Choosing a Video Projector

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Originally published: February 1996
Last updated: January 2001

Courtesy of: Conceptron *Associates*

Introduction

Video projectors come in a wide variety of flavours, from a compact unit smaller than a notebook computer to a 700 Kg behemoth – the one you should choose depends on your application. *It is critical that the projector type and specifications be matched to your signal source, your projection screen, and your use (present and future)*.

CAVEAT: Any article written about video projection technology has a limited life – this technology can change significantly in six months. A one- or two-year old article may be out of date – we will try to update this article periodically (check the mast head for the update date).

We will cover the pros and cons of different projector technologies later in this article. Initially all you need to need to know is that there are two broad types: **fixed resolution projectors** that convert all input signals to a single fixed display resolution; and **multi-scan projectors** that will lock to any input signal within their range of resolutions (generally, CRT-based).

How much resolution do I need?

The simple answer is: as much as you can afford. The trend in computer graphics is towards higher and higher resolution. What may be high resolution today, may be considered standard in two years.

The more complicated answer is that you need to consider the type of presentation you are making, the output resolution of your computer, and the desired image quality. If you are showing a few bullet points on a coloured background, then 800 x 600 (SVGA) resolution will do just fine. If you are showing detailed images such as spreadsheets or photographic images, you will need higher resolution – from the source through the entire signal processing chain.

The first consideration, of course, is the available output resolutions of the computer you will use to generate the images. The best quality projected image will result when the native resolution of the projector exactly matches the output resolution of your computer (or, failing this, is higher). If your application is a boardroom or similar multi-use facility, then you will need to consider the average resolution of notebook computers currently on the market.

Currently, 1024 x 768 (XGA) is considered to be the standard graphics resolution for an installed video projector; 1280 x 1024 (SXGA) is considered high-resolution (i.e.: some future-proofing, but at a higher cost); and anything higher is very high resolution (high-end graphic workstation quality or specialised applications). Buying a projector with only 800 x 600 resolution may save some money on the initial purchase, but may prove to be false economy in the long run. If your computer outputs a signal at a higher resolution than the fixed display will allow, the projector will down-convert the graphics to its native resolution. Some projectors will simply leave out every *n*th line, while others will use intelligent processing – either way, **you will lose resolution**, and the results are typically less than desirable.

NOTE: as the resolution of the source and projector increase, so do the demands on the rest of the video system. This is a frequently overlooked area. Your substantial investment in a high resolution projection system will be ***completely wasted*** if the interface units, switchers, and even the video cables are not capable of handling the higher bandwidth required of these displays. A common bandwidth specification for graphics systems today is 300 MHz (-3dB) – this figure will continue to rise as the graphics resolution requirements go up.

Be sure to anticipate your future needs! Saving $5,000 on the initial purchase of a projector is false economy if six months down the road you decide you want to display high-resolution graphics, and the projector won't do it.

Is It Bright Enough?

It is important that the image be bright enough for both the application and the venue. For example, if you are in a lecture or seminar situation, the ambient light in the room will be much higher than in a more controlled environment such as a theatre. The ambient light should be at least 54 lx (5 fC) for note-taking.

There are ANSI/SMPTE standards that define optimum screen luminance levels. A detailed calculation must be done to determine the required projector brightness based on this luminance requirement, the size of the screen, the gain of the screen, the reflectivity of the screen, and the ambient light level. Once you have done this, you will have a projector brightness target in ANSI lumens. **If such a calculation is not done, your choice of projector brightness is a pure guess** – you can have just as many imaging problems from a display that is too bright as with one that is not bright enough.

When comparing brightness specifications, be sure to compare apples with apples. The majority of manufacturers will quote brightness measured according to the ANSI standard ('ANSI Lumens'), but some may use other methods. These other specifications cannot be meaningfully compared.

For LCD and DLP projectors, three-element projectors will generally be brighter than a single-element unit – colour saturation also suffers in a single-element device. Be wary of a projector that claims higher light output than its closest competitors in the same class. Observe this projector carefully to ensure that whites do not have a greenish tinge. The green portion of the spectrum is perceived as (and measures) brighter than the red or blue. Some manufacturers will increase the green ratio to achieve a higher lumen rating (at the expense of pure whites).

Uniformity of brightness is also an important consideration – many manufacturers will publish a specification for this. It is important that the projector spread its light output evenly over the projected image (i.e.: you don't want an image that is brighter in the centre than in the corners).

Note that LCD projectors will generally drop in brightness as the graphics resolution increases – the opposite is true for DLP projectors. Any projector that relies on an incandescent light source (i.e.: LCD, DLP, and light valve) will lose brightness, and will likely experience a colour shift, as the lamp ages.

Contrast Ratio

Contrast ratio is as important as brightness, and ***is often misunderstood or totally ignored***. Contrast ratio is a system-wide problem, and the final perceived image quality will be affected by the element in the chain that is weakest. In an **ideal** projection situation we try for between a 400:1 and a 600:1 ANSI screen contrast ratio. This is achieved by a combination of the projector brightness, the screen construction, and the ambient lighting – we are assuming, of course, that the source material has a decent contrast ratio.

While these contrast ratios are easily achievable with film or slides, **video projectors do not normally come close to this level of contrast ratio** – typical video contrast ratios range between 100:1 ANSI and 200:1 ANSI. To compound the problem, it is very difficult to get accurate figures from the manufacturers – figures are either quoted as "contrast ratio," with no indication of the measurement method, or "full white," or "ANSI" (this is the only figure that can be accurately compared), or nothing at all. Thus, it is critical that the screen and the ambient lighting be designed so as not to degrade the situation further.

Remember: a projector cannot actually project "black" – in an ideal world, it would simply project nothing (no light) when required to show black. To quickly evaluate your projection system's contrast ratio, therefore, set up the lighting conditions as they will be when viewing the presentation, turn off the projector, and look at your screen. What you are looking at is the blackest black you will ever see – if you are seeing a bright white screen, you obviously have a problem.

The Players

Video projectors can be loosely grouped into four categories. Here is a brief overview of each:

1. Fixed-Resolution Projectors

LCD: Light is passed through a **L**iquid **C**rystal **D**isplay element.

Lowest contrast ratio of all fixed resolution technologies. Space between pixels occupies 40 to 60% of the active image area, resulting in a visible pixel grid ("screen door" effect). Currently available up to 1280 x 1024 (SXGA). Quite compact and portable. Standard units can range from about $5K to $20K US. **We only recommend three-chip units**, as the lack of contrast from single-chip projectors is, in our view, objectionable.

DLP: **D**igital **L**ight **P**rocessing uses a semi-conductor imaging chip developed by Texas Instruments called a DMD (**D**igital **M**icromirror **D**evice). Each pixel consists of a mirror on a micro-motor armature. When the pixel is "on," the mirror is oriented so that the light source is reflected through the optical chain. When a pixel is "off," the mirror is oriented so that the light is deflected out of the optical path.

Highest contrast ratio of any fixed resolution device. Space between pixels occupies 10 to 12% of the active image area, resulting in a much less visible pixel grid. Currently available up to 1024 x 768 (XGA). Very compact and portable. Standard units range from about $4K to $12K US. **We only recommend three-chip units**, as the flicker and rainbow artefacts from single-chip projectors are, in our view, objectionable.

Reflective LCD: Light is reflected through an LCD matrix by a mirrored substrate behind the panel.

Excellent contrast ratio. Transistor switches that control each pixel are located behind the reflective surface, rather than embedded in the LCD material as with conventional LCD technology. Thus, the space between pixels occupies only 7% of the active image area, resulting in a virtually invisible pixel grid. Currently available up to 1280 x 1024 (SXGA) with 2048 x 1536 (QXGA) slated to come out this year (2001). Relatively compact and portable. Standard units can range from about $9K to $25K US.

Each of these technologies uses an incandescent lamp source and a single lens – often optional lenses (i.e.: various focal lengths), including zoom lenses, are available. Brightness is generally between 600 and 3,000 ANSI lumens, with 1,000 being average. High-power units for large displays are also available (see Large-Venue category below). Contrast ratio is, on average, about 150:1. Support video plus graphics. Since the display elements are fixed resolution devices, lower and higher resolutions are internally converted to this fixed resolution. Minimal set-up is required – these require no convergence. Unlike a CRT projector, however, compensation for keystoning, skew, and bow is impossible – making this an unsuitable choice for a difficult projection geometry or a curved screen.

Because the display resolution is fixed, ensure that the graphics resolution of the display element is sufficient for your intended purpose – note that some units are only 800 x 600 (SVGA) and a few are only 640 x 480 (VGA).

We recommend these projectors for general-purpose use. If being used for special effect projection in a themed attraction or planetarium, test the proposed units under simulated conditions – the combination of high-brightness and low contrast ratio may be a problem if the image needs to meld seamlessly into a "black box" background.

2. Multi-Scan CRT Projectors

The original video projector, now mainly used for specialised applications. Uses three CRT's (**C**athode **R**ay **T**ubes) and three lenses. Optional lenses are not normally available (i.e.: the projection distance is fixed for a given image size).

Not considered portable – usually weigh well over 100 lbs. (45 Kg), with some units weighing over 300 lbs. (136 Kg). Brightness is generally between 100 and 250 ANSI lumens, with 200 being average. One current model with 12" CRT's can achieve over 400 ANSI lumens. Contrast ratio is, on average, about 100:1. Support video plus graphics. Graphics resolution is normally quite high (from a minimum of 1024 x 768 to over 3200 x 2560) – have a multi-synch capability that can lock to any resolution within their range. Require technical set-up, as the individual images from each tube must be converged – some units are available with auto convergence. Recommended for unusual projection geometries such as a domed theatre, as they can adjust for keystoning, skew, bow, etc. Typically used in planetarium theatres where a solid black background is required.

3. Large-Venue Projectors

This class of projector is intended for high-brightness, large-screen projection (e.g.: a theatre). They achieve their very high level of brightness by modulating a high-intensity incandescent light source (such as Xenon) with the video signal. It is possible to achieve over 50 times the light output of a CRT projector! At the time of writing, there are four available technologies: DLP, LCD, reflective LCD (sometimes called D-ILA), and light-valve. They usually, but not always, have a single lens, and optional lenses are usually available. High-power LCD, DLP, or reflective LCD units can range from about $12K to $140K US – a typical price is about $45K US. Light-valve projectors are used for digital cinema applications, are extremely high brightness (12,000 lumens), and cost over $200K US.

Brightness is between 3,000 and 12,000 ANSI lumens, with 5,000 being average. Contrast ratio is, on average, about 200:1. Support video plus graphics. LCD, DLP, and reflective LCD projectors are fixed resolution devices, limited by the resolution of the display chip (see the resolution limitations above). Light-valve projectors use CRT's to create an image that is transferred to an LCD layer with no inherent pixel structure, and have the same high resolution and multi-scan capabilities as a CRT projector and can adjust for keystoning, skew, bow, etc..

We recommend these for very large screens, unusually high ambient light levels, or for high-impact situations such as a world's fair, theme park, or museum. Pay particular attention to the modulation method vs. your application. Contrast ratio is an important consideration for entertainment use – DLP and light valve have the best contrast ratio. Test the proposed units under simulated conditions – the inability to go completely black may be a problem for particularly dark environments.

4. Ultra-Portable Projectors

Portable projectors are designed for "road warriors" who want to bring their own projector, rather than depending on an unknown unit for their critical presentation. In an ideal world, these projectors should be as portable as a notebook computer. There are two main categories of these projectors: portables and ultra-portables. While neither have all the features and performance of a permanent installation projector, they can be the means to a truly mobile presentation. If you can live with some compromises, the new breed of ultra-portable projectors may give you the self-sufficiency and freedom you want for giving presentations on the road.

Portable projectors usually weigh between 9 and 30 lbs., with an average of about 15 lbs. They currently range from about $5K US to $15K US, with an average of about $9K US. They are usually equipped with zoom lenses, a variety of inputs, speakers, and fairly impressive image quality.

Ultra-portable projectors usually weigh 8 lbs. and under, with an average of about 6 lbs. – some are even under 4 lbs! Currently, they range from about $3K US to $9K US, with an average of about $6K US. Remember that you never get something for nothing – as you might guess, making a projector smaller and lighter involves some compromises. Other considerations such as built-in speakers, video inputs, a zoom lens, color saturation, contrast, and edge-to-edge image uniformity may be sacrificed or eliminated. Ultra-portable projectors are a hot product and a lucrative new market. A considerable amount of R&D is being expended, and portables and ultra-portables are currently being made by over 25 manufacturers. Note that new models of these projectors appear about every three months.

To determine which features you are able to sacrifice in an ultra-portable, you have to consider your use for one of these projectors. If you solely do computer-based presentations, you may be able to get along without video inputs. If you don't use sound in your presentations, or your notebook speakers are sufficient for the meeting space, you may be able to get by without speakers in the projector. Our recommendation, however, is not to sacrifice a zoom lens for a fixed lens – for the small savings in weight, you are giving up a lot of flexibility. Further, if you can afford both the higher purchase price and increased size and weight, a portable may be a more versatile choice than an ultra-portable.

Scalers, Doublers, & Quadruplers

Composite video was originally designed to be viewed at a distance of 10 feet or greater on a monitor measuring no larger than 19-inches diagonally. When this rather low resolution image is projected and magnified to a much larger image, a lot of problems become evident – one of the most noticeable artefacts are scan lines. Electronic processors have been developed to make a video image look better when projected.

For fixed-resolution projectors, this device is called a scaler. This unit digitises the video signal, converts it to a non-interlaced signal, then scales it to a fixed resolution exactly matching that of the display element in the projector. Although some projectors have built-in scalers, with few exceptions, an external unit will yield a noticeably higher quality result. Factors affecting the quality of a scaler include: the type and quality of video decoder; how the converter deals with horizontal motion; detecting 3:2 pull-down (for content originally shot on film); algorithms used to scale the image; and video processing (such as detail enhancement).

For CRT-based projectors (including light valve projectors), the solution is a scan doubler or, even better, a scan quadrupler. In simple terms, a scan doubler stores the first field of video in memory, combines it with the second field, and then outputs a complete frame as non-interlaced video – thus, eliminating the scan lines. A scan quadrupler actually doubles the number of lines in each field resulting in an effective doubling of the vertical resolution. Many factors affect both the quality and price of a scan doubler/quadrupler including: the type of video decoder used; how the converter deals with horizontal motion; detecting 3:2 pull-down (for content originally shot on film); and video processing (such as detail enhancement). For a scan quadrupler, another quality determinant is the method used to double the resolution (anything from simply repeating lines to intelligently creating new information by real-time interpolation of two or three other pixels). Note that the video projector ***must*** have a higher horizontal scan frequency to be able to project the output of the converter – the original video signal had a horizontal scan frequency of 15.1 KHZ, a scan doubler increases this to 31.5 KHZ, and a quadrupler increases this to 63 KHz. As a matter of interest, scan-quadrupled video is equivalent to about 1280 x 1024 resolution.

Evaluating Projectors

The most important piece of advice we can give is this:

Look at several prospective projectors in an environment that most closely simulates your intended use.

Ensure that you are comparing the various projectors under as similar conditions as possible – the ambient lighting should be at the same level, the screen material and gain should be similar, etc. If you are planning to use rear projection, observe the various contenders on a rear projection screen. This is especially important if the application is unusual (e.g.: a planetarium or a special effect in a themed environment). Characteristics that may not normally be a problem may show up under these special circumstances (for example, some high-quality CRT-based video projectors we know of have a white overscan line at the top of the image – not a problem under normal circumstances, but in a "black box" environment it jumps out and spoils the effect). Here's what to look for:

First, observe the overall image quality. Do the colours seem realistic? Are the colours bright and saturated, or washed out? Are blacks truly black, or are they grey? Are whites truly white, or yellowy or greenish? Is the overall image crisp and sharp, or does it look as if it were behind a dull film? If the projector uses a fixed resolution device (such as LCD or DMD) does the image look obviously "pixelated" from a normal viewing distance?

Next, look at the mechanics of the image. Are the sides of the image parallel? Do the corners form a 90° angle? Does a single colour change in hue as it moves across the screen? Are the edges of objects (and transitions from one bold colour to another) crisp and sharp, without crawling dots? Is the focus uniform across the screen? Is the brightness uniform across the screen, or are there "hot spots"? **NOTE:** this last problem may also be the result of a poorly specified screen.

All of the above observations should be carried out separately with each type of source material you intend to project (e.g.: video, SVGA, and XGA). ***Bring your own source material with which you are familiar***. This should be representative of the type of material you will project.

Operating Costs

Bear in mind that non-CRT projectors use incandescent lamps that require replacement. Lamps used in most standard video projectors range in life from 1,000 hours to 4,000H and range in price from about $300 US to about $600 US. Lamps for large-venue projectors can cost much more, and some are not user-changeable (requiring dealer service). Be sure to factor bulb replacement cost into your operating budget – this is particularly important if the projector is part of a display or exhibit that may run 10 hours a day, seven days a week.

You should be aware that you may not get the full rated lamp life. As a halogen or metal-halide lamp ages, its brightness and colour temperature change. This results in a projected image that is dimmer and more yellowish than when the lamp was new.

Is It Supported Locally?

An important, but often overlooked element is the dealer or manufacturer's level of **local** service. Video projectors require initial set-up, ongoing maintenance, and periodic repair. Ensure that your contractor/supplier can provide this service locally for at least three years. Also consider the service response time vs. your allowable down time (e.g.: a boardroom can probably be down for a few days, a themed attraction cannot).

Summary

The type of projection technology you choose should be carefully matched to the intended use – with an eye to the future. It is important to ensure that the resolution matches any graphics or scan converter you are intending to use. The brightness and contrast ratio must be selected for the intended application, screen characteristics, and environment. Different projectors should be compared under as similar conditions as practical – and one which emulates your intended use as closely as possible. A critical eye is needed to compare units properly. Operating costs are an important, but often overlooked, factor. Local support must be available for ongoing service and to reduce down-time.
