The New Monitors

Technology in Transition

By Lynn Wasnak

Call them monitors or displays, the visual interpreters of digital files are the windows into the soul of digital design and prepress applications. “Monitors should be the simplest part of a system,” says Jeff Stangle, product manager for NEC’s professional FP and FE series CRTs. But when *The Big Picture* went out to ask what’s new in monitor technology, “simple” was not the answer.

Recent changes include the introduction of the new standard for digital visual interface (DVI); incredible complexity and choices in color calibration options; a movement to proprietary ‘perfect flat’ CRT tubes that improve on the ‘flat, square’ model; niche-market use of multiple monitors on one computer (example, Appian), or multiple computers on one monitor (example: NEC); and a renewed debate among professionals about the performance of shadow mask vs aperture grille technologies. New ICC profiles are also brewing, with specified black points as well as white points to improve accuracy in color matching. Today’s need for accurate color is driven largely by e-commerce. Online retailers experience return rates as high as 50 percent on apparel, partly due to uncalibrated home monitors. The color a consumer sees on the screen is not the color she gets in the box, so the item is returned.

There are two basic ways to create color images on monitors. Traditional box-like cathode ray tubes (CRTs) employ a triad of electron beams scanning colored phosphors to create an image. In the newer flat screen liquid crystal displays (LCDs), organic compound crystals covered by colored filters are triggered on and off, digitally. While the CRT market is relatively stable and mature, LCDs are coming up strong, particularly for large office and call center applications. San Jose-based market researcher Stanford Resources Inc. predicts 18 million LCDs will be shipped by the end of 2002.

The transition to LCDs won’t happen overnight--especially for professional print graphics applications. Current LCDs are suitable for web design because the display is crisp and clear, and the resulting image will be seen on a screen in RGB. But for print use, LCDs are more problematical. Our sources say they can’t yet be accurately calibrated, and are not a good match for CMYK. There are other issues, too. (*See box, Ready for Prime Time*). Even if all the LCD technology bugs were worked out there’s a huge base of existing CRT technology that offers reliable graphic foundations.

Now that you’ve seen our landscape view of modern monitors, let’s crop and focus in tighter on each of the issues:

DVI for LCDs and CRTs

If you like acronyms--those zippy abbreviations for complex titles and phrases, such as “radar” for “radio detection and ranging”--you will love the wonderful world of display technology, with its cascading capitalized conglomerations. Spouting off a string of these babies to your boss should put you in the “valuable team member” category. (See Glossary for a little extra help).

But seriously, folks...since the Digital Display Working Group (DDWG) of industry leaders announced the standard for Digital Visual Interface (DVI) in April 1999,

most monitor manufacturers have introduced completely digital LCDs, while including digital options on new CRTs as well. The acceptance of a standard digital interface such as DVI was critical for growth of the LCD market. LCDs create images using digital signals to turn each liquid crystal cell on or off. VGA-type graphics adapters converted digital information to analog, which was then reconverted back to digital by the LCD for image display. Such repeated conversions degrade file information and image quality. With DVI, new digital-based graphics cards will send unconverted information straight to the all-digital LCDs.

Some vendors, such as Apple, already offer digital LCDs for professional graphics use. Scott Brodrick, product line manager for Apple displays, says the primary difference between CRTs and flat panels now is price. More complex production processes make flat panels more expensive. While the restricted viewing angle of LCDs remains a factor, he says, "Most people aren't sharing the monitor, with others looking at it from different angles." With DVI in models such as Apple's 22-in. Cinema display, "You get no distortion whatsoever. You're writing images directly from the graphics card memory right to the screen," he says.

A subset of the standard, known as DVI-I, supports either analog or digital displays. DVI-I interfaces are now offered by a number of vendors, such as Philips, Mitsubishi and NEC. NEC's new Ambix technology features dual connectors—one VGA, one DVI—on the monitor back. "Our customers all say the same thing. They lease the PC, which will only last two or three years, but they'll buy a monitor, because they expect it to last at least five years. If your monitor is going to outlast your PC, you want to be sure it's compatible with the next system you buy," says NEC's product manager Stangle.

CRT's: Shadow mask vs aperture grille

CRT technology may be "mature," but it is definitely not static. Tweaking continues in the two technologies used to separate individual pixels on CRTs: shadow mask, and aperture grille. Both types are heavily used in graphics applications.

A shadow mask tube uses an invar mask with small round holes to prevent the electron beams from hitting the wrong phosphors. Aperture grille tubes use a vertically slit plate to mask those wild beams. Aperture grilles render graphics especially well. However, such tubes have fine "damper wires" that show as thin lines across the screen.

Christian Brantley, spokesman for monitor manufacturer Eizo Nanao, says that in the past, aperture grille technology was best for graphics. "Now, shadow mask technology has improved so far that our best product on the market is shadow mask, not aperture grille. Shadow mask gives a longer tube life, and it's the sharpest color I've ever seen," he says. The company continues to offer both technologies in its monitor selection, but Eizo Nanao research states that shadow mask consumes 10-20% less power, and is less sensitive to magnetic fields than aperture grille.

Luc Colle, product manager of color imaging systems at Barco, also thinks shadow mask technology has caught up with aperture grille. "It works with very tiny circles while the aperture grille works with tiny lines. My preference goes to the circle because horizontally or vertically they have the same visual effect." He suggests this experiment: "On a black background, draw a vertical line one pixel big, and a horizontal line one pixel big. With shadow mask technology, it will be exactly the same horizontally

& vertically. On aperture grille, you'll have a different feeling for the two lines. But some people won't ever want to work on a shadow mask. They just don't like it," he says.

Sony, developer of the first aperture grille tube, the Trinitron, maintains that aperture grilles create a brighter image with better contrast. Resolution is not affected by the vertical spacing of pinholes, and it is less susceptible to warping by heat.

CRT Tube Improvements

Those in the know realize that 'flat-square' picture tubes are not flat, but slightly curved. Light is reflected at numerous angles, creating glare. To reduce glare, completely flat faced tubes were developed which reflect light at a single angle. But this created another problem. A totally flat-glassed monitor delivers a distorted image due to refraction of light off the flat surfaces. Several manufacturers have developed solutions to solve this problem, including Samsung (DynaFlat™), Panasonic (PureFlat),LaCie (100% flat), Mitsubishi (Natural Flat), and more. Each has proprietary variations. For example:

To create its flat image, the "flat aperture grille" tube from NEC incorporates a precisely calculated curve on the outer radius of its glass bulb. Additional modifications were made to strengthen the glass itself, redesign the aperture grille, the electron gun and improve convergence performance.

Another variation, Philips "Real Flat" technology, features a small curvature on the inner surface of the front glass to make the optical image appear perfectly flat from the viewer's perspective.

The new flat screens reduce glare nearly as much as an LCD, but are these screens really distortion free? Says Stangle, "Typically when a user converts from a flat square CRT to a totally flat CRT, the first six hours they work on it, they think the image is caved in. They're not used to the flat screen. It's an optical distortion of the eyes, not the tube," he says.

Double 'em Up?

Appian Graphics provides display cards that control 2 to 8 monitors from one computer, improving productivity for CAD, desktop publishing and design, and multitasking applications. Its newest offering, the Jeronimo 2000, comes with HydraVision software, and operates at resolutions as high as 1920 x 1080 x 32 bpp at 85 Hz. "Designers can see finished output as well as the design in progress, or double the size of the display space," says spokesman Joe Martorano. The Jeronimo is an analog card, but Appian offers a Gemini DVI-I card to control digital or analog monitors. AppianRotate offers control of multi-monitors in portrait and landscape modes.

On the flip side of the 'multiple' technology, some monitors can be connected to two separate CPUs. The benefit here, says NECs Stangle, is that one CPU can be reserved strictly for designs, while another is for word processing, internet use, etc. One touch of a screen button lets the operator switch from one PC to the other, without moving from his chair.

Color Calibration: Complexity Squared

A dizzying range of color calibration options are currently available—everything from a free download of software off the Internet, to a $4000 increase in monitor price. Some calibration options demand input and technical savvy from the user. Others are billed as auto-calibration techniques. Auto-calibration requires a hardware feedback system that takes measurements of monitor conditions and readjusts the system for gradual degradation of phosphors and other components, as well as short-term issues such as changes in the magnetic field or temperature.

It's much more difficult to color calibrate an LCD than a CRT with today's technology. "If you're using your eyes, matching it up on a downloadable format from the Internet, there's not much difference. But if you press into an LCD screen you can actually see your thumbprint there for a few seconds. So the traditional colorimeters, or "pucks" used for color sensing don't typically work with an LCD," says NEC's Stangle.

Luc Colle of Barco believes the main area for differentiation among CRTs is color calibration. Colle says calibration feedback is necessary because of the long-term and short-term variations in monitor components. "For example, long term you're exhausting your phosphors. The problem is, there are three kinds of phosphors and you're not exhausting them at the same rate. If your red phosphor is exhausted 20%, but your green is not, then your display will look greenish. It will skew your entire color balance, and your profile won't be correct anymore." Even new monitors are individuals where precise color balance is concerned, because each has a unique set of components.

Barco's Reference Calibrator V includes several feedback systems that constantly track what is happening in the display. Each optical sensor is matched with its respective monitor at the factory. "We can correct 72 times per second," he states. The best way to test a monitor's calibration is by testing its gray scale. "If you send a 2% gray to the display, you're supposed to see gray, not a color. But if the electronics cut off too early, and one channel doesn't give light, you'll miss a color and see the two complimentary colors instead," he explains.

Colle adds, "We are continuously trying to correctly calibrate LCD panels. But there are a number of technical issues that are not yet solved." Black levels are one example. If you close everything on an LCD, you will still see light... in the dark tones you will have huge Delta E's."

Backlights on LCDs are another problem. "We know the spectral data of phosphors. But with backlights, the spectra are not stable. That means, as a measurement device for calibrating a panel, a colorimeter is not good enough. You really need a high-end spectrophotometer," which is cost-prohibitive.

While Colle agrees that LCDs are a great technology that will eventually transform the display marketplace, he also states that Barco's professional line won't introduce them until they can reach the accuracy level of at least its Personal Calibrator CRT. "That's the minimum accuracy we want, and we're not there yet," he states.

The Bleeding Edge Future: Soft-Proofing LCDs

A new patent recently awarded to the Graphics Arts Technology Foundation (GATF) and R.R.Donnelly & Sons Co. may dramatically improve the potential to soft-proof, using LCD technology.

The goal of soft proofing (color-matching on the monitor without generating hard-copy proofs) has been a holy grail since digital imaging began. Not only does it avoid the time and materials costs of generating hard-copy proofs, but it also enables designers to have a more realistic view of how their designs will appear when output. Soft-proofing also paves the way for collaborative, on-line proofing from multiple locations.

Though CRT color-management systems are improving, John Lind, senior research chemist and acting research director at the GATF, says CRT technology has built-in differences that undermine soft-proofing efficiency. CRT phosphors are self-luminous colors, while printing inks use reflective color. Color science states that when two colors have matching spectral curves, they will match under any light source and to any observer, but the 'spectral curves' of RGB's self-luminous color and CMY's reflective color do not match.

GATF's newly patented technology applies a pigmented acrylic color foil material for the LCD pixel filters in cyan, magenta and yellow pigments and their overprints, matching the printing inks. Displays using this new filter material would show a close spectral match to ink on paper--much closer than RGB filters can produce.

"This is bleeding-edge technology, " says Lind. "I wish I had a display to show you how it worked, but we still have to build one."

The research was initiated under a government DARPA grant, but Lind adds that GATF and R.R.Donnelley patented the idea together because "We wanted to give it back to the graphic arts industry. We didn't want it to be exclusively owned by anybody."

So, Now What?

The monitor market is in flux, to put it mildly. Where does that put the designer or prepress operator who is considering a monitor purchase today, or next year? While designers are increasingly asked to work on everything from internet sites to forty-foot murals, the monitor manufacturers are not consolidating their technology. With the CRT versus LCD debate, there is not yet an "all-in-one-optimum" solution.

Meanwhile, the typical manufacturer has no strong urgency or motivation to develop a multi-purpose "answer" for graphic design and print industries. Sure, monitors are critical in your business...but how many monitors will you buy in a given year, compared to the number sold to Fortune 500 companies, or stockbrokers, or customer call centers, or even hospitals or libraries?

At the same time, big volume buyers want price breaks that cut into profits. So selling fewer, super-high-quality monitors may bring a better end result for the manufacturer who does take the digital imaging industry seriously. This motive spurs the continued interest in research and refining graphics monitor technology. And there's bound to be some benefit for everyone in the color-consciousness driven by e-commerce

concerns. Better color management from the digital design stage on to the web may eventually bring fewer color headaches to digital imagers everywhere.

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What the Experts Say*:*

Nimol Chap, ViewSonic engineer: "Flat panels such as ViewSonic's VP181 are ideal for web design work, but perfect-flat CRTs with an aperture grille (ViewSonic PF 815, etc.) are best for graphics designers and pre-press specialists."

Scott Brodrick, product line manager for Apple displays: "CRTs are not on their way out. The majority of Apple's monitors are still CRTs. The cost base is much lower now than an LCD, and it's a no-brainer to crank out a CRT at this point, from many, many suppliers."

Jeff Stangle, product manager, NEC FP and FE CRTs: "LCDs have a native resolution they're supposed to run at. Our 20-in. LCD runs at about 1280 x 1024, and you don't run it at any other resolution. That's the main reason I'd still recommend the CRT for graphics."

Box:

LCD's – Ready for Prime Time?
It's true that current LCDs have a lot to offer for some graphics applications, especially web design and video. But before you buy a coffin for the Bug-Eyed Monster CRT staring you in the face, check out the pros and cons of LCDs for your kind of work.

LCD Strong Points:

- The LCD flat panel is thin and lightweight, requiring much less desktop space than a similar-sized CRT. It also uses about 1/3 less power, so generates less heat, saving on air conditioning costs in crowded office environments. LCDs are being heavily marketed to financial businesses, call centers, and large corporate environments. A cramped digital studio might also benefit.

- Current LCDs can handle 1600 x 1200 resolution; sizes range to 18-in. and above. The non-glare face is easy on the eyes. Each liquid crystal cell is either on or off, so the image is automatically crisp, bright and stable. The image won't flicker because there is no electron-beam scanning.

- Custom Designs: Sick and tired of the plain vanilla look of computer equipment? Design-oriented buyers who want equipment that's beautiful *and* functional will be intrigued by developments in LCD design from vendors such as Mitsubishi, which offers its Obenhofer series in several luxury finishes including various woodgrains and metallics. Sculptor Joe Thrift of LCDmonitors.com offers even more "fine furniture": real mahogany, birds-eye maple, stainless steel and brass in unusual configurations.

LCD Problem Areas:

- Precise color calibration with present LCD technology is problematic. While LCDs can match web colors, matching CMYK colors is a different story.

- Fluorescent backlighting on flat panels may be inconsistent, leading to variations of brightness in the image area. Viewing angle limitations are improving, but still don't match the CRT's 180-degree view.

- With millions of pixels per panel, some defects in pixel-cells are almost inevitable. Cells that are permanently "on" or "off" cause bright or dark defects on the screen.

- LCDs offer just one optimal resolution for a full-screen image. So if you need to display varied resolutions, a CRT is superior.

(End Box)

(Sidebar)

News from the ICC: New Monitor Profiles Are On the Way

The International Color Consortium (ICC) will soon introduce improved standards that may make color matching more accurate. These improvements are driven less by marketing and more by technology interests within the color science community, says George Pawle, ICC chair. “These are people who push the envelope, and there are things they expected they should do, and couldn’t do.”

The ICC standard provides both a processing model which mathematically converts colors from one device to another device, and information, such as whether the profile used corresponds with your monitor and its environment.

The current processing model came out of Apple Computer’s ColorSync I, specifying three tone response curves (gamma, etc.) and three colorants, which roughly described the primaries of the monitor. “Though this was a workable model, it was somewhat ambiguous,” says Pawle.

Soon, the ICC will add a new informational tag that specifically identifies the chromaticities of the primaries, so there’s no ambiguity about what the device primaries are. It will also specify a black point, as well as the white point. “Every device has a dynamic range, from dark to light, which it can represent,” he explains. But when transferring a picture from a device with a high range to one with a low range, you want the top to match with the top of the destination, while the bottom similarly matches to the bottom. The new profiles will be more precise. “You really need to know where the black is. In the past, everyone would do it slightly differently. They’d all be fairly close, but it wouldn’t be ‘there’. The more you push quality and want to get better results, then the black point becomes more important,” he adds.

Pawle doesn't want monitor manufacturers to modify their products in response to the new ICC standards. He greatly prefers stability. “If you have a moving target it’s hard to hit it. We’re trying to improve what we’re doing, but if they change at the same time, we’ll get a mismatch again. We don’t want device manufacturers changing.”

Pawle expects the new standard will be voted on in October, and presuming everything is accepted, the guidelines will be official and widely available a year from then. “We have to give time for Apple, Sun, Microsoft and others to get the new software into their operating systems, and we also have to generate the new profiles.”

The ICC standard is a transmission protocol that will be used as the technical basis for all calibration systems, but the implementation, user interfaces, etc. are strictly the individual vendor’s call. In Pawle’s view, color matching depends on how much effort you want to put into it and your quality requirements. “Color science is really a difficult science, and most people do not appreciate the complexity. Color is just something everybody has. They don’t think of it as being something special. Even people who are developing scanners, for example, don’t appreciate the complexity of getting the color of their scanner onto a printer.

“We’re really working hard to get past the hurdle of people saying color shouldn’t be difficult. On the one hand, they’re right. You shouldn’t have to think about color. It ought to just happen the way it normally does. But the technology it takes to get there? Well, we’re working on it. We’ll get there, but we’re not there yet.”

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Sidebar:
Spec Sheets Interpreted
(Special thanks to Panasonic for an excellent web-glossary at www.panasonic.com to get us started.)

Aperture Grille Tube: A CRT tube that uses a slit plate as a mask to block electron beams from hitting incorrect phosphors. Example: Sony Trinitron. The size of slits is measured as "Stripe Pitch" or "Grille Pitch" numeric values. a .26mm grille/stripe pitch is roughly equal to .29mm dot pitch. Also see: Shadow Mask

BNC Terminal: A connector that allows RGB signals and horizontal/vertical sync signals to be feed through separate lines of coaxial cable. Helps to reduce signal degradation.

CRT: Cathode Ray Tube. Electron beams scan phosphors coating the front of a glass "picture tube", usually 75+ times per second, horizontally and vertically, causing it to glow where the signal falls.

Delta-E: Delta Error, a complex formula to determine color accuracy; the lower the figure, the closer to stable. Monitors range between 3 and 20 depending on age and type of calibration used.

DPMS: Display Power Management Signaling, a standard to promote power savings in CRT monitors.

DVI Connection: Digital Visual Interface, a new standard developed by the Digital Display Working Group (DDWG) to promote direct digital connections between high-powered PCs, graphics boards and LCDs and other monitors. By eliminating digital to analog conversions, the original integrity of the digital signal is preserved and displayed. With its subset, DVI-I (DVI Integrated), both digital and analog display signals are supported, maintaining analog compatibility until digital upgrades take place.

FST Tube: Though called a "flat tube" it is actually a slightly curved CRT. "Flat, square" tubes also are slightly curved. FlatSquare CRTs reflect light at numerous angles. "Perfectly flat" tubes (each manufacturer has a different trade name for this style) are flat completely into the corners of the screen, and reflect light at a single angle.

LCD: Liquid Crystal Display. Also called "Flat Panels." LCD cells are directly addressed by the digital signals.

LUT: Look-Up Table. Memory limitations prevent video cards from displaying all colors. The LUT stores mapping information which shows which subset of possible colors is available at any given time.

OSD: On Screen Display. A menu of on-screen adjustment items that control monitor display.

Phosphors: chemical compounds that emit light while being excited by electrons. Monitors use three different colors of phosphors--red, blue and green—to create the full spectrum of color, hence RGB.

Shadow Mask: An invar mask that uses holes to direct the electron beam to the correct phosphors on a CRT, while shadowing its neighboring phosphors. “Dot Pitch” refers to the distance between dot triads. The closer the spacing, the crisper the image. Smaller dots lower brightness, increase resolution.

Spectrophotometer. A photometric device for the measurement of spectral transmittance, spectral reflectance, or relative spectral emittance.

USB: Universal Serial Bus. A standard to unify connections of all computer peripheral equipment using the same interface.

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