color happened 60 times per second. This rotation speed in the first generation products was known as a "1x" rotation speed. In second-generation DLP products, the color wheel rotation speed was doubled to 2x, or 7200 RPM. The doubling of the color refresh rate reduced the time between color updates, and so reduced the visibility of rainbow artifacts for most people. But a 2x rotation speed was still not fast enough for products to be used in home theater and video applications.

Today, some DLP projectors being built for the home theater market use a color wheel containing two sets of red, green, and blue filters. This wheel still spins at 7200 RPM, but because red, green, and blue are refreshed twice in every rotation rather than once, the industry refers to this as a 4x rotation speed. And by increasing the physical rotation speed beyond 7200 RPM, some projectors now have 5x or 6x speed wheels. For the large majority of users, the 5x and 6x speed wheels in most current home theater models have reduced rainbow artifacts in video display to the point where they are of little or no concern.

However, most DLP projectors built for commercial/presentation use still use 2x speed wheels because they are less expensive. This is perfectly fine if the presentation matter is static charts, graphics, photography, or anything that does not stimulate rapid eye movement. We do not recommend DLP projectors with 2x speed wheels to buyers for whom video display or part time home theater are important intended uses.

**Color saturation/color brightness.** Some DLP projectors have excellent color saturation, and some are exceptionally poor. This is related more to the vendor's implementation than anything inherent in the technology itself. Advocates of 3LCD technology have been quite vocal about the lack of color brightness on single-chip DLP products, particularly those that have white segments in the color wheel. This phenomenon is worth commenting on.

When a color wheel has a white (clear) segment, the lumen output of the projector is increased dramatically, and the ANSI lumen rating skyrockets. Most business class DLP products have white segments in the wheel to boost the all-important lumen rating. Conversely, most DLP projectors built for home theater have no white segments because they can compromise color saturation and the overall balance of the video image. Moreover, the lumen rating is not a big driving factor in the sale of home theater projectors.

When you use a light meter to measure the brightness of red, green, and blue on an LCD projector, the sum of the values usually adds up to the brightness reading you get for white. This makes sense because on an LCD projector, white is created by turning the red, green, and blue channels all fully on. But on a DLP projector, this is often not the case. Due to the presence of a white segment in the wheel, the white reading can be as much as double the sum of the brightness readings for red, green, and blue. In other words, if an LCD projector measures 2000 lumens of white light, you will also get 2000 lumens of color light out of it. If a DLP projector measures 2000 lumens of white, you might get only 1000 lumens of actual color light from it, the rest being white light.

Because of this, proponents of 3LCD technology have been lobbying for color brightness specs to be included along with ANSI lumen specs on the industry's specification sheets, and support
for this has been building in the industry. In the spec wars, quite clearly this would be one metric on which LCD has a commanding advantage over DLP. Not surprisingly, Epson and Sony have already begun to publish color brightness specs on their LCD projectors to drive home the point. The color spec is always the same as the ANSI lumen rating, and the specs will read, as an example, "2600 lumens color light output, 2600 lumens white light output."

As a rule, DLP projectors with a white segment in the wheel do not look very appealing when measured for color brightness. The color reading always fall short of the white reading, and sometimes it falls short by 50% or more. This is especially true when the color wheel contains the basic red, green, blue, and white filters only. Many DLP projectors have complementary color filters such as cyan, magenta, and yellow. In this situation the color brightness measurements become more problematic. Thus we can understand why Texas Instruments and the DLP projector vendors have little interest in publishing color brightness specifications.

From a practical perspective, we have mixed feelings about all of this. Clearly, the 3LCD camp is correct that the traditional ANSI lumen spec does not tell the whole story. But neither does the color brightness spec. To be sure, the color on some DLP projectors looks dull and anemic next to some LCD models of the same lumen rating. Ironically, this can be particularly true when the "BrilliantColor" feature is enabled. Though BrilliantColor boosts the brightness of the image, it can substantially reduce color saturation in the process. It is peculiar that in order to get the richest and most saturated color from many DLP projectors, one needs to turn BrilliantColor off. (This is not universally true of all DLP projectors with BrilliantColor, since the BrilliantColor system can behave quite differently based on how it is implemented by the vendor.)

Oddly enough, on some DLP models with white segments in the wheel, even those on which color brightness falls far short of white, we see a rich, vibrant color that can easily match an LCD projector in the same price and lumen class. One reason is that the color filter configuration of the wheel has a lot to do with the end results. Another reason is that, though the DLP's color brightness may fall short of white, the effect of the DLP's inherent contrast advantage helps to compensate for it. That compensating effect cannot be quantified in a spec. Even when color brightness falls very far short, the picture sometimes does not end up looking much dimmer at all when put side by side with an LCD projector of the same white light output.

When a DLP projector's color vibrancy looks poor next to a comparably priced and spec'd LCD projector, it is due to a variety of design and product cost decisions made by the vendor, and not anything inherent to DLP technology per se. DLP can look truly spectacular or downright dismal depending on what is done with it. With so many variables in play, the specs can't tell the whole story, even if a color brightness spec were added to the mix. The publication of color brightness specs would be interesting, and would certainly draw attention to a noteworthy technical difference between LCD and DLP. But it is not conclusive information that would help an astute buyer sort out which model to buy.

**Dithering artifacts.** At any moment in time, each mirror position on a DLP chip is either fully on to render maximum brightness, or fully off to render black. There is no way a DLP mirror can be "partially on" to represent gray, like an LCD liquid crystal can. Therefore, the way the DLP chip renders gray is to flip the mirrors on and off very rapidly, such that they are on just enough
of the time for the eye to average the "on's and off's" to a desired level of perceived brightness. This approach to rendering grays is called dithering. It works well enough for rendering gray values, but it can produce some visible instability in solid fields, mostly dark areas, referred to as dithering artifacts. It looks like digital noise, but it is a separate type of artifact caused by DLP technology itself, and not by the signal.

Dithering artifacts do not occur on LCD products because there is no dithering used to achieve varying levels of gray. The liquid crystals can be either fully open, or closed, or partially opened at intermediate positions to achieve the desired level of light transmission--again, similar in concept to shutters on a window.

**Restricted compatibility with zoom lenses and lens shift.** Due to the nature of DLP light engine mechanics, it is difficult for vendors to incorporate long zoom lenses or extended range lens shift features into a DLP projector. These limitations are not relevant in mobile presentation projectors since the primary design objective is small physical size, so none of them have big zooms or lens shift anyway. But in the home theater market in particular, LCD vendors have captured significant market share in part due to their ability to incorporate long 2.0x zoom lenses and extensive lens shift capability into LCD projectors. This makes it much easier for the consumer to install the projector anywhere they want, which is quite frequently on a rear shelf in the room. Due to lens restrictions on DLP projectors it is rare to be able to install a DLP model on a rear shelf.

**The Advantages of 3LCD**

Many of the advantages and limitations of 3LCD have already been touched on above within the context of the DLP discussion. However, there are several advantages of LCD not yet discussed, and some of the issues already noted warrant a recap and/or further expansion. The following are the key benefits of LCD technology:

**Better price/performance in HT products.** The primary key to the success of LCD products in the home theater market is their tremendous price advantage. In the 1080p niche in particular, LCD products deliver outstanding image quality performance for the money. Moreover, they are generally loaded with extra features that don't appear on DLP models in the same price range, if they are offered on any DLP model at all.

The price advantage of LCD over DLP is most obvious in consumer/home theater products. There is no similar disparity in pricing on commercial products built for mobile presentation and conference room use. One reason is that DLP makers can use the cheaper 2x speed wheels on most business products, whereas it is mandatory to have high speed color wheels and the faster electronics associated with them on products designed for home theater.

**Higher contrast in HT products.** Many LCD projectors built for home theater have achieved better overall contrast performance and deeper black levels than DLP models. This is specifically the case on LCD models using inorganic LCD panels and auto iris technology. Inorganic panels are more expensive to produce, so they are not used in cheaper, commercial grade business projectors. They achieve higher contrast due in part to the fact that the resting position of the
liquid crystal is closed (i.e., black), and voltage is required to open it. This is the opposite of traditional organic LCDs wherein the resting position is open (maximum light transmission), and voltage is required to close it. The inherent contrast advantage of inorganic panels has made LCD substantially more competitive in the home theater marketplace. ANSI contrast in particular has seen significant improvement. In our measurements, LCD projectors with organic panels typically run in the range of 250:1 ANSI contrast, whereas the models with inorganic panels have been reaching performance levels of 400:1 to 450:1.

3LCD vendors have been aggressive in developing effective auto iris systems which contribute an incremental perceived contrast advantage on screen. There is no technical restriction that we know of that would prohibit DLP vendors from doing the same thing. But it would add further cost to DLP projectors that are already at an apparent cost disadvantage relative to LCD in the home theater market. There is also a perception among vendors that DLP contrast, while not leading edge, is sufficient, so enhancement via auto iris is not vital. Thus, most DLP vendors have been slow to incorporate auto iris systems on DLP projectors being marketed for home theater.

**Fewer artifacts/greater image stability.** As noted previously, dithering artifacts and rainbow artifacts are unique to single-chip DLP projectors. Since these artifacts do not exist on LCD products, it is not unusual to perceive a more stable video image on an LCD projector when viewed side by side with a DLP counterpart in a similar price and performance class. The LCD's video image can look cleaner and more free of noise.

**Sharper image with data display.** Since LCD pixel structure is more sharply defined than DLP pixel structure, it tends to render a sharper image. This is most noticeable in lower resolution business products (SVGA and XGA), and specifically with data display. It is in these resolutions that LCD's screendoor effect is somewhat more visible in a video image, but the advantage is that the sharper pixel definition can produce a sharper display of data. By comparison, a DLP projector in SVGA and XGA resolution can look a bit soft when displaying data images.

On higher resolution products the difference in apparent sharpness is minimal, and it is a non-issue with video display on 1080p products. Both technologies can produce very sharp images in 1080p, and any perceived differences in sharpness typically have to do with factors unrelated to the display technology, such as lens quality and video processing.

**Greater installation flexibility in HT products.** LCD projectors built for home theater often feature 2.0x zoom lenses and extensive vertical and horizontal lens shift. This makes them easy to install just about anywhere. By comparison, DLP projectors usually have short zooms with little or no lens shift. Fixed throw angles limit the projection geometry, and often dictate where a DLP projector must be placed in order to accommodate a given screen size and location.

For the DIY home theater enthusiast on a budget, the lens flexibility of LCD models has great appeal. For the fact is, most DLP projectors need to be ceiling mounted, and most LCD projectors don't. Thus they save the extra cost of a ceiling mount and long run video cables. They also eliminate the prospect of having to run cables through walls and ceiling, or living with an unsightly track of cables across the ceiling.
**Better light efficiency, less power usage.** LCD technology is inherently more light efficient. For the most part LCD projectors use lower wattage lamps to produce the same image brightness that you'd get from DLP. This is most noticeable when comparing LCD projectors to DLP projectors that have no white segment in the color wheel. As an example, compare two currently popular 1080p home theater projectors—the Panasonic AE3000 LCD projector uses a 165-watt lamp to produce 1600 ANSI lumens. Meanwhile, the Sharp Z15000 DLP projector needs a 250-watt lamp to get the same 1600 lumens. That can make a noticeable difference in power consumption. It can also make a difference in the amount of heat being generated by the projector's exhaust in the viewing room.

**Weaknesses and Limitations of LCD**

**Unknown lifespan of LCD panels.** Given enough prolonged exposure to high intensity UV light and extreme heat, the organic compounds used in most LCD panels are expected to degrade over long periods of time. This degradation can lead to a discoloration of the image and a reduction in contrast. The only way to fix it is to replace the damaged LCD panel, which is typically a cost-prohibitive proposition. You are normally better off buying a new projector.

The big question of course is how long the panels will last. There is no good data on this subject that has been compiled by an independent lab and published for general consumption. LCD vendors do not typically acknowledge LCD degradation can occur, so they don't make any representations about expected life. In general, most LCD vendors maintain that to the degree LCD panels might be subject to eventual degradation, it will be beyond the practical life of the product.

One trusted and very experienced industry source who develops products using both LCD and DLP technology believes that LCD panels have a lifespan in the range of 4,000 to 10,000 hours, with the lifespan depending on how bright the projector is—the brightest LCD light cannons will produce the most stress on the panels resulting in quicker degradation. Low brightness models such as those made for home theater will produce the least stress, and are expected to last longer.

Texas Instruments has performed several tests on LCD lifespan over the past seven years. Based on these tests, they believe that LCD panels will degrade faster than the LCD vendors are willing to admit, and certainly more quickly than the 4000 hours just quoted. The 3LCD camp’s response is that TI's tests have been performed by running LCD projectors continuously 24 hours a day, 7 days a week, for several months straight. According to 3LCD and Epson, since the projectors used in TI's lab tests were never designed for a continuous operation high-stress duty cycle, the results are not indicative of what the typical user would experience.

The introduction of inorganic LCD panels is an important new development that is germane to this issue. Inorganic LCD panels, in theory, should not be subject to the same degradation patterns as organic LCDs, simply because the organic compounds that fail under intense heat and UV light are not present in inorganic LCDs. However, the LCD camp will not confirm or deny any anticipated differences in panel life because as a matter of policy they do not discuss the issue at all. Texas Instruments has not commented on the expected lifespan of inorganic LCDs either.
**Lower contrast ratings in business products.** Most commercial and education LCD projectors are made with the relatively inexpensive organic LCDs and no auto-iris. Contrast ratings on these models typically run in the 400:1 to 700:1 range. Meanwhile, DLP projectors in the same resolution, lumen, and price class can often be rated at 2000:1 or higher.

In reality, this constitutes more of a marketing disadvantage than a technical one. In most business/commercial and classroom settings, projection display is done with room lights on. With moderate ambient light--enough for children in a classroom to take notes for example--a projector's contrast rating is largely irrelevant. Actual contrast on screen with moderate ambient light is typically in the range of 50:1 regardless of the theoretical contrast potential of the projector. But for buyers who are not aware of the huge impact of ambient light on contrast ratios, the apparent advantage of DLP over LCD in contrast ratings can appear to be more significant than it really is.

**Susceptible to dust spots.** Since LCD light engines are not sealed, it is possible for dust particles to alight on the LCD panels, thereby creating a dull, indistinct spot on the projected image. This usually causes little distraction when displaying static images such as data or photographs. But in full motion video, seeing a stationary element in a moving picture can be extremely distracting.

When dust lands on an LCD in the red or blue channel it is rarely visible enough to create a distraction. But when it occurs in the green channel it can become quite visible. Some vendors have provided methods by which the user can remove the dust without having to send the unit in for cleaning. Sanyo's home theater models come with a hand pump that will blow a jet of air across the panels, but since we've never seen a dust spot on a Sanyo projector, we've never been able to test the device. Other than this sort of solution, packing the projector up and sending it to a maintenance depot for cleaning is the method of last resort for getting the projector back into serviceable shape.

LCD makers claim that today's air filter systems are superior than those of the past, and that dust contamination is highly unusual if the filters are cleaned and replaced as per normal maintenance instructions. Most LCD vendors cover dust removal under warranty, which is a good reason to buy LCD projectors with extended warranties.

When we review projectors, we have no way to assess the actual risk to the user of dust contamination on any particular model. We can say that it is rare for us to notice dust spots on LCD projectors that we get in for review, or on units that we keep in operation for ongoing reference purposes. However, it is easy for users to forget to clean filters since under normal usage vendors recommend this be done every two months or so. When filters are left unattended, the user increases the risk that dust will eventually find its way into the projector.

**Conclusion**

The fight for market share between 3LCD and DLP continues at a fevered pitch. It is a fascinating thing to watch as vendors of both technologies continue to innovate to stay a step ahead of the competition. Picture quality in digital projectors has improved dramatically over the past decade with significant increases in contrast, resolution, and color performance. Prices have
dropped like a rock, and high quality projection systems that once were within financial reach of wealthy consumers or businesses who really needed them, are now within the budgets of mass consumers. Thus the consumer is the ultimate beneficiary of the intense competitive struggle between the DLP and 3LCD technologies.

As we've tried to make clear in this article, both DLP and 3LCD have key advantages over the other. They also both have limitations that the buyer should be aware of. But in the end, we see better image quality performance today from both LCD and DLP than we've ever seen in the past. And it just keeps getting better.