SID '98 PREVIEW ISSUE

Information DISPLAY

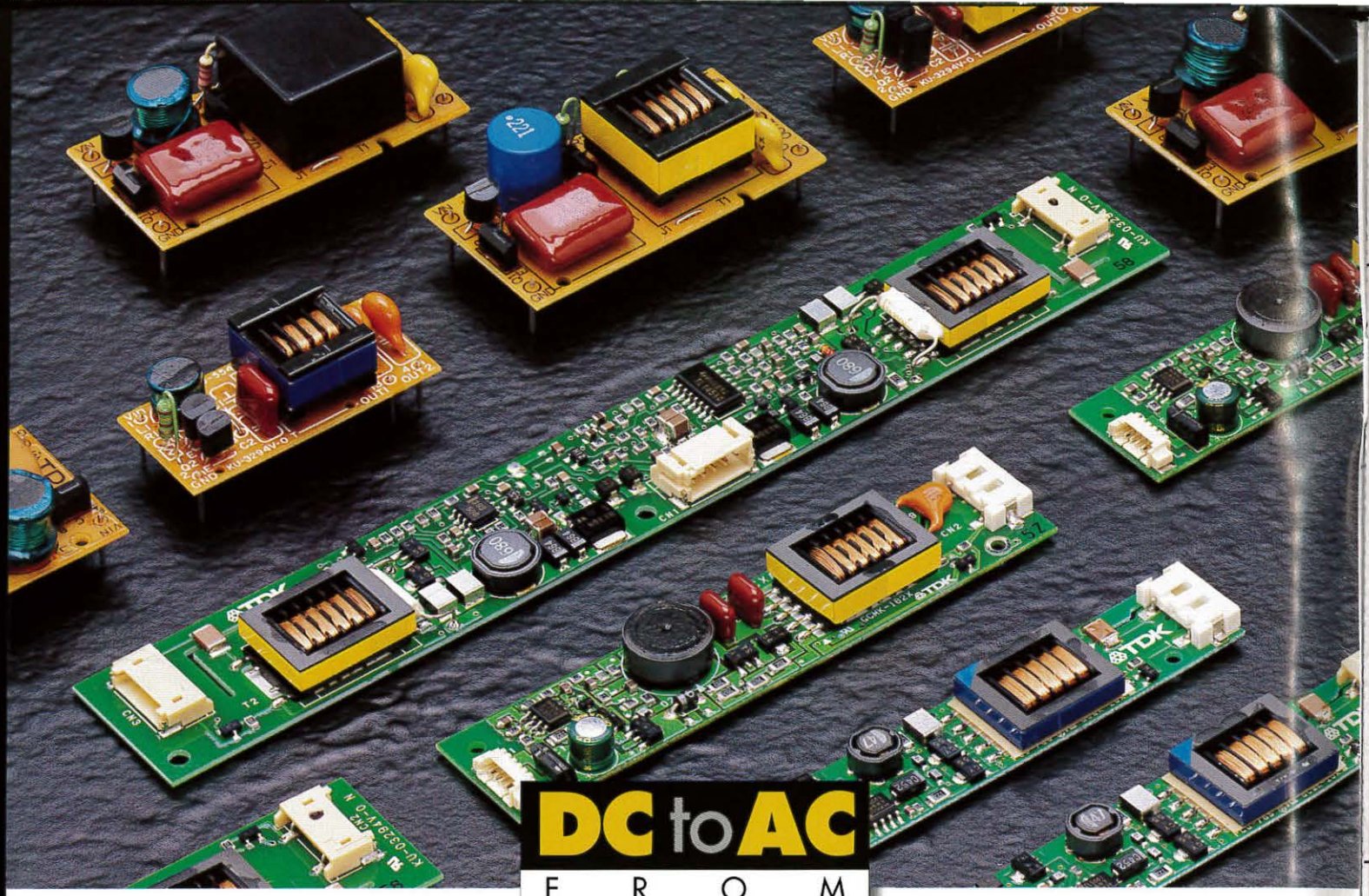
SID

March 1998
Vol. 14, No. 3

Official Monthly Publication of the Society for Information Display

Anaheim to Host SID '98

- *SID '98 Preview*
- *Marketing Rugged Displays*
- *EID Review*
- *CIC5 Report*
- *Views from Europe by Ernst Lueder*



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BPA INTERNATIONAL

COVER: From May 17 to 22, the huge Anaheim Convention Center will house the largest SID Symposium and Exhibition ever held.

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For more on what's coming in *Information Display,* and for other news on information-display technology, check the SID Web site on the World Wide Web: **http://www.sid.org**.

Next Month in *Information Display*

SID '98 Show Issue
- Products on Display
- FPD interfacing
- Display Works review

Special Section: PALC displays
- How PALC displays work
- The future of PALC displays

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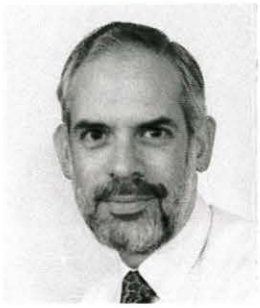

In Assessing Display Technology, Culture Counts

As technologists, most of us are inclined to see the importance of a particular technical development as absolute. It is innovative, or it isn't. It inspires significant new products, or it doesn't. It has significant social impact, or … ah, there's the rub. A technological development that produces significant social impact – or, in fact, significant new products – in one culture may not produce them in another.

Just this point came up in an intercontinental electronic discussion among some members of the display community. They were discussing the importance of several technical display developments, and found themselves in agreement concerning all of the developments except one. Concerning that one development, there was a clear division of opinion. Most of the Asians in the group thought this technology was highly significant, while most of the North Americans and Europeans liked the technology but just didn't find it very significant.

So what is this technology whose significance struck people from different cultures so differently? It is the full-color light-emitting-diode (LED) video-rate display system for outdoor and indoor applications. The reason for the cultural difference is clear to anyone who has visited major cities in Japan (and other Asian countries). Outdoor LED signs are a major fixture of the Asian cityscape, which is simply not so in North America and Europe.

Therefore, the transition to very large, full-color, higher-resolution LED displays – which has been spearheaded by the Akami Electric Company, Ltd., of Hyogo, Japan – has had a significant impact in Japan and will have a significant impact in other Asian countries, but its impact in Western nations is, at least for the time being, slight.

In a recent visit to Nagoya, I saw for myself how striking these displays are. A huge billboard-sized video display – sometimes silent and sometimes with sound levels that are equally huge – showing high-quality video images visible at extended distances can be a very effective (and sometimes distracting) advertising and information medium.

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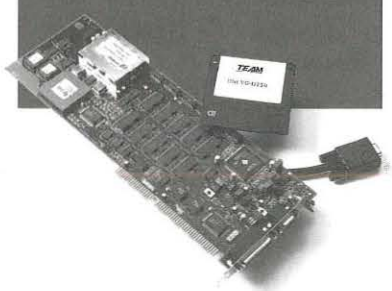

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the display continuum

The Software Wars ...

by Aris Silzars

Lately, as had become almost his daily habit, and in spite of self-promised better intentions, Softwrenginr found himself once again ensconced on a park bench facing Lake Washington. Although he had a top-floor condo nearby with a nearly identical view, the small beach-front city park had become like a second home to him. Mostly he just sat there and pondered. If the occasional passerby noticed him at all, they would most likely think that he was simply enjoying the view of the city skyline across the lake with the Olympic mountains beyond. Or maybe they would think that he came to this quiet spot to meditate. His bushy beard and receding hairline with the opposing bald spot would fit that image pretty well. After all, workday mid-afternoons, in the typically cool and cloudy climate of the Northwest's early spring wasn't the time to find too many other folks sitting on park benches.

By now, Softwrenginr was able to reconstruct every detail of the not-too-distant city skyline from memory. Fortunately, that was not the case for the water and the clouds, which each day played out their ever-changing shapes and patterns. These and the birds, the ducks, the geese, and the sea gulls. He could watch them for hours on end - and did. Sometimes he even brought stale bread to make sure that they would be there for him.

But always he thought. He thought and he pondered. Mostly he thought about the past. And he thought about all the changes that had occurred in his life. And occasionally, if a sympathetic soul would come by, he would make sure he shared his thoughts with them. Whether they listened or not didn't matter all that much. The words would simply begin to form and tumble out from behind his beard-covered lips.

"... You're probably too young to remember... You know, back during that time at the turn of the century - the millennium. That was really something... Those were the really great times..."

Then there would be a long pause and Softwrenginr would knowingly gaze off across the lake at that distant skyline.

"Of course, that was all before the time of the Software Wars... That time before it all fell apart. It sure was great fun while it lasted though... It just seemed that there was no way it could come to an end or that we could lose. We dominated everything. Would you believe that we were so powerful that we could tell people what they had to buy and we could make people buy our products even if they didn't want them or they weren't the best ones?"

And then Softwrenginr would stop for another long pause and glance over to see if the listener was showing the expected interest.

"All the powerful people in the world came to pay homage to us. Everyone assumed that we had such power, that we knew all the future trends, and would be the creators of whatever was to come. And if we somehow missed an opportunity, we would simply assimilate or acquire it. We had so much going for us. There wasn't anything in the world we weren't going after. We were unstoppable. We were into television, banking, newspapers, travel, magazines, toys - you name it. We were doing it all.

"And for a while it all seemed to be going so great. We had the technology.

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Europe: Filling the Gaps

by Ernst Lueder

Europe's display activities are largely centered around its industrial capabilities and the pertinent financial support by the European Community (EC) for research and development. There are four major areas in which most of the efforts are concentrated: active-matrix LCDs with a consortium of eight companies led by Philips, The Netherlands; large plasma-display panels investigated by Thomson Tube Electroniques, France, together with three other companies; color electroluminescent displays under the leadership of Planar, Finland, supported by six more institutions; FED color displays with PixTech SA, France, and five partners; and, finally, three smaller endeavors on reflective displays.

The AMLCD project was recently completed. The outcome includes printing techniques for color filters, non-metallic black matrices, improved ITO, an AMLCD projector, poly-Si integrated drivers, and advanced optical materials such as PDLCs. Further, an electron-beam substrate prober for LCDs based on the voltage-contrast method in a REM was successfully completed by Etec EBT, Munich, Germany, and will be available on the market.

The research for large plasma displays is aiming for 40-in.-diagonal panels, 3 in. thick, and with 1280 × 1024 × 3 color pixels. Industrial process control could be a suitable application.

Planar is already on the market with an attractive range of EL displays. Forthcoming color EL panels supported by the EC are based on broadband white-emitting phosphors from which filters extract the various colors. The objective is to build a 10.4-in. VGA panel. Major applications are in the field of transportation.

PixTech's products are based on research performed at the LETI laboratory, which is supported by the French Government. The consortium around PixTech pursues the goal of demonstrating a 5.2-in. 150-cd/m^2 full-color FED with phosphors exhibiting a luminescence efficiency of at least 3 lm/W in the white and a 12-in. color XGA display. Multimedia displays are among the potential uses.

Reflective displays are being investigated by the University of Stuttgart, Germany, and partners, particularly reflective FLCDs on plastic substrates for applications such as smart cards, pagers, and PDAs. Bistable nematic LCDs are being developed by the University of Paris-Sud, Orsay, France, and partners, primarily for the same applications. Finally, a reflective light valve on a monocrystalline-Si wafer that contains active-matrix addressing is the focal point of a group centered around BARCO, Belgium.

Le Club Visu, France, has proposed setting up a European Center of Excellence for displays. The idea is supported by three European SID chapters, namely the chapters in the U.K. and Ireland, in France, and in Mid-Europe. The task of this center would not be the fabrication of displays but the dissemination of information on displays, including guidance for the selection of the appropriate display technology and its implementation, the organization of seminars, summer schools, and training sessions, and the establishment of a CD-ROM with a directory of the profession, as well as an archive of presently available printed information. The CD-ROM is intended to also provide a large audience-oriented presentation on the fundamentals of displays, as well as teacher/student-oriented material on all presently discussed display panels.

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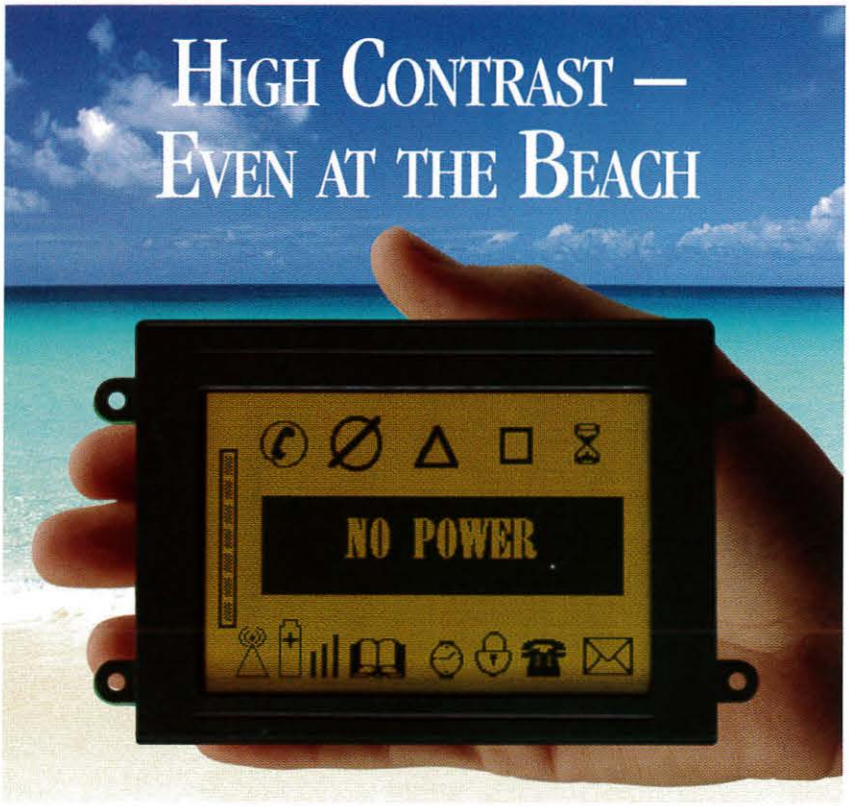

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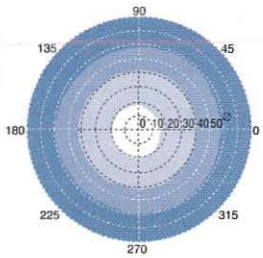

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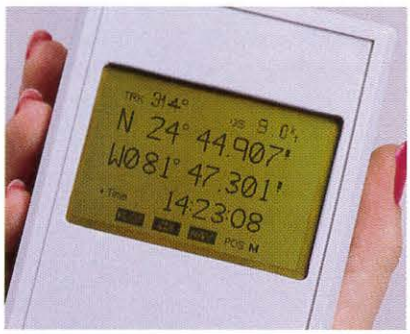

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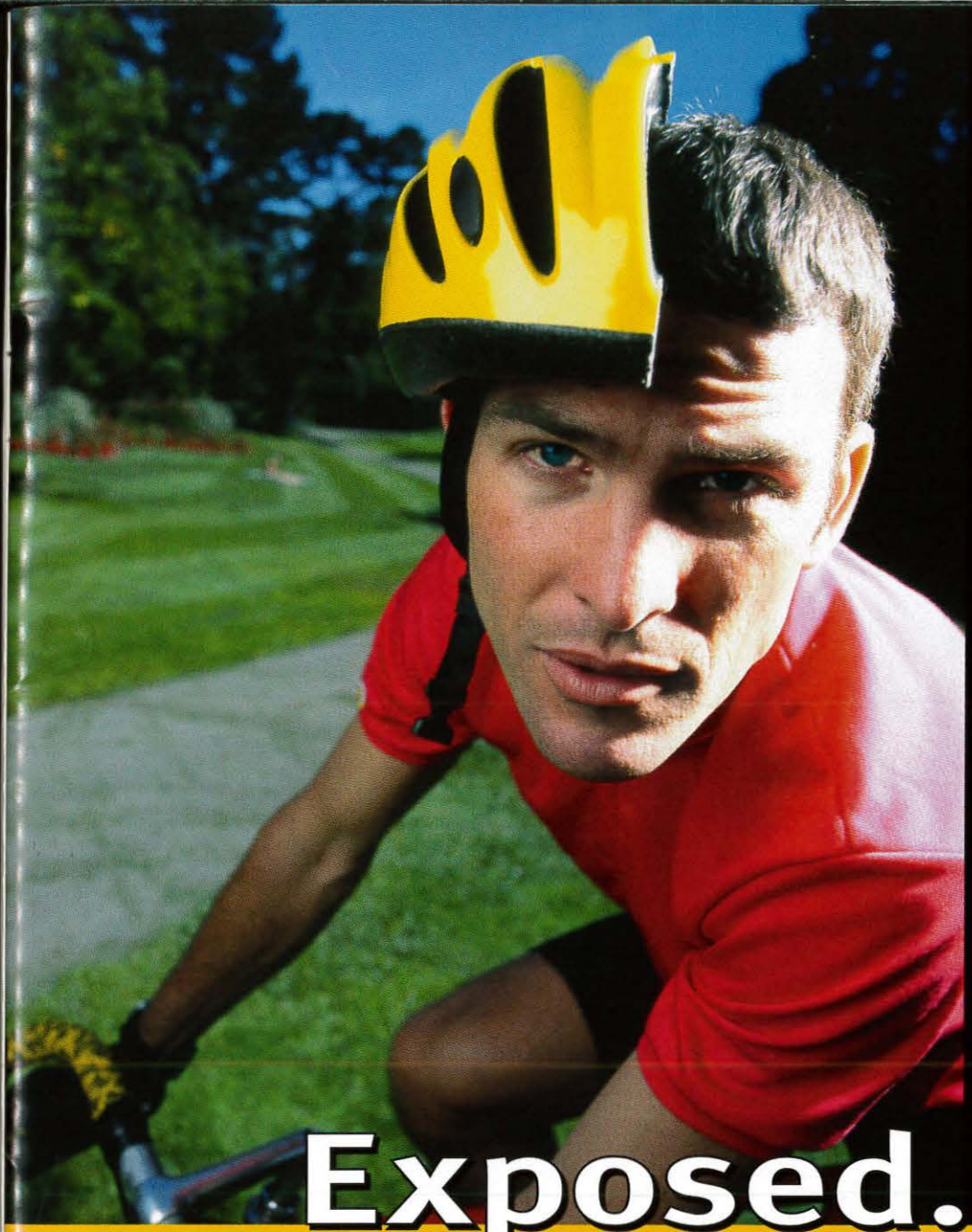

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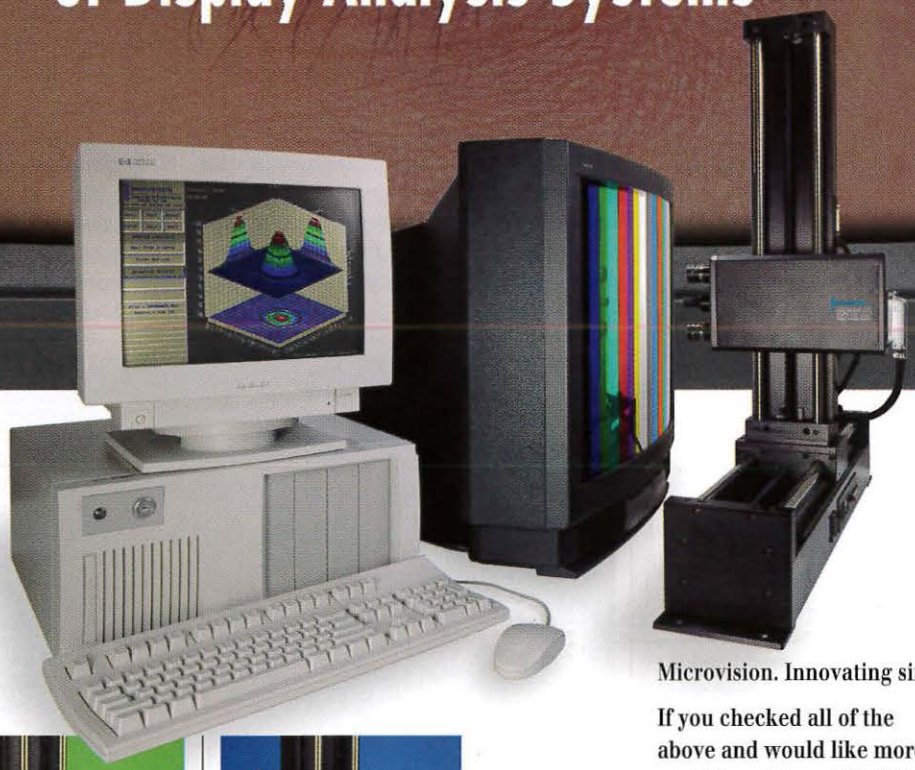

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Circle no. 12

Marketing Rugged Displays: Opportunities and Options

Originally limited to military customers, the vibrant market for rugged FPDs now represents the next great opportunity for the global display industry.

by Roger Ellis

THE FLAT-PANEL-DISPLAY (FPD) market has two segments. Both are application-driven to the extent that their end users drive all performance issues. One segment centers on high-volume, relatively low-performance, extremely price-sensitive consumer-driven applications such as portable computers. The other segment is smaller and addresses the needs of high-performance end users (Fig. 1). Historically, military requirements have driven this high-performance segment, but that is beginning to change. An exciting, energetic rugged-display industry is in the process of emerging.

The various possibilities for rugged FPDs are generating new opportunities. To identify those opportunities, managers must learn the reasons why customers purchase new technology. In fact, the reasons vary, but the simple model we are about to present can serve as a valuable aid in understanding the market forces inherent in the use of new technology. Although any assessment of a market situation is static, a snapshot in time of an extremely dynamic phenomenon, the model can help a company understand its position in a swiftly changing market.

***Roger Ellis** is Display Products Manager at Korry Electronics, 901 Dexter Ave., N., Seattle, WA 98109; telephone 206/281-1300 ext. 382; fax 206/273-4126; e-mail: rellis@korry.com.*

This article will review some basic marketing concepts and then discuss the increasingly diverse opportunities for rugged displays. Our analysis will provide insights into who will be the eventual winners and losers in the rugged-FPD market.

Technology-Adoption Process

The high-technology landscape is littered with companies that focused on technology development while neglecting market-development activities. Successful implementation of new technologies requires an understanding of

AlliedSignal

***Fig. 1:** The U.S. Air Force's C-141 aircraft uses rugged flat-panel-display technology for its color AMLCDs.*

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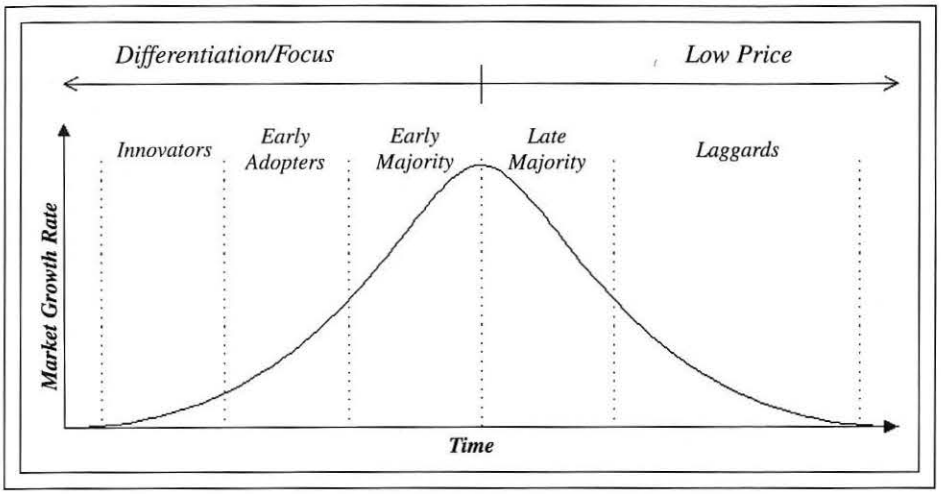

Fig. 2: *A valuable model known as the "technology-adoption process" presents the total market over time as the area under the curve. Five key segments are identified, and the generic strategy pursued by each segment is indicated across the top of the diagram.*

how - or if - markets will accept them. Lessons learned from the experiences of Silicon Valley start-up companies indicate that successful development and implementation of a new display technology require leadership in both technology and business.

A useful tool for the development and characterization of an emerging market - or technology - has evolved from the analysis of thousands of high-technology start-up companies. Referred to as the "technology-adoption process," this model presents the total market over time, and identifies five key segments (Fig. 2).

The first three of these key segments - the Innovators, Early Adopters, and Early Majority - tend to follow strategies centered on product differentiation or market focus. Their primary interest in new technology is based on the need to use it to add new product features or improve their market focus.

The remaining segments - the Late Majority and Laggards - tend to follow strategies concentrating on offering the lowest-priced product. Their primary interest is in a technology's ability to reduce cost and price.

This market-segmentation idea is simple in principle, but its implementation can be challenging. In the early stages of market formation, it is a technology's ability to support new product features that drives the purchasing decision. As the market matures, price becomes an increasingly important decision factor. In the final stages of the adoption process, price is the sole purchasing factor as the product becomes a commodity.

As we shall see, knowledge of the buying habits of each segment and the ability to market new products to these segments are critical for a new display technology's success. Table 1 presents some of each segment's characteristics. We will use the technology-adoption concept to analyze both the opportunities and options for rugged displays.

Rugged-FPD Opportunities

There are almost as many definitions of rugged displays as there are people working on them. We will define them through the following statement: *A rugged display must provide usable visual information while operating under widely varying environmental conditions.*

Color performance, viewing cone (viewing angle), brightness, contrast, and dimmability determine the usability of visual information. Widely varying environmental conditions include temperature, daylight viewing, and mechanical insults such as being shaken, dropped, or kicked.

The initial users of rugged FPDs were the U.S. Army and Air Force, which filled the role of innovator. Working through the Defense Advanced Research Projects Agency (DARPA), they drove the development of FPDs that promised to meet their strict operating-performance requirements. These important users were so far ahead of the curve that they funded formation or expansion of the companies that would become the Early Adopters of their FPDs. Table 2 summarizes the technology-adoption process applied to rugged-FPD markets.

The market-formation process for rugged FPDs is now in the Early Majority phase. The Holy Grail for rugged FPDs is the extremely large and price-sensitive automotive market. In the technology-adoption-process model,

Table 1: Technology-Adoption-Process Segments

Segment	Approximate Size (% of idealized total market)	Key Characteristics
Innovators	2.5%	Demand latest technology ASAP. Drivers of innovation.
Early Adopters	13.5%	Visionaries. Challenge is to develop products and leave the segment before high-volume manufacturing becomes an issue.
Early Majority	34%	Driven to optimize efficiency in design or manufacturing. Ride the market through rapid rise, then move to new solution.
Late Majority	47.5%	Demand lowest-cost solution. Use any technology that reduces cost and price.
Laggards	2.5%	Afraid of technology. Wait for perfection.

Quest for Custom-Made Rugged LCDs Fails

There are only a handful of companies custom-building AMLCD panels for military, avionics, and industrial applications: Litton Display Systems Canada, Etobicoke, Ontario, Canada; OIS Optical Imaging Systems, Inc., Northville, Michigan; Honeywell's Defense Avionics Systems Division, Albuquerque, New Mexico (which packages 4 × 4 glass from OIS for the F-16); dpiX (whose panels are packaged by Planar Advance, Beaverton, Oregon); Thomson-LCD, Moirans, France; Image Quest Technologies, Fremont, California; and perhaps a few others. Now, Image Quest is leaving the field, although just how it is leaving was not entirely clear as we went to press.

Image Quest was established in 1992 as a joint venture between Hyundai and a group of experienced display people headed by Scott Holmberg, who had previously founded Alphasil. The idea was to establish a pilot-production line in Fremont on which FPD technology would be developed and transferred to Hyundai for high-volume applications. Then Image Quest would use the installed equipment to manufacture custom displays for the military and
avionics markets.

A facility was established with 9000 ft.^{2} of Class 10/100 cleanrooms and $13 million worth of manufacturing equipment, and the company began delivering 4 × 4-in. and 6 × 8-in. product to military contractors in 1996. Shortly before that, Dan Syroid, Image Quest's VP of Product Development, told *ID* the company anticipated capturing 33% of the military/avionics AMLCD market.

But, according to knowledgeable sources outside the company, Image Quest never got over its yield problems. Even had they learned to build displays to MIL-SPEC at high yield, "10,000 displays a year [which was the capacity of the Image Quest facility] doesn't pay the bills." By November 1997, Hyundai - which was still the company's main source of funding - had given Image Quest 60 days to close down the operation, said one of the sources.

According to David Lieberman, Displays Editor for *EE Times*, a Hyundai corporate spokesman told him that Image Quest had served its purpose in developing the AMLCD technology and teaching Hyundai how to use it.

Another industry source told *ID* that Image Quest was out of business. Still another source said that the company was trying to reconstitute itself as a ruggedizer of standard glass. Phone calls from *ID* in early January were picked up by an answering machine but not returned.

– KIW

this would represent a Late Majority segment; there is presently no flat-panel technology that can serve this market. But some technologies are closer than others.

Rugged-FPD Options

The FPD industry's drive through the technology-adoption process is accelerating. In the beginning, the cost of manufacturing an FPD, along with the corresponding price, was not especially important to the end users. Their concern was performance - life-saving performance. As time went on, cost became increasingly important, which led to the development of new FPD technologies and new implementations of existing technologies.

There are three options for traversing the technology-adoption process for FPDs:

- Customized FPDs (AMLCDs and AMELs).
- Ruggedized commercial active-matrix LCDs (AMLCDs).
- New flat-panel technologies.

Each of these approaches caters to a different segment of the adoption process. Recognizing and exploiting this principle ensures successful market acceptance of rugged FPDs.

By way of example, let's apply the model to a leading FPD technology suitable for rugged applications: AMLCDs. AMLCDs present an interesting situation. Originally, the only AMLCDs suitable for rugged applications were specifically designed and manufactured for that purpose by companies like OIS (Optical Imaging Systems) and Litton. However, because of cost and availability, companies are now ruggedizing low-cost commercial AMLCDs. Leaders in this new market include Rockwell Collins, EDI, and ADC. Let's look at this phenomenon within the context of the technology-adoption process.

Innovators consist of users and developers driven to push technological frontiers in order to meet their needs. Their market segment is so small that high-volume manufacturers would view it as being virtually non-existent. In rugged AMLCDs, the innovators consisted of DARPA and their High Definition Systems program, the U.S. Air Force (with its need to push FPDs into military cockpits), and the U.S. Army (with its need to upgrade tracked-vehicle capabilities). In this phase of the process, the military acted as the *market maker*.

This market consisted of a large variety of non-standard display sizes. Mission-critical performance drove the designs, and manufacturing costs were secondary to operating performance. Total production quantity was minute compared to the portable-computer market, and delivery schedules stretched over decades. Only a few companies, the Early Adopters, could justify participating in such a market.

Early Adopters comprise visionary organizations that recognize the inherent values of innovative technology and work to develop finished products. In rugged AMLCDs, Early Adopters were OIS, Image Quest, Litton, and

Table 2: Rugged-Display Opportunities

Segment	Target Market
Innovators	Military Avionics
Early Adopters	Commercial Avionics
Early Majority	Military Land Vehicles Industrial Instrumentation
Late Majority (Future)	Commercial Land Vehicles

Table 3: Rugged-Display Options

Option	Target Customers	Current Customers
Custom	Early Majority	Early Majority
Ruggedized Commercial	Late Majority	Early Adopters
New Technology	Late Majority	Innovators

Honeywell. In the area of active-matrix-electroluminescent (AMEL) technology, Planar assumed the role of Early Adopter. These visionary companies recognized an opportunity to support the military markets and position themselves for expanding non-military opportunities. Their approach involved utilizing custom-FPD technologies to meet their customers' needs.

As time passed and the market grew, issues emerged surrounding the cost of FPDs. This produced opportunities for other rugged-display approaches to enter the market. One of these approaches involves ruggedizing standard, inexpensive AMLCDs. Another approach involves developing new flat-panel technologies such as field-emission displays.

The first approach offers a ruggedized commercial FPD. Ruggedization consists of mechanical repackaging, optical repackaging, and improved supporting components. These components, provided by companies such as Korry Electronics, include robust dimming power supplies and high-performance backlights. This approach is suitable for many, if not most, applications, and offers a significant reduction in cost and price compared to the custom-design approach.

The other approach is to develop a new technology that is inherently rugged. One candidate is a flat cathode-ray tube (CRT) called a field-emitter display (FED). These displays offer potentially significant improvements in rugged FPDs. Several major companies are interested in this technology, including Motorola, Raytheon, and Hewlett-Packard. The technology-adoption process will provide a useful model for examining this technology's evolution over time.

We can apply the technology-adoption-process model to the three available options for rugged FPDs. By assessing the state of each technology, as measured by its current customers and its eventual target customers, comparing the statuses of the options becomes straightforward (Table 3).

This analysis shows that the custom solution is meeting its targets and must fundamentally change its approach to expand its market appeal. Ruggedizing commercial glass is in its relative infancy. Its challenge is to quickly move from the Early Adopter customers interested in novel technology to the cost-sensitive Late Majority customers. Still earlier in its market evolution is the new technology of FEDs. Most FED-development activity is occurring in a few university and corporate research laboratories and in a few small start-up companies. Its first challenge is to find Early Adopter customers that can provide visionary market leadership.

Summary

We have introduced a tool that is useful in analyzing the markets for emerging technologies and applied it to rugged FPDs. By understanding each customer segment and its reasons for purchasing rugged FPDs, we can more effectively serve all market segments.

In the end, success in the display business depends on long-term profitable growth. Key to achieving this success is the effective development and marketing of new products. This, in turn, requires an effective partnership between display technologists and their current and future customers.

The rugged-FPD market is vibrant, exciting, and dynamic. It represents the next great opportunity for the global display industry to continue its growth. ■

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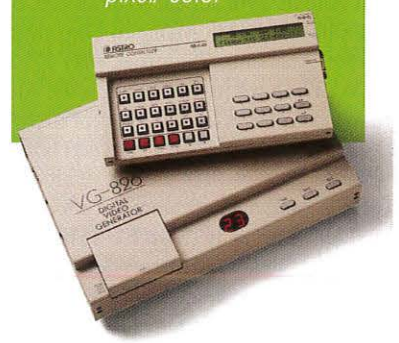

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Circle no. 13

Finding Anaheim

The biggest, most varied SID Symposium in history will be held in Anaheim, California. Where is that?

by Ken Werner

THE SOCIETY FOR INFORMATION DISPLAY will hold its 29th annual Symposium, Seminar & Exhibition at the Anaheim Convention Center, Anaheim, California, May 17–22, 1998. The headquarters hotel is the Anaheim Marriott Hotel, which is adjacent to the Anaheim Convention Center. Several hotels are within a short walk of the convention center (Map A) and over 30 more are a longer walk or short drive away (Map B). (These hotels also serve visitors to Disneyland, which is adjacent to the convention center, so early reservations are recommended. A hotel reservation form appears elsewhere in this issue).

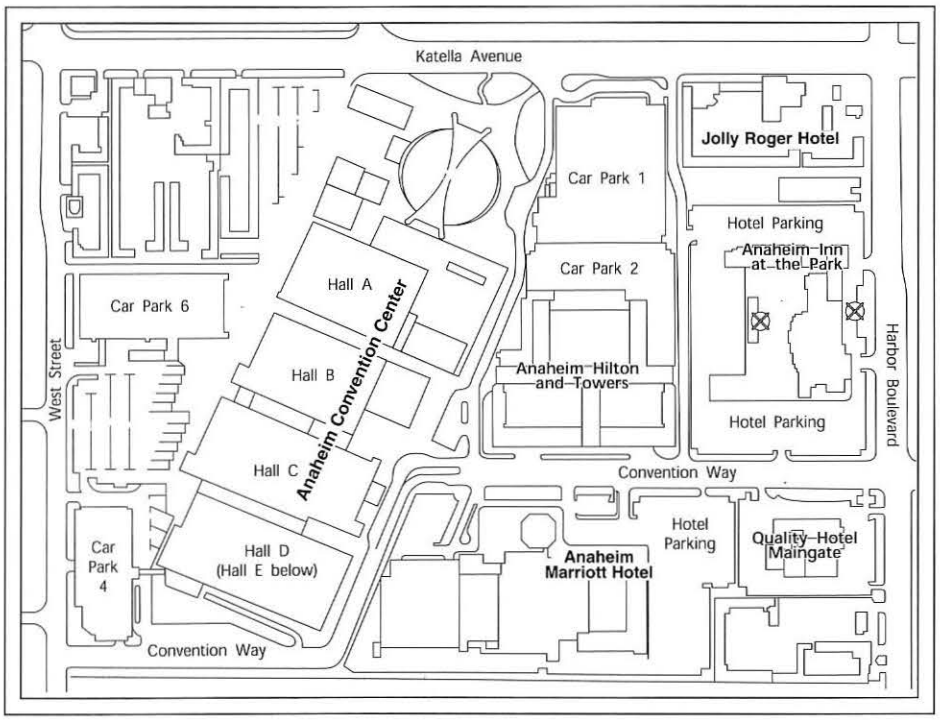
The annual SID event has become the leading international forum for advances in electronic-display products, technology, systems, integration, applications, product engineering, manufacturing, testing, human factors, and display measurements. It is covered by technical and business journalists from around the world. This year's edition, SID '98, will be the largest ever held in North America, featuring displays, display components, display-manufacturing equipment, display test and measurement equipment, display controllers and electronics, backlights, display products and materials, software, services, and publications. By the end of 1997, 200 exhibitors had already booked over 350 booths, and conference management was discussing whether it would be necessary to contract for more exhibit-hall space. Among the exhibitors will be the world's leading display companies, including Sharp, NEC, Mitsubishi, Sony, Optrex, and Planar.

***Ken Werner** is the editor of* Information Display Magazine.

There will also be a special exhibit at SID '98, the Display Technology Showcase (DTS). The display showcase will provide cross-technology comparisons of displays/monitors of similar sizes intended for similar applications - operating from the same signal sources.

Current plans include showcases for:

- Large video and graphics displays using plasma, LCD, CRT, and front- and rear-projection technologies.
- Medium to medium-large monitors (17–32 in.) using a variety of technologies.
- LCD monitors using TFT, standard STN, and enhanced STN technologies.
- Medical displays, which must adhere to such remarkably demanding specifications that they are pushing the display envelope along several axes.
- Small datagraphic displays using LCD (including reflective and guest-host), VFD, FED, LED, and EL technologies.



***Map A:** Hotels within walking distance of Convention Center.*

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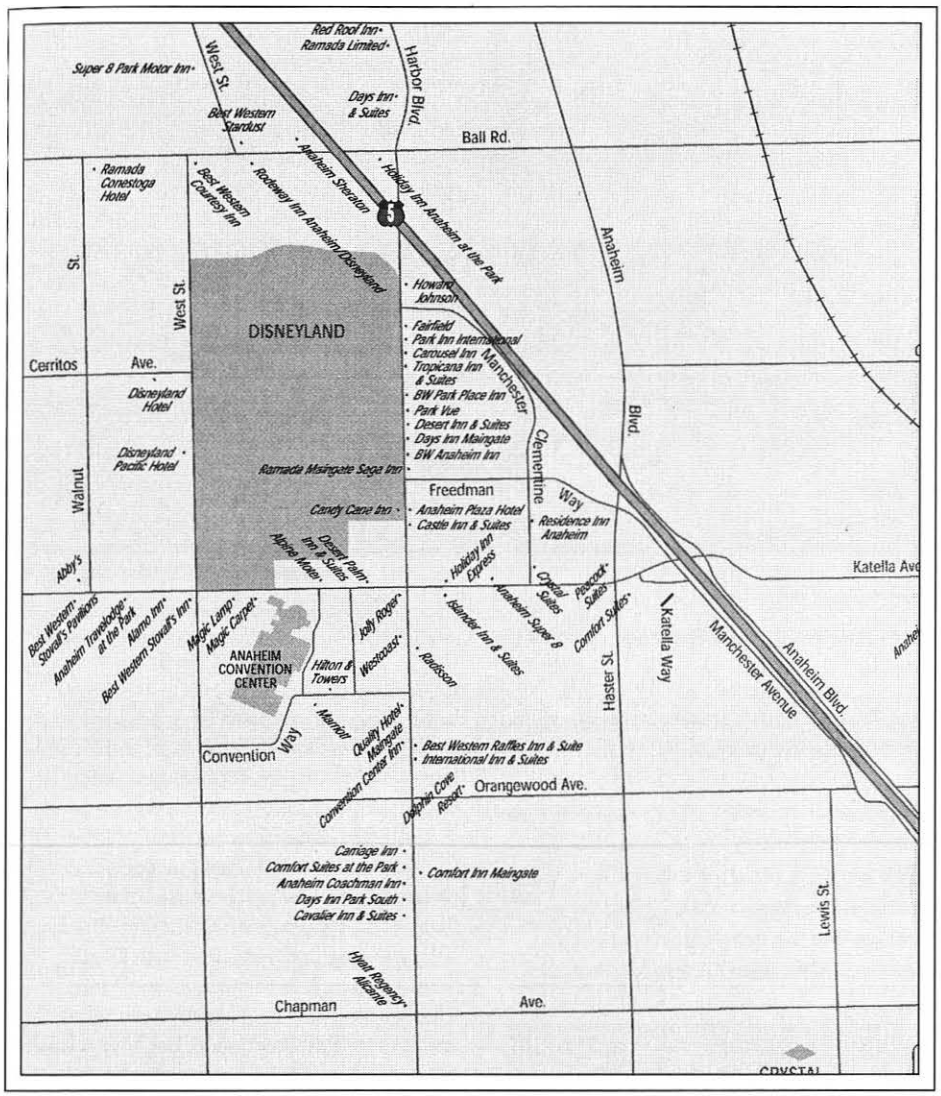


Map B: Hotels a longer walking distance or short drive from Convention Center.

"We are anticipating the cooperation of many leading display companies," said Phil Heyman of Sarnoff Corp., Vice Chair of the DTS Steering Committee. "NEC, Mitsubishi, CTX Opto, dpiX, Motorola, PixTech, Planar, Clinton, Orwin, Arithmos, Genesis, TEAM Systems, Photo Research, AVED, and Sonera" have already committed their support. In an era when different technologies have begun to compete for the same applications, and where even display professionals may have limited experience in assessing the relative merits of technologies that are not traditional for a given application, the ability to look and see should provide an exciting and extremely informative event," Heyman said.

Display Week will kick off with half-day short courses on Sunday, May 17, and 90-minute seminars on Monday, May 18. There will also be seminars on Friday, May 22. A rich multi-track menu of technical-symposium papers, vendor exhibits, applications sessions, and applications seminars will all be held from Tuesday, May 19, to Thursday, May 21.

Keynote Addresses and Invited Papers

The Tuesday morning plenary session will feature two distinguished keynote speakers, addressing topics of great importance to the display community. Hisashi Yamada of Toshiba Corp. (Kawasaki, Japan) will speak on "DVD in a Multi-Source Multimedia Era." Then, Eric Haseltine, Vice President and Chief Scientist of Walt Disney Imagineering, will present "The Future of Displays in Entertainment."

Approximately 25 invited papers will enliven the technical sessions. Display technology is fascinating, in part, because it spans areas of great maturity, bubbling cauldrons of unproved new ideas, and everything in between. Technical developments in mature areas can be exquisitely sophisticated and subtle, while those in new areas can startle with their originality or with why didn't I think of that "obviousness." The invited papers span all these possibilities.

Canon's surface-conduction electron-emitter display has created great excitement by promising to drastically reduce the cost of FED-type displays. There has also been concern that these displays, as well as the process for making them, are insufficiently understood. M. Okuda's "Electron Trajectory Analysis of Surface-Conduction Electron-Emitter Displays" should improve that understanding.

Reflective color displays are arousing great interest because of their likely extensive application to portable electronic devices. Minolta's K. Hashimoto will discuss one particularly interesting variety in "Reflective Color Display Using Cholesteric Liquid Crystals." The challenge in reflective displays generally is how to get them to reflect more of the ambient light, thus creating a brighter display. Martin Tillin of Sharp Laboratories Europe Ltd. presents an interesting approach in "Reflective Single-Polarizer Low- and High-Twisted LCDs."

Automotive navigation systems are a major display-centric application in Japan. Both display makers and car companies are trying to figure out how to replicate this success in the huge North American market. Perhaps they will get some help from Yoshihiko Utsui of Mitsubishi Electric Corp. when he gives his invited paper, "Information Display and Content for Automotive Navigation Systems."

One of the hottest areas of display development today is large color plasma displays, with several display companies producing units in the 42-in. range and several consumer-electronics companies beginning to build television receivers around them. But leading companies are already producing the next generation of PDPs. NEC's Y. Sano will describe one of the most striking displays of this new generation in "High-Contrast 50-in. Color AC-Plasma Display."

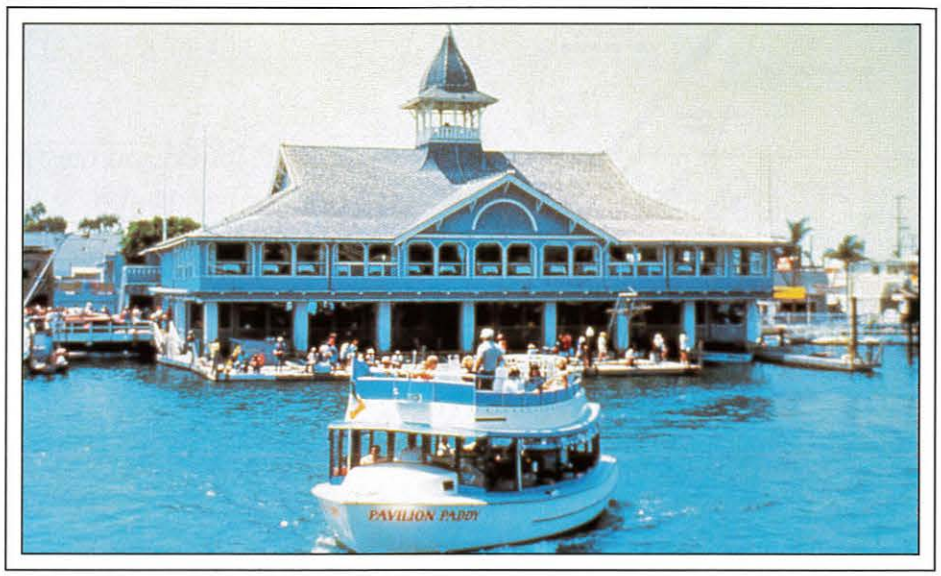
SID '98 preview

At the International Display Workshops in Nagoya last November, Sanyo Electric Company exhibited a remarkably good LCD-based XGA autostereoscopic display. In his SID invited paper, "3-D Display Systems: New Parallax Technology and Related 3-D Technology," Goro Hamagishi will share some of Sanyo's 3-D know-how.

The idea of making high-resolution LCDs on rugged and very lightweight plastic substrates, particularly for portable electronics, is extremely attractive, so there must be some good reasons why people aren't doing it. J. N. Sandoe of Philips Research Laboratories will discuss the problems and some solutions in his invited paper, "AMLCDs on Plastic Substrates."

The problem of maintaining a high vacuum inside a glass housing has long been solved for conventional CRTs, but in flat CRTs (including FEDs) the combination of large area and small volume is requiring new solutions. Bruno Ferrario of SAES Getters will provide some assistance in "Vacuum Issues and Gettering in Conventional and Flat CRTs."

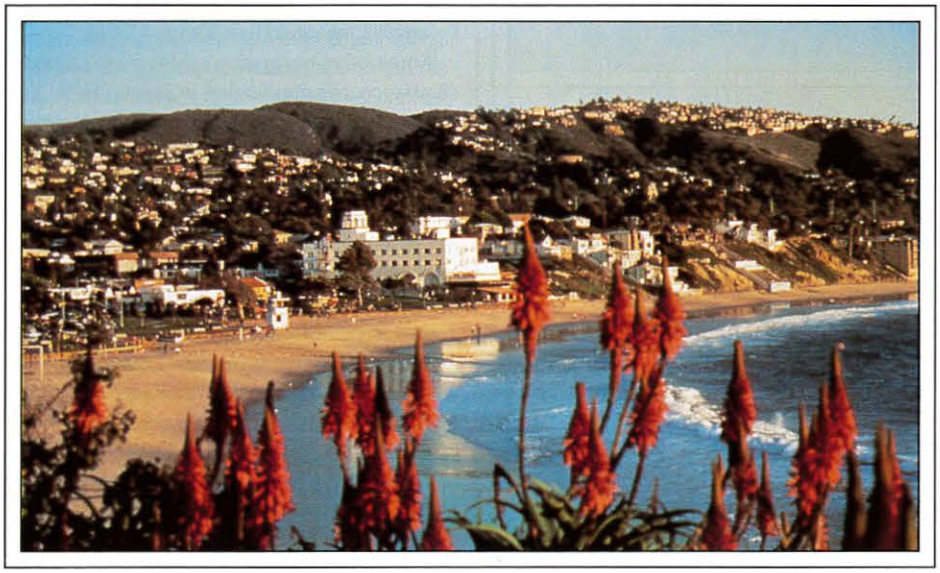
Other invited speakers and topics include Aron Vecht (University of Greenwich, London, U.K.) on spherical phosphor particles, Robert Melcher (IBM) on IBM's silicon-microchip LC projector, Hideki Matsumura (Japan Advanced Institute of Science and Technology) on TFT applications of low-temperature-deposited Cat-CVD for poly-Si films, Brad Culkin (New Logic) on novel photocathode display technology, David Amm (Silicon Light Machines) on grating light-valve technology and applications, N. Kurata (Sumitomo Chemical Co.) on recent developments in optical films for LCDs, Larry Tannas (Tannas Electronics) on the application of backlit AMLCDs to avionics displays, Masakiyo Matsumura (Tokyo Institute of Technology) on excimer-laser-based ultra-large-grain growth technologies, and Y. Honguh (Toshiba) on illumination optics for LC projection displays.



Anaheim-Orange County Visitor and Convention Bureau

The Balboa Pavilion on Balboa Island opposite Newport Beach, where boats leave for famous Catalina Island.

Then, of course, there are the hundreds of carefully peer-reviewed papers contributed by leading display professionals from around the world. The Program Committee holds a large meeting in conjunction with Display Works in San Jose to make its selections. That meeting was held shortly after this article went into production, but "the number of paper submissions is a record high for a SID Symposium," said Program Chair Mary Tilton of Planar Standish.



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Stylish Laguna Beach is in southern Orange County.

Special Events

The President's reception and the Awards Banquet will be held on Monday evening, May 18. (Tickets for the Awards Banquet must be purchased in advance.) The formal opening of SID '98 will be on Tuesday morning, with welcoming remarks by local dignitaries and officers of the Society. The exhibitor-sponsored reception will be held in the exhibit hall at the Anaheim Convention Center on Tuesday evening, followed by the evening panel sessions.

At the gala Wednesday luncheon, the Third Annual SID/*Information Display* Display of the Year and Display Product of the Year Awards will be presented. The winners this

Anaheim Hosts SID '98

Anaheim and surrounding Orange County, California, embody many of the world's stereotypes of southern California: beautiful beaches, trendy restaurants, charming Spanish missions, famous tourist attractions such as Disneyland and Knott's Berry Farm, quintessential American suburbs, palm trees, and lots of sunshine – not to mention crowded freeways and smog. In short, the southern California lifestyle in all of its varieties is to be found in Orange County. But more to the point for SID '98 attendees, Anaheim has a large, top-flight convention center that is adjacent to a Hilton and a Marriott hotel (with other hotels within walking distance), and the surrounding area has a rich concentration of large and small technology-based companies.

In the active schedule at the Anaheim Convention Center, there may be other events of interest to SID attendees. Public events include the Franchise & Investment Expo (May 16–17) and the Crossroads of the West Gun Show (May 23–24).

Professional events include the Pacific Equipment and Technology Exposition at the Doubletree Hotel at the Orange County Airport (May 10–17), the large meeting (30,000 attendees) of the Association for Information and Image Management at the convention center and the Hilton and Marriott hotels (May 12–14), the meeting of the Association for the Advancement of Medical Instrumentation at the Disneyland Hotel (May 16–19), and the meeting of the Society for Technical Communication at the convention center and the Hilton (May 17–19).

In addition to the tourist attractions that are well-documented in traveler's guides are a variety of non-technical events that will be held around the time of SID '98. The major-league Anaheim (formerly California) Angels now play at Anaheim Stadium. There are home night games against Oakland (May 19–21) and against Minnesota (May 22–24). Game-day tickets range from $4.00 to $22.50. Call 714/663-9000 for availability.

The musical *Some Like It Hot*, based on the famous Marilyn Monroe/Jack Lemmon/Tony Curtis movie, will play at the Fullerton Civic Light Opera, 714/879-1732, May 15–31; and *Great Expectations*, a drama based on the famous Charles Dickens novel, will play at the Irvine Barclay Theatre (714/879-1732) on May 15.

The Bowers Museum of Cultural Arts (714/567-3600) will be displaying the traveling exhibition, *Realms of Heroism: Indian Paintings from the Brooklyn Museum*, May 16–August 2. The Garden Grove Strawberry Festival (714/638-7950) includes a carnival, arts and crafts, a parade, and free entertainment between May 22 and 25. There will be a Scottish Festival at the Orange County Fairgrounds (May 23–24) and an Art & Jazz Festival at the Santa Ana Zoo (May 24–25).

There will be music before and after SID '98. Don McClean will sing at the Cerritos Center for the Performing Arts (562/916-8500) on May 16; the sophisticated folk group The Limeliters will hold forth at Orange Coast College (714/432-5880), also on the 16th; and the fusion-jazz group Bela Fleck and The Flectones will perform May 22–23 at the Cerritos Center for the Performing Arts.

Getting to Anaheim

Anaheim is served by Los Angeles International Airport (LAX) for international and long-distance flights and by the Orange County John Wayne Airport (SNA) for local and regional flights.

It takes from 45 minutes to an hour and a half to drive from LAX to the Anaheim hotels, and from 30 to 45 minutes to do so from SNA. Rental cars are readily available, but perhaps the most convenient and economical means of transportation is the ubiquitous SuperShuttle. This fleet of blue vans with yellow "SuperShuttle" lettering operates 24 hours a day, 7 days a week. The one-way fare is $13.00 per person from LAX or $10.00 per person from SNA. If you arrive at LAX, collect your luggage and call to arrange for SuperShuttle pick-up by using the courtesy phone in the baggage-claim area at the Ground Transportation Board to dial 56735, or dial 310/417-8988 from a public phone. The pick-up area is located on the lower level at the Blue Van Stop area on the outer island. To ensure that you board the correct carrier, inform the LAX Curb Coordinator you are waiting for a SuperShuttle.

If you arrive at SNA, it is necessary to make SuperShuttle reservations in advance. Call 714/517-6600 for reservations and ask for further directions.

year are Fujitsu's and NEC's 42-in. color plasma-display panels and Clarity's LCD rear-projection point-of-purchase displays. Honorable mentions go to Sony's completely flat FD Trinitron® CRT and Hewlett-Packard's PhotoSmart Printer. Awards for the best papers from SID '97 will also be presented. Following SID's tradition, the luncheon speaker will be stimulating and entertaining.

The special evening event – entertainment and dining on the grounds of an Orange County hacienda – will be held on Wednesday evening, May 20. ■

conference report

CIC5-ers Mine for the Gold Standard in Color

The need to maintain the integrity of digital color – whether over the Internet or between two hardwired devices – has brought the issue of color standards front and center.

by Michael H. Brill

THE FIFTH Color Imaging Conference (CIC), held November 17–20, 1997, drew 335 color scientists and engineers to the Radisson Resort in Scottsdale, Arizona. This attendance is a record for the conference, jointly sponsored by the Society for Information Display (SID) and the Society for Imaging Science and Technology (IS&T). Each year the attendance has grown substantially, this time up from 280 in 1996.

Color technology is now reaching a watershed moment: soon an important decision must be made about how best to communicate digital colors between devices such as cameras, scanners, displays, and printers. This need is especially acute in digital television and the Internet. A single consensus solution to the problem will be better than two good solutions that carry their competition into the consumer's living room. (Remember Beta *vs.* VHS?) So what is needed is a single standard for color communication between devices.

In response to this need, nearly every session of the CIC referred to color standards. Several standards organizations orchestrated meetings around the CIC, including the International Electrotechnical Commission (IEC), the International Standards Organization (ISO), and the Commission Internationale de l'Eclairage (CIE). Also, the International Color Consortium (ICC), an industrial coalition that is a *de facto* standards body, met two days before the CIC.

As a sort of segue into the CIE Experts Symposium on Colour Standards in Imaging Technology, the last CIC session – held jointly with the CIE – dealt with color standards. Here, several investigators (backed by large companies) were turning months-old research into draft standards documents that they hoped would soon become the basis for a new "universal language" of color.

The spectacle was invigorating but a bit scary, perhaps like watching the prospectors descending on Sutter's Mill in 1849. This time the prospectors are mining for the gold standard of color communication, and major industrial investments hang in the balance.

The Stakes to Be Claimed

To understand the size of the stakes, one has only to look at the battle in digital television between progressive (P) and interlaced (I) image scanning. This issue is much larger than color, but was an important discussion topic at the CIC. Progressive scanning traverses all the lines in one image before proceeding to the next; interlaced scanning (used in current television systems) scans odd-numbered lines in one image and even-numbered lines in the next. The interlaced technology was introduced almost half a century ago to allow more frequent images for the same transmission bandwidth, thus avoiding image flicker. I and P technologies would seem as inimical to each other in a living room as Beta and VHS.

In a keynote address whose topic was not announced in advance, Alvy Ray Smith – a Graphics Fellow from Microsoft – described a debate between backers of P and I technologies as to which should be standardized in digital television. Two coalitions of large companies vie for the standard: DVD (including Microsoft, Intel, Compaq, and Lucent) for the P scan and the Grand Alliance (including AT&T, General Instrument, MIT, Philips, Sarnoff, Thomson, and Zenith) for the I scan.

Smith strongly defended the P scan for digital television. In a nutshell, Smith argued that because digital television will be able to convey more information than conventional television, it makes more sense to use this ability to fill in the missing lines on a lower-resolution image (480 lines) than to continue to use interlace on a higher-resolution image (720 or more lines). (Smith assumed a common image rate of 60 Hz.) The visual system will forgive the loss of resolution, and in fact the phosphors of a CRT can be driven to higher brightness if the image information has a resolution low enough not to be compromised by "blooming" of the phosphors.

Interlaced scanning, however, introduces motion artifacts that can be troublesome at the 60-Hz image rate, and also is not well suited to viewing small-print text because of interline flicker. Smith also said that it would be a lot cheaper to implement P scanning. Finally, he said that people should not buy digital TV receivers until the debate is resolved, lest *two* standards lead to a Beta-*vs.*-VHS kind of disaster in one's living room. (For the Grand Alliance position, see "The Grand Alliance Position on P *vs.* I Scan.")

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The Grand Alliance Position on P *vs.* I Scan

It is important to distinguish between the transmission and display functions of digital television, whose independence is highlighted by the complete transformation of video in MPEG compression.

First, let's look at transmission. The U.S. Digital Television Transmission Standard has *already* been formally adopted by the FCC (as of 24 December 1996). This standard, developed by the American Television Systems Committee (ATSC), contains a table of picture formats with *both* P and I options. That table is not included in the FCC ruling because the FCC refrained from imposing any requirement on picture formats, leaving this decision to the marketplace. However, broadcasters and receiver manufacturers view this table as a *de facto* guideline, and receivers are being made that can handle any of these formats (but no others - it's just not possible to receive without some idea of what you're receiving).

Now, let's move to the display function. Nobody needs to standardize presentation formats for display receivers. Receiver manufacturers can decide how to display what has been transmitted. Therefore, the battle in the living room that Smith predicted is not going to occur.

You might ask, "Why do we need a variety of transmission formats?" The answer is that different kinds of images are better in different formats. For computer viewing and for cinema, P transmission is better. For sportscasting, one needs fast-motion following and small spot size, so I is more appropriate.

Independently, on the display end, there are also tradeoffs between I and P scanning. Viewing text on a computer screen is clearly better in P images, but interlaced images allow a higher screen resolution - or, perhaps more importantly, a larger image at the same screen resolution. To quote Glenn Reitmeier, a Sarnoff participant in the Grand Alliance, "Just because a progressive display is better than an interlaced display for computer viewing doesn't mean you should outlaw interlaced transmission."

– MHB

Because these issues bear on whether one can receive an image at all, they bring the need for standards into high relief. The need is less dramatic, but just as real, in the more limited context of color management.

The Starting Line

The paper "Making Color 'Plug and Play,'" by Todd Newman (Silicon Graphics, Inc., Mountain View, California), gave a good summary of the basic tasks of color management. Colorant matching determines the proper combination of colorants to match a required tristimulus specification; appearance modeling adjusts the tristimulus values to account for differences in viewing conditions; and gamut adjustment intentionally distorts local color appearance to accommodate all or most image colors in the destination device's limited gamut. "There are no standards for any of these operations," said Newman.

This challenge may be why Roy Berns, Professor of Imaging Science at the Rochester Institute of Technology, said of the progress of the Color Imaging Conference: "At CIC 1 in 1993, people were asking what needed to be done to get good color management. By CIC 4, people knew what to do. Now, in CIC 5, the need for a single standard has driven people back to the original question of what to do."

Color: Faithful or True?

Central to the question of what to do is the dichotomy between "color fidelity" and "color integrity," two terms coined at last year's conference by Giordano Beretta of Hewlett-Packard, Palo Alto, California. Color fidelity is the extent to which objective color measurements on a source (tristimulus values) match those on a destination device. Color integrity is the extent to which the colors on a destination device portray the intent of the colors on the source device - most commonly, to match in appearance the colors on the source device, given different viewing conditions such as surroundings and ambient light.

Color integrity seems to be the right criterion for judging color reproduction, but what is a good metric for it? A panel discussion, "Color Fidelity *vs.* Color Integrity on the Internet," led by James C. King of Adobe Systems, offered several views on this question. The panel consisted of Matthew Anderson (Microsoft), Roy Berns, Tony Johnson (Cheddington, U.K.), and Giordano Beretta (Hewlett-Packard).

Anderson was confident that existing or emerging Web tools will ensure sufficient color integrity, with the bonus of being transparent to the user of these tools. Johnson said that we need not pay much attention to color integrity on the Internet because people are not very fussy about present-day color television, or even about color in telemarketing. On the other hand, Berns claimed that even tone reproduction is a significant problem, and told a story of placing a photograph of himself on a Web site: No matter what Berns did, his students using other displays said the photo quality was bad. Finally, Beretta said that a good metric must await careful visual modeling, including the semantic content of the image.

To the probing question, "Why do we need color management at all on the Internet?" one member of the audience responded that at least automatic search tools rely on good color, particularly the tool developed by David Forsyth at Berkeley that finds photos of nearly naked people in large databases.

A take-home lesson from the panel discussion - and from the whole CIC - was that color integrity depends on the application. This is a challenge to those seeking standards.

Progress in Standards

The CIC began with a keynote address, "Bits, Bytes, and Square Meals in Digital Imaging," by Prof. Robert W. G. Hunt, from the University of Derby, U.K. Acknowledged by Conference Co-chairs Lindsay McDonald and Ricardo Motta as "the world's leading authority on color-image reproduction," Prof. Hunt offered a 50-year perspective on the field.

The field has advanced a lot, largely due to standards. Hunt's focus was on the transmission of digital images with as few bits as possible. He showed that to transmit an image with spatial definition comparable to a 35mm photographic slide would require about 42 Mbytes, were this to be done naively. The 42 Mbytes can, however, be reduced by adjusting

the light level in scanners, by using nonlinear scales for tonal digitization, by allowing for the limited reproduction of color gamut, by compressing luminance and chrominance signals according to visual sensitivity, and by allowing for the modulation transfer function of the eye.

Some of these techniques, such as nonlinear tone scales, were known before the days of digital images – and even before television. Some, such as chrominance bandwidth compression, were mandated by the National Television Standards Committee (NTSC) in the 1950s. This U.S. standard set the precedent for its European counterparts, PAL and SECAM. With the advent of digital imagery, the Joint Photographic Experts Group (JPEG) standardized a way (using the Discrete Cosine Transform, among other things) to encode stationary images in accord with the spatial-frequency dependence of visual sensitivity. The Motion Picture Experts Group (MPEG) extended these successes to video streams. Hunt concluded, "By engineering color in these ways, the number of bits per pixel required in a high-resolution image can be reduced from about 42 to about 1 for still images, and to about 0.3 for motion pictures."

Color-management standards do not have such a success story, but the history is much shorter – less than 5 years. Michael Stokes (Hewlett-Packard, Boise, Idaho) made this clear in "The History of the ICC," as did Todd Newman in the paper mentioned previously.

Newman noted important problems that the ICC has not solved. For example, too many ambiguities and menus are needed to ensure replicable performance. In addition, the choice of color to be declared "white" on a monitor is arbitrary and perhaps inappropriate.

Much of the problem arises because all the intelligence of color management resides in the ICC's device profiles – mappings from input-control variables to a color space. This is done in part so as not to reveal intellectual property such as gamut-remapping algorithms. Although Newman decried "... putting all the intelligence in the profiles and not standardizing on algorithms," it was clear that the ICC profile format provides a structure within which improvements can be made.

Standards in Progress

Even as standards are being developed by the ICC to communicate color using known device profiles, the devices are turning out to be more complicated than first thought. In "Reconsideration of CRT Monitor Characteristics," Naoya Katoh and T. Deguchi (Sony Corp., Tokyo, Japan) pointed out that turning on more than one of the RGB channels produces less than the sum of the light obtained when turning on each channel individually. This means the simple 3 × 3 matrix from (RGB) to (XYZ) may sometimes not be a good enough model of the production of color. Katoh described a model for this effect and a procedure for measuring it which are part of an IEC draft standards document.

Ironically, the same committee makes the (RGB) to (XYZ) transform the basis for a "no-frills" default color-management system (sRGB) when no device profiles are specified. This system is proposed as a simple default color system for the Internet. Michael Stokes, one of the developers of sRGB, revealed in his paper that the ICC has not subscribed to the sRGB default. Thus, one proposed IEC standard (Katoh's) makes full use of ICC profiling, and another (sRGB) avoids profiling altogether. The latter is expected to be sufficient for most applications.

In response to the digital ambiguities in today's color management, this author gave a

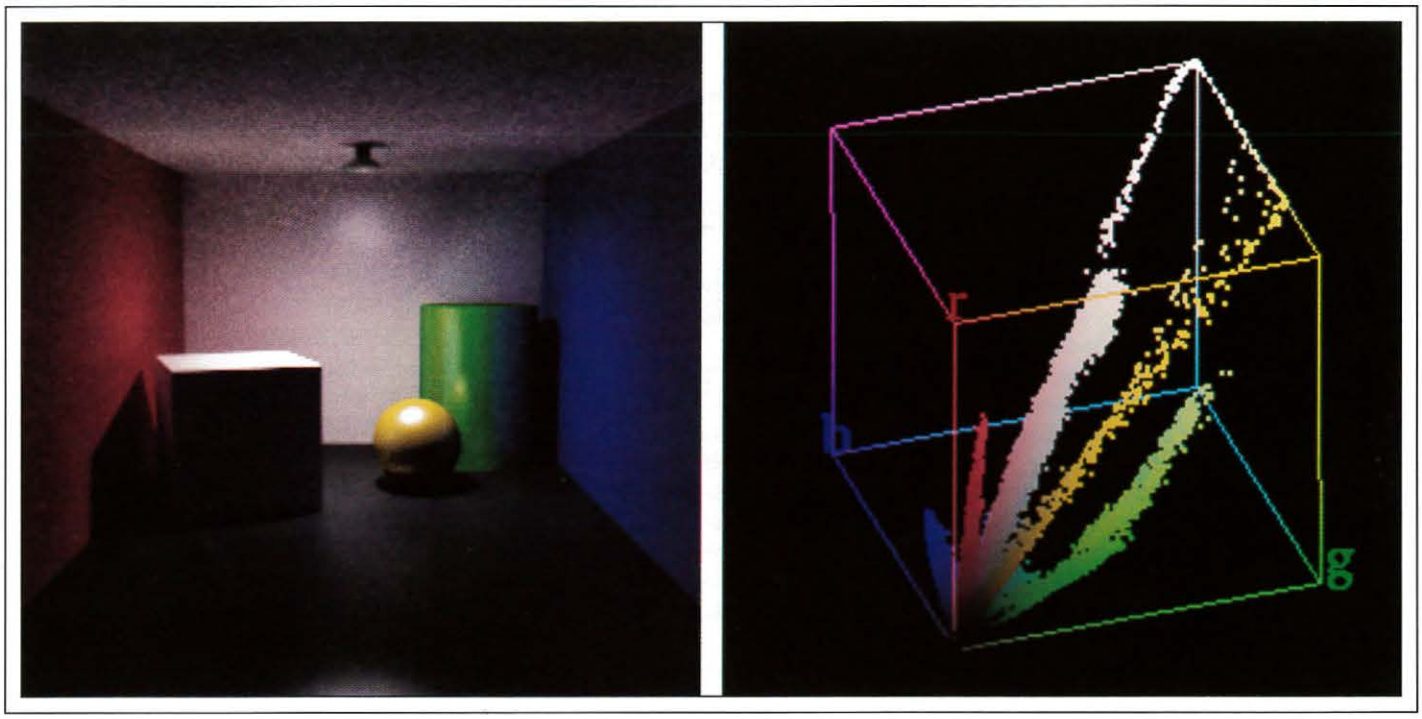

Fig. 1: *Synthetic scenes such as this one have physical models behind them, with interreflections making the colors more realistic. (Photo courtesy of Liang Peng, Cornell Univ. Program of Computer Graphics.)*

keynote address, "Color Management: New Roles for Color Transforms," that proposed a way to verify whether a destination device has understood the digital color instructions it has received from a source device. That method is a simple extension of sending a test pattern, measuring the destination screen, and comparing the tristimulus values with published target values. The extension consists of choosing unsaturated colors to avoid gamut problems, and compensating for the white point using an illuminant/reflectance model. This verification procedure is now part of the draft Flat Panel Display Measurement standard being considered by the Video Electronics Standards Association (VESA). In addition to verification, this author suggested a way to use a spatio-chromatic vision model (the Sarnoff JND model) to allow image content to guide color management.

Other Work Goes On

Along with the standards theme at CIC 5, there were many other presentations of research and innovation. Lee Guth (Indiana University, Bloomington, Indiana) reported basic vision research in "The Chromatic Contrast Sensitivity Myth." The "myth" is that when luminance is held constant, visual sensitivity to spatial sine waves in chrominance is greatest at the lowest spatial frequencies. Guth showed evidence that this is not true if the background stimulus is highly chromatic. Just as the luminance visual channel performs low-pass filtering only at low luminance, the chromatic visual channels may be low-pass filtering only at low chrominance. It would seem that both these facts result from the visual system's averaging out quantum noise at low channel-input levels.

Another important paper was "Color by Correlation," by Graham Finlayson (University of Derby, U.K.), Paul Hubel (Hewlett-Packard), and Steven Hordley (University of Derby, U.K.). This paper offers a new model of color constancy, which is the ability of humans to see object colors independently of the illumination spectrum. Since most color-constancy theories require an estimate of the illuminant color, and humans don't carry a white tile around to reflect the illuminant, it is a puzzle how we perform this feat.

Finlayson's model estimates illuminant color by correlating the chromaticity histogram of a test scene with that of a typical reference scene under a number of likely illuminants. This approach is being used to perform color correction in a variety of color-technology applications, and should also be useful for machine vision.

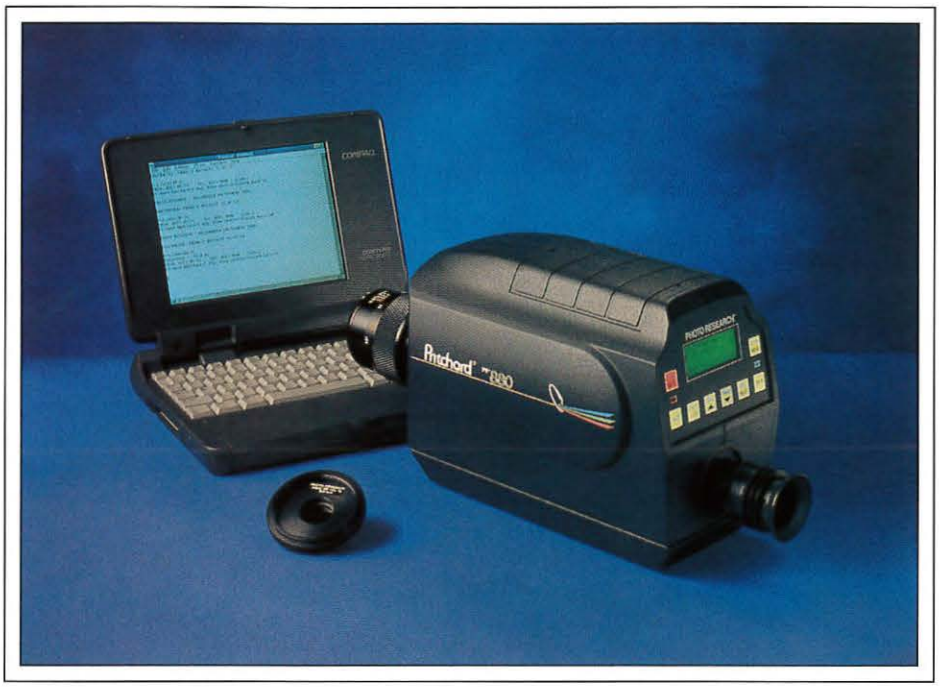

Photo Research

Fig. 2: *Devices like the Pritchard PR-880 Automatic Filter Photometer afford easy and efficient color measurement of display screens.*

There were also several papers that improved understanding of the physical production of color. One was the very clear paper, "Modeling the Yule-Nielsen Effect on Color Halftones," by J. S. Arney, T. Wu, and C. Blehm (Rochester Institute of Technology). Whereas the departure of halftone color prediction from simple equations was previously corrected by an *ad hoc* factor, Arney introduced a more physical model through a point-spread function, and the model has borne up well under tests.

Another clearly written paper, by Patrick Emmel and David Hersch (Ecole Polytechnique Federal de Lausanne), presented a model of transmission and excitation through a fluorescent sheet that should be valuable in predicting colors of fluorescent transparent inks.

Computer graphics came into play, both in publishing synthesized color pictures on the Internet and in visualizing color in engineering environments. The first of these topics was explored in "Color in Web-Based 3-D Graphics," by Maureen C. Stone (Xerox PARC, Palo Alto, California), which reviewed the Virtual Reality Modeling Language (VRML) that is used for Web publishing. (Color management is just now being incorporated into VRML.) In "Techniques for Gamut Surface Definition and Visualization," Gustav Braun and Mark Fairchild (Rochester Institute of Technology) used computer graphics to visualize the rather complicated gamut surface of an HP ink-jet printer. This paper won an award for best poster paper.

The second topic was addressed by two papers from Cornell University that featured tests of the modeled physics of virtual reality (Fig. 1).

Progress was reported in display-related hardware. Susan Highnote and Graham Flint (Laser Power Research, San Diego) gave a paper called "Extending the Gamut: Micro-laser-Based Display Technology." It seems that a laser-based projection display with operating wavelengths of 457, 532, and 650 nm is not only very efficient, but also has a color gamut that extends substantially beyond NTSC limits. Equipment to perform efficient measurement of displays was also featured prominently in the exhibition hall (Fig. 2).

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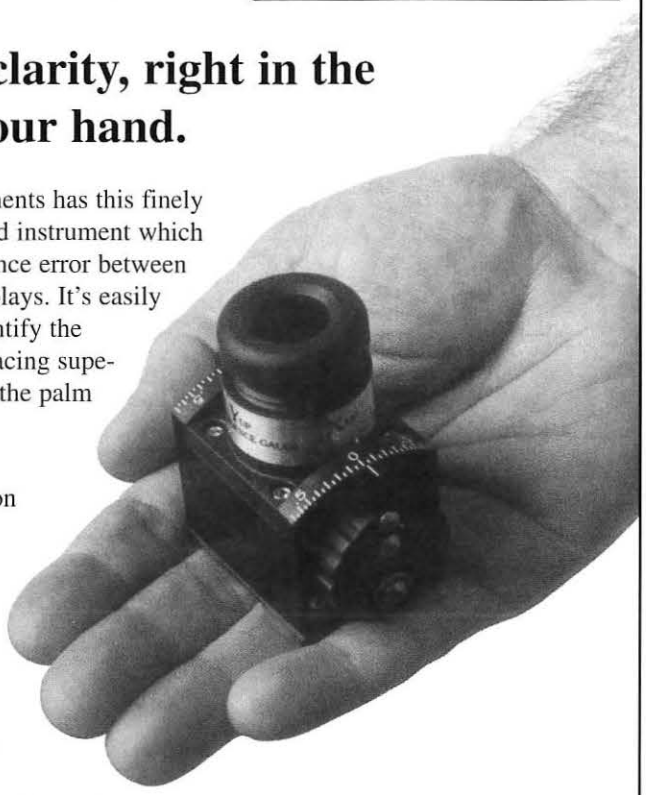

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conference report

To offset this impressive technology, a cautionary note was voiced by Franziska Frey (Rochester Institute of Technology) and Sabine Susstrunk (Corbis Corp., Bellevue, Washington) in "Color Issues to Consider in Pictorial Image Databases," which asked when one can afford to discard a photographic original after making a digital copy of it.

Frey questioned the "permanence" of digital images - which is eroded by the obsolescence of reading devices as well as by bit decay. She also viewed as a challenge the capture of all the intended information in the original: "Operator judgments made in terms of color and contrast cannot be reversed in a 24-bit RGB color system." And nuances of color management are an additional encumbrance. As a solution, she proposed that the sRGB system should be able to capture the information in a photograph if afforded 10 or 12 bits/channel. For now, though, cherished original photos should be kept.

Plan for 1998

In the last 5 years, the CIC has become a unique and dependable forum for color technology. In 1998, the CIC will once again be held in Scottsdale, Arizona, on November 17–20, but the site will be the SunBurst Resort Hotel. The focus of CIC 6 will be on color communication, so many themes from previous years will be revisited and explored further. ■

SID '98
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IDRC '98
International Display Research Conference
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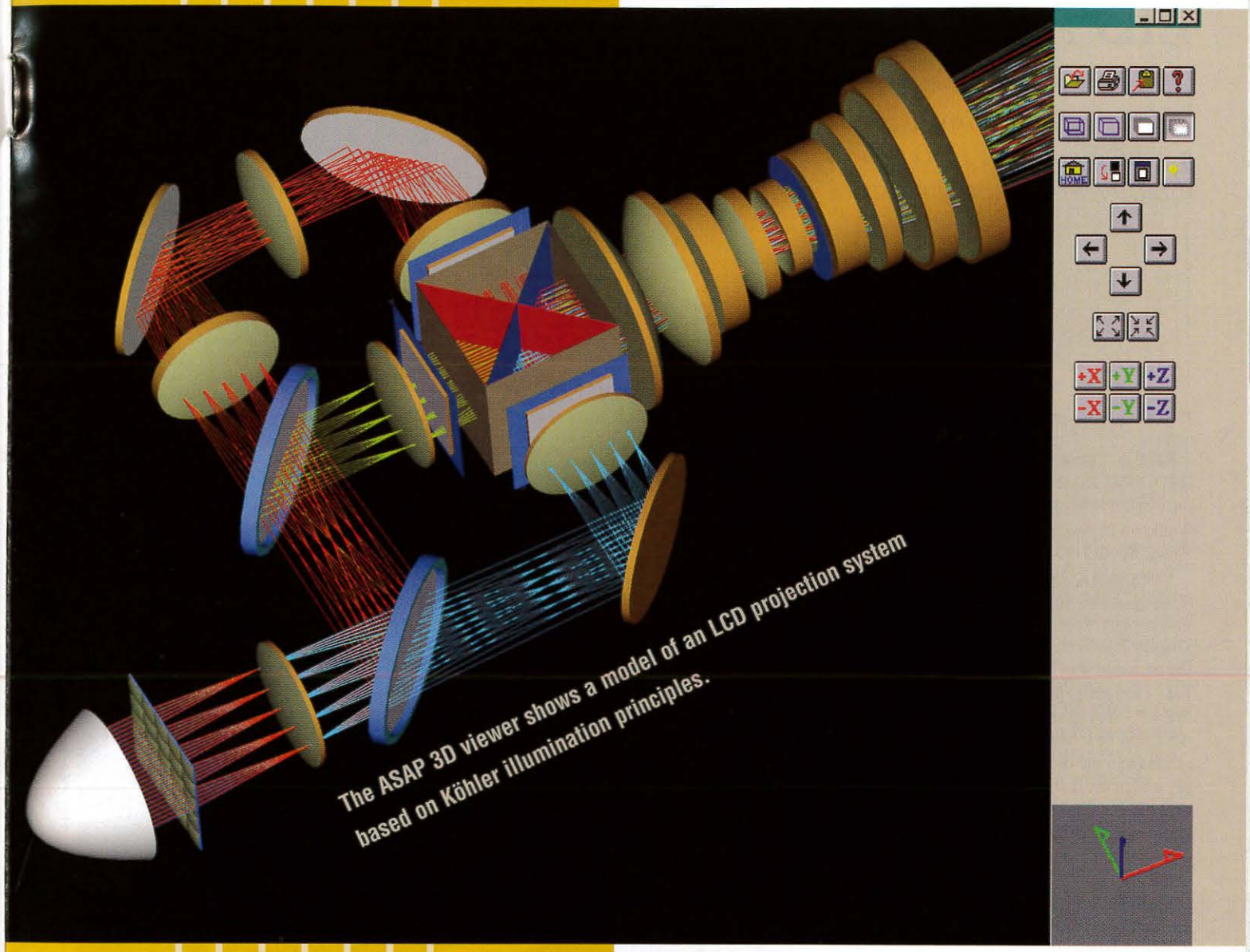

The ASAP 3D viewer shows a model of an LCD projection system based on Köhler illumination principles.

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EID Again Runs at Sandown

Calmer without EuroDisplay, EID still provided a valuable look at FPD and CRT integration from a European military/industrial perspective.

by Bryan Norris

THE ELECTRONIC INFORMATION DISPLAYS (EID) 1997 Exhibition and Conference was once again held at its normal venue – the Sandown (racecourse) Exhibition Centre, Esher, South London, 18–20 November 1997.

Compared to 1996, when it was held at the National Exhibition Centre in Birmingham, in conjunction with SID's triennial International Display Research Conference (EuroDisplay), the occasion was very subdued. Nevertheless, EID – the aptly nicknamed "Flat Panel Show" – was again an ideal forum to learn what was new on the flat-panel-display (FPD) scene from the dual perspectives of panel supply and panel integration. In particular, many of the companies that exhibit regularly at the show specialize in providing both FPD- and CRT-based product for industrial and military applications.

During the Tuesday lunchtime, there was a special press conference where presentation times were each limited to 5 min. Two excellent and very interesting presentations came from Julian Parfitt, Product Manager for Dis-

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Hitachi

Fig. 1: *At EID, Hitachi introduced its new SX3 range of high-performance-addressing (HPA) color STN-LCDs, which are fast (150 ms response time, with 80 ms coming) and have high contrast ratio (50:1) compared to conventional color STN-LCDs – at 60% of the cost of an active-matrix LCD.*

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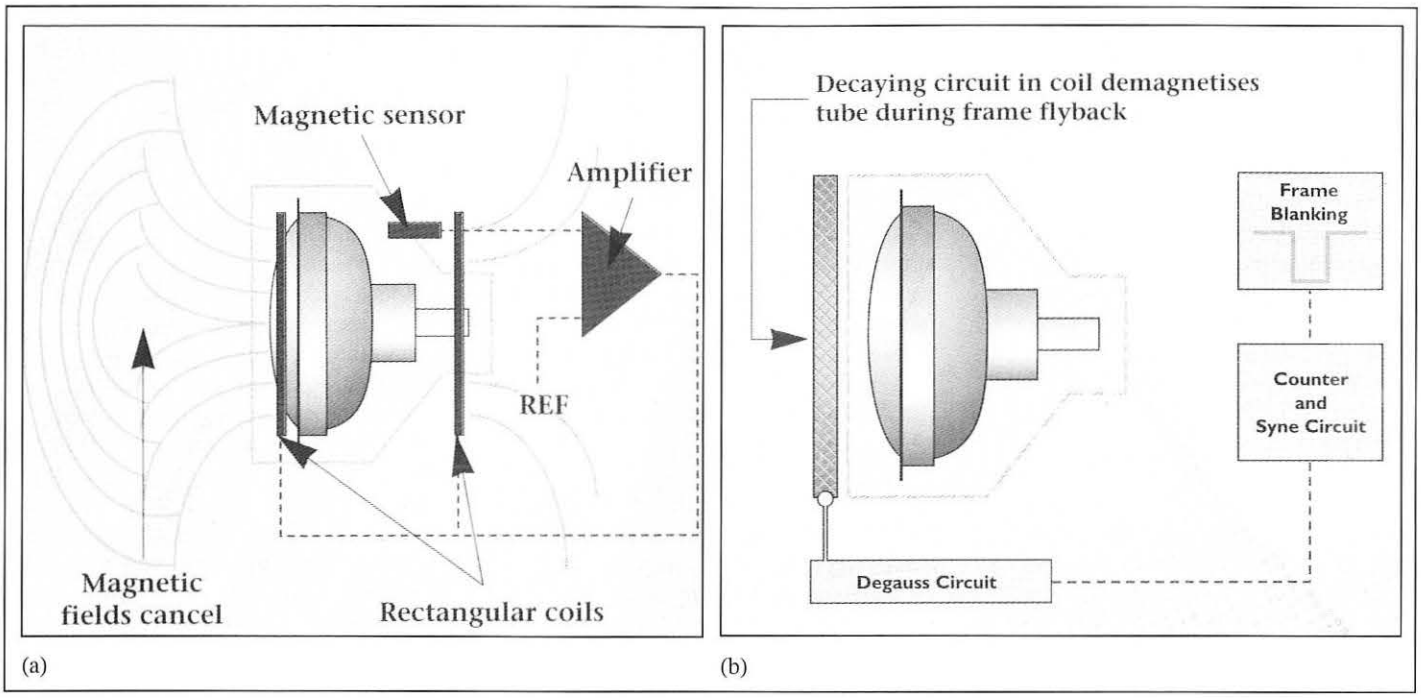

Fig. 2: *Microvitec introduced three "Magnavoid" magnetic-management systems, of which two are illustrated here. (a) The "Magnavoid A" solution is an active magnetic-cancellation system that cancels fields as they occur. (b) "Magnavoid B" demagnetizes a CRT in a way that is not noticeable to the user.*

play Products, Hitachi Europe, Maidenhead, England, and Jutta Rasp, Manager of TFT-LCD Marketing at Samsung Semiconductor Europe GmbH, Schwalbach (near Frankfurt), Germany.

Parfitt introduced ***Hitachi***'s new SX3 range of high-performance-addressing (HPA) color passive-matrix STN-LCDs. He explained that this new technology is intended for products suitable for the desktop-PC-monitor, mega-notebook, and notebook sectors, and that it has significant advantages over existing passive-matrix STN displays. In particular, HPA has response times of 150 ms – and projected response times of 80 ms – which are very much faster than those of conventional color STN-LCDs (at 300–270 ms) and much closer to the TFT response times of 55 ms. Also, the new product's contrast ratio of 50:1 is a significant improvement over existing technology, the shadowing is negligible, viewing angles are excellent, and the cost is only around 60% that of an AMLCD.

On ***Hitachi***'s stand in the exhibition hall, the first available SX3 products were on show: the SX3XS003 12.1-in. SVGA model with a standard interface, and the SX33S001 13.0-in. and SX39S002 15.5-in. XGA models with LVDS interfaces (Fig. 1). The fourth family member, the SX39X001 15-in. XGA panel with a conventional interface, was expected to be on sale in early 1998. Also on the stand were samples of LCD monitors incorporating ***Hitachi***'s LCD modules, namely, ***Microvitec***'s Proteus 34X (first seen at EID 1996), ***Nokia***'s 300Xa (using the Super-TFT 13.3-in. LCD panel), and the latest range of 12.1-, 14.2- and 14.5-in. monitors from Swedish ***MultiQ***.

Jutta Rasp gave a particularly detailed overview of ***Samsung***'s plans to become a leading player in the AMLCD-panel and LCD-monitor markets. She began with an overall FPD market review and outlook, before moving on to Samsung's progress to date and its predicted progress. In 1994, Samsung began two-up production of 9.4- and 10.4-in. panels using its D(evelopment)-Line, which employed 300 × 400-mm mother-glass. In 1995, Line 1 started up using 370 × 470-mm glass and was, at the time of her talk, the main line for (four-up) production of 9.4- and 10.4-in. panels and (two-up) production of 14.0/14.1-in. XGA panels – plus some two-up production of 13.3-in. XGA panels.

With a 1997 start-up and using 550 × 650-mm glass, Line 2 became the main production line for the (six-up) 12.1-in. SVGA/XGA panels and (four-up) 15.0-in. XGA panels. In addition, Samsung had recently announced its intention to establish Line 3 at Cheonan in Korea using 600 × 720-mm mother-glass, with a planned start-up for the second quarter of 1998. This line will be capable of producing six-up 13.3-in. panels, four-up 17.0-in. SXGA panels, two-up 21.3-in. UXGA panels, and a one-up 30.0-in. panel.

At the time of the show, Samsung LCD monitors were available in sizes from 13.1 to 15.1 in., while the 17.0- and 21.3-in. units will be available in 1998. Jutta assured us that by the end of 1998 we would actually be able to buy the 30.0-in. LCD monitor! All the Samsung TFT-LCDs available for sale were promoted on the stand of its newly appointed, first UK distributor, ***Hawke Displays***, the specialist optoelectronics division of ***Abacus Polar***.

Seeing the Future

A glimpse of the future for displays was provided by the speakers presenting during the

three conference days. A wide range of papers covered the technological aspects and potential of CRT, EL, FED, plasma, and STN- and TFT-LCD. During the first day, J. Norman Bardsley of the ***U.S. Display Consortium*** (USDC) gave an explanation of the formation and aims of the USDC and a progress report. The first of his conclusions was that "by paying attention to the dynamics of a rapidly evolving global industry and the special opportunities presented by the needs of [U.S.] government agencies and other niche applications, U.S. display manufacturers have developed distinctive technologies."

The previous paper, by Alan Mosley, DTA Project Manager for ***CRL*** at Hayes, Middlesex, UK, related how the ***Display Technology Alliance*** (DTA), which started in January 1997, is a 3-year UK-government-supported "Technology Foresight" project aimed at focusing on the development of the UK's (flat-panel) displays industry. The DTA currently involves 14 companies and six universities, and contains five "sub-projects."

The paper "LCDs: Capabilities and Possibilities" by P. A. Gass of ***Sharp Laboratories of Europe Ltd.*** (Oxford, UK) provided an excellent and extensive review of the status and likely developments of LCD technologies. The following extract from the paper's many conclusions provides a particularly interesting (and realistic) insight from the world's leading LCD producer: "However, for these [desktop and video display] applications, LCDs are competing directly with CRTs, whose longer development history results in a significant price advantage. In the short term it seems likely that LCDs will only displace CRTs from those environments where space is at a premium."

But that doesn't mean that the medium-term CRT-displacement market is small in absolute terms. R. A. Young and B. E. Young of ***DisplaySearch*** in Austin, Texas - who were brave enough to provide forecasts of the sales of "alternative" desktop monitors - told of how an (extensive) cost model for calculating CRT and TFT-LCD costs over the next 5 years had (eventually) led to the prime conclusion "that TFT-LCDs will grow to 11% of the desktop-monitor market, or 14.3 million units, by the year 2002, representing a 101% (CAGR)."

Launching New Products at EID

Back to the present and the product launches at the show. LCDs again predominated, often in products specially designed for industrial environments. For example, ***Craft Data*** introduced the ***Carroll Touch*** flat-panel-monitor range, which is able to withstand exposure to harsh environments, severe temperatures, vibration, shock, and EMI/RFI. The models in this range employ 13.8-in. AMLCD panels. They can operate without routine calibration or maintenance, and include open-frame configurations and the choice of an infrared touch frame or guided-wave touch screen.

Datalux (Europe) was showing its U.S.-made rugged LCD units, in particular the LMV10 10.4-in. VGA panel and the LMX12 12.1-in. high-brightness (200 cd/m^2) plug-and-play monitor that autosynchronizes to VGA, SVGA, and XGA. The sealed housings of both these models make them resistant to liquids and dust, and they are thus ideal for industrial use. ***Digital View***'s extensive selection of LCD monitors included the Series 3000 rugged units, Series 5000 sealed units, Series 6000 open-frame units, and ruggedized versions of its AV Series of video monitors.

Dolch's DataView™ and PanelMount flat-panel monitors, available in sizes from 10.4 to 16.1 in. and supporting resolutions of VGA, SVGA, XGA, and SXGA, are all housed in rugged all-metal enclosures designed to withstand high levels of shock and vibration and to protect against dust, water, and contamination to various NEMA standards. Use of the Dynalink™ fibre-optic interconnection systems allows the displays to be located remotely (up to 20 km) from the host computer, as in factory-floor industrial-automation systems, shipboard networks, and mine workings.

KME is continually adding new LCD monitors to the line of industrial CRT monitors made at its Rochester (Kent) plant in 10–21-in. screen sizes. Last orders are being taken for 12- and 13-in. models. The latest 29LS range of open-frame-chassis TFT-LCD monitors, in sizes from 10.4-in. VGA to 13.8-in. XGA, combines TFT panel, power supply, and A/D converter board in a single package that can be installed behind a console or front panel. The 12.1-in. SVGA model is also available in an industrial metal desktop case.

The UK office personnel of ***Sharp Electronics*** (Europe) GmbH, Hamburg, were exhibiting some of Sharp's extensive range of products, including the LM80C312 12.1-in. STN display specially developed for use in test equipment, portable units, and other industrial applications. The company says this is the first color STN screen to offer "a wide-viewing-angle film giving high-brightness distribution" and flexibility of installation.

Trident Microsystems, an important outlet for LCD monitors from ***IBM***, showed numerous examples of the latest 10.4-, 12.1-, and 16.1-in. IBM models, including some ruggedized units. In addition, Trident was promoting a 10.4-in. VGA TFT-LCD that could be read in bright sunlight. This new display offers an operating temperature range of -25 - +85°C, a wide viewing angle, and a 500-cd/m^2 super-high-brightness backlight. Trident promised to introduce a 1000-cd/m^2 model in the near future.

Sunlight-readable TFT displays were also one of the features on the ***Dicoll Electronics*** stand, where four new panels from ***Computer Dynamics*** were on view. The 10.4-in. H927 and the 13.8-in. panels have luminances of 900 and 800 cd/m^2, respectively!

Other LCD panels at EID worthy of note included the ***Sanyo*** range on the stand of ***Semicom*** (the exclusive UK and Eire distributor, and the agent for ***Sanyo Electronics Components***) and ***NEC***'s 10.4- and 20-in. panels on the booth of dedicated distributor ***Sunrise Electronics***.

Sunrise also featured ***NEC***'s impressive new 33-in. plasma display. Plasma panels/monitors were also in evidence on the stands of ***Delphi Information***, ***Hantarex***, and ***Thompson Tubes Electroniques***. Delphi announced that it had just finalized an agreement with ***Fujitsu General*** (UK) and had been appointed the official European representative for that company's "Plasmavision" plasma panels. Moreover, Delphi stated that during the 12 months since the release of the 42-in. Plasmavision display onto the European markets, sales had considerably "exceeded the thousand mark." The Hantarex 42-in. self-contained information-display plasma monitor, launched during the 1996 EID show, was announced as going into production. Thompson's two new plasma panels were in 19- and 24-in.-diagonal screen sizes. Boasting 1280 × 1024 pixels with 0.38-mm spacing, the 24-in. unit showed images of exceptional quality.

Cathodes Still Emitting

Not yet consigned to oblivion, CRT monitors aimed particularly at industrial and information-display uses were shown by a number of

exhibitors. These included Italian-made models from ***Hantarex*** (21–34-in. units by ***Sambers***) and ***Sabre Computers*** (21-, 28-, and 33-in. by ***Selti***); and UK-made models from ***PD Systems*** of West Molesey, South London (28 and 32 in.); ***Sascal Displays*** of Hayes (North London); newly named ***Xcel Corporation Ltd.*** of Melbourne (Hertfordshire); and ***Calibre*** and ***Microvitec*** of Bradford.

Worthy of mention is the unveiling by ***Microvitec*** of its Magnavoid magnetic-protection technology. This comes in three variants which can be customized to combat particular problems in certain environments. The "Magnavoid A" solution is an active magnetic-cancellation system that prevents displays from being affected by magnetic fields; it cancels these fields as they occur [Fig. 2(a)]. This method is suitable for use in environments where mu-metal screening is ineffective. The "Magnavoid B" solution prevents the effects of residual magnetism by demagnetizing the tube in a way that – unlike traditional degaussing – is not noticeable to the user [Fig. 2(b)].

Microvitec introduced at the show its ProScan 17SX 17-in. 30–95-kHz plastic-cabinet monitor that features Magnavoid A as standard and Magnavoid B as an option. There was also an impressive demonstration of the new 21-in. fitted with B as standard (A is optional), combating continually changing fields.

The remaining option, "Magnavoid C," "makes use of mu-metal products to deal with low magnetic fields or to enhance the effects of the cancellation and demagnetization system."

Summing Up

Although the 1997 EID was much quieter than the 1996 show, it still provided the visitor with an excellent overview of the current display products on offer in the UK and Europe – especially for the flat-panel and industrial markets – as well as the future direction of the displays industry on a global scale. ■

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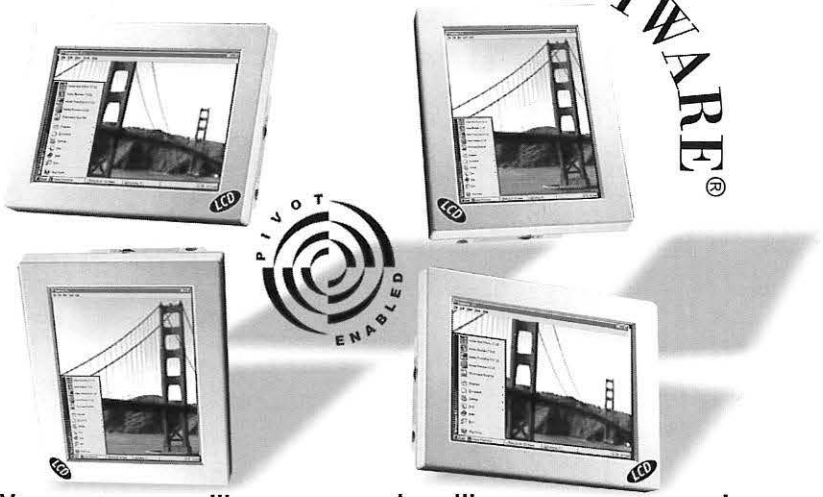

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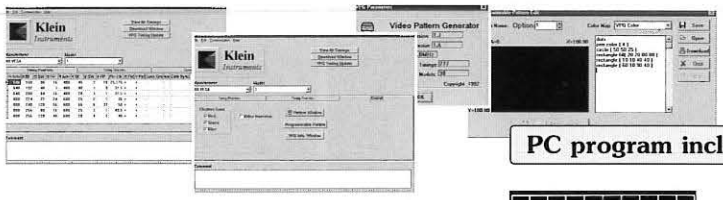

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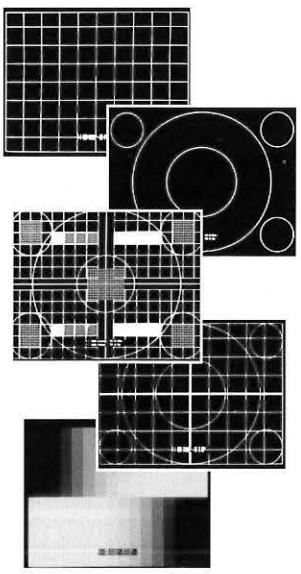

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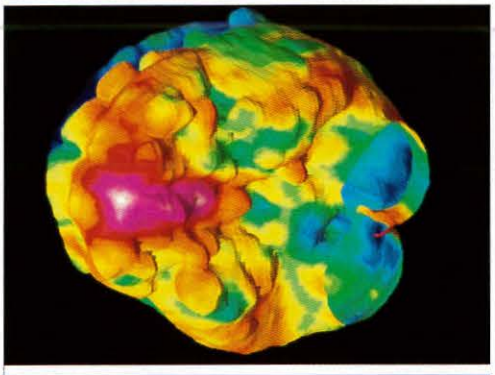

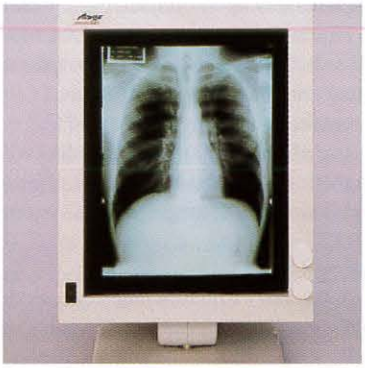

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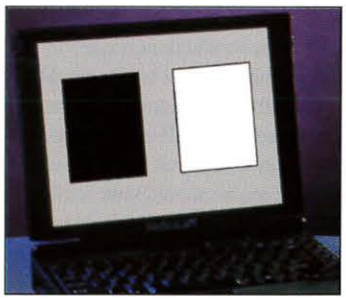

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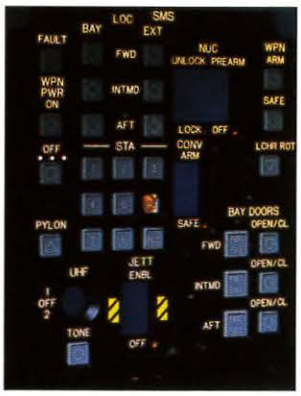

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continued from page 4

We had more money than anyone. Money and power – how could anyone even think of trying to stop us? I guess the only thing we missed seeing was how the established businesses would react when we began to significantly impact their ability to survive. We knew we would mortally wound many of them, but did they have to get so prissy about it? First the travel agents started to protest that we were putting their whole industry out of business. Well big deal, couldn't they just go find something else to do? Then the newspapers started complaining that they were losing want-ad revenue to our on-line services. And then the television folks got mad at some of our efforts to combine computers with TV. Couldn't they see that we were building the great Information Society?"

By this point in his well-worn story, Softwrenginr would get quite agitated and most listeners would make some polite excuse and make a hasty departure. However, for the few who couldn't come up with a quick excuse or were too polite, the story would continue.

"After all these years, I still can't believe how they wanted to mess up everything we were trying to do. And all because of a few politicians who listened to all this whining about jobs being lost in their districts. Weren't we creating the better society?

"But you know what? You know what? We beat them all! The politicians, the bankers, the newspaper guys, the television executives, the software companies that tried to take us on – we beat them all! Oh man, that was so great! We actually conquered the whole world. The Internet, the Information Society, whatever you want to call it, all was under our control."

Softwrenginr's eyes would dance and sparkle as he got to this point in his story. His rotund body looked absolutely energized, as if ready to leap from the bench. But then just as suddenly, like a heavy cloud that drifts across the sun on a spring day, he would sink back into the bench. Now, the energy drained from his voice, he would continue.

"And then after all this, it happened… How could we possibly have seen it coming… I had hired all the smartest software people to work in my research group. They were making such great progress. We were doing as well as anyone developing software for voice processing. How could we have foreseen that once this technology matured, it would be more effective to design it right into the hardware? Once the algorithms for voice communications were developed and once it was found that direct hardware implementation was the best, it just seemed that we couldn't counter the trend. We weren't circuit designers – we didn't know how to do wafer-scale layouts. And… oh yes… then there were the smart displays. Where did those come from?"

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Almost without thinking, he reached for his pocket communicator and held it up for his listener to see.

"Just look at this display! Isn't it a beauty? Just look at all it can do. All that and without a GUI.

"How could the change-over happen so quickly? Why were people almost glad to get away from having to use our software products? Oh sure, pieces of the company survived. But those of us who only knew how to run great software projects didn't have much of a chance.

"Twenty years. All this in the span of just twenty years. Oh what I wouldn't give to turn the clock back to just after the turn of the century. Those were the days. Those were the days when people respected me and called me Nathan…"

And then Softwrenginr would slowly rise from his bench, lost in his own thoughts, oblivious to his listener, and slowly shuffle back to his aging Humvee parked among the newer SUVs in the small lot next to the shopping mall across from the park. Invariably, he would take one more look at his pocket communicator and its bright, full-color high-res display. Tomorrow, he would most likely return to think some more. After all, what else was there to do? He certainly didn't need the money.

Softwrenginr looks back, but in 1998 we look forward – and many of us are obsessed with the evolution of the Information Society and the Internet and all the changes that are yet to come. To hear some people tell it, the Internet is of greater significance than anything else that has happened in the history of mankind. In fact, I had one person tell me that the Internet is like a giant brain and that we each are like a neuron within this global mind. And once this giant brain fully develops its capabilities, some incredibly awesome but as yet unpredictable changes will take place in the human condition. To me, that starts sounding like an unholy merger between religion and Star Trek – like the Borg that act as one giant God-like mind.

Well, if this seems a little extreme, and it does to me, to what can we expect the Interconnected Society to evolve?

First, let's propose a model for how we humans interact with information. I would suggest that we accomplish everything through the following four-step process: ***(1) We get information; (2) we think about this information and maybe modify or add to it; (3) we send the modified information somewhere or to someone; and (4) we look for a response and then we repeat steps 1 through 3 until some greater power pulls our plug.*** Now, isn't that about as simple as anything can be? It is, as long as we don't underestimate the importance of Step 2.

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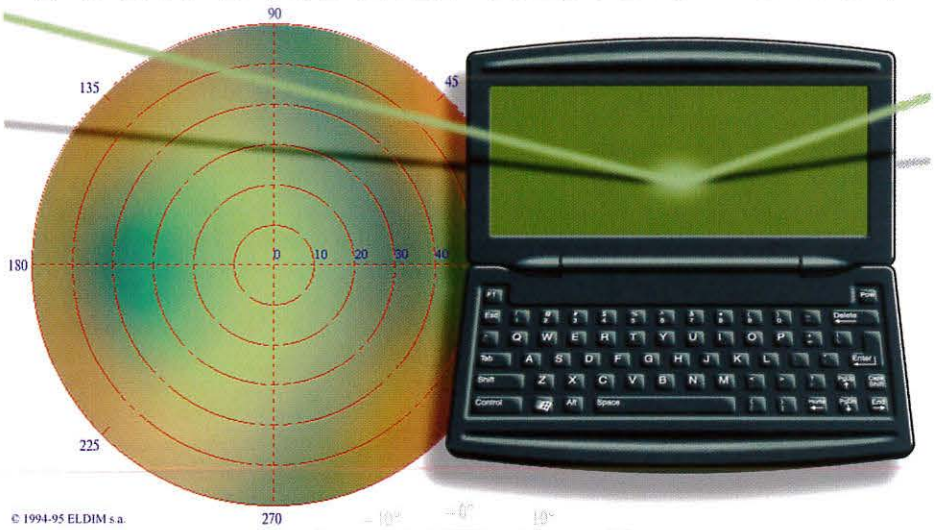

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Of course, to do Step 1, we want to get the information we think we want as quickly as we can (instant information gratification). To do Step 2, we want complete freedom to do or not to do anything with the information we receive. To do Step 3, we want to send the information to where we think it will do the most good (typically, for us), and again as quickly as possible.

Well then, where do we get the information in order to do Step 1? Over the centuries we have developed some well-known data repositories, but lately they seem to be proliferating at an exponentially increasing rate. The earliest databases were, of course, human brains, sometimes supplemented by a few cave paintings. Then we learned to keep written records of such things as business transactions, religious events, historical happenings, and diaries. These record-keeping procedures eventually became highly refined and today exist as the ubiquitous laboratory notebooks. Then came books, and libraries, and bookstores, and magazines, and newspapers. Then, about a century ago, we started adding film media like movies, slides, and microfiche. And even more recently came magnetic media like audio and video cassettes.

Finally, all this came together in ***computer memory.*** This started out with the now-almost-forgotten punched cards and proliferated to magnetic tape, and disks, and great big drums, and tiny little magnetic cores, soon followed by solid-state memory - doubling in capacity every pi/2 years. Then we added CD-ROM and multi-gigabyte disks and we're not anywhere close to being done yet.

In order to meet the expectations of Step 1, ***we want access to all this information instantly.*** The only way to be able to do that is to have it all on computers that we can query from wherever we are, whenever we want. The converse of this meets the conditions of Step 3. ***We want to send our processed information equally instantly.*** To meet the criteria of Step 2, ***we just want and need to be left alone.*** Step 4 sometimes is just like Step 1 but other times needs another human to do a Step 2 first. ***We also don't want to pay very much for doing Steps 1 and 3 but we want to get paid lots for doing Step 2.***

The obvious conclusion is that ***once we have all the information that exists stored away in readily accessible computer databases, we need some really convenient and fast way to get at it.***

Getting information from one human to another seems to have evolved to support the quantity of information that is generated. The earliest method was human-to-human interaction. The well-known disadvantage of this process is that this sometimes requires one or both humans to change location (giving rise to the travel industry). In addition, we humans aren't very good at the accurate storage - or at least retrieval - of certain kinds of data. Next, we started writing things down and delivering this stuff to each other (giving birth to the Post Office). Then we realized that faster information transmission might be a good thing, and along came the telegraph - the first demonstration of the virtues of *digital* communication. The telegraph should have led to the first fax machine, but didn't. (I continue to wonder why not.) Then with the invention of the telephone, the radio, and television, we forgot all about *digital* and went for an all-analog world. It sure seemed like an advance at the time.

Today, we have seen the error of our analog ways and returned to re-invent the *Automated Telegraph* - which, to make it sound more contemporary, we have decided to call the Internet. We send our dot-packets all over the world and other dot-packets come back to us in response. Our desktop and laptop computers and cell-phones have made the translation process highly efficient. The massive amount of data being stored in readily accessible computer-controlled data banks allows the access to occur mostly without human intervention. But little dot-packets is what they are.

Remember back in December 1993 when I wrote a column about "Information Velocity" and "Information Acceleration?" The Internet zips those little dot-packets of information along their way at close to their ultimate speed-of-light limit. That and lots of locatable data storage is all it does.

In that context, it is poignantly amusing to read the pronouncements of some of the Information Society pundits who endow the Internet with some mystical properties that are expected to change the world - always for the better, of course. Esther Dyson, among the most respected of these thinkers, in her book *Release 2.0* writes that the Net offers people a chance "to design a world that is more open, more accessible to everyone and just a nicer place to live in." Really? That can only happen in Step 2, and the Net has nothing to do with that. The only thing the Net can do is to make us be good or bad *faster.* If we are inclined to do good works, the Net will enable us to reach more of our fellow humans faster. And if we are inclined to take advantage of our fellow humans, the Internet will give us the tools to do that faster as well.

Think of it this way. If we want to go shopping, we can go to a store and make a personal transaction (the thousands-of-years-old method), we can look in a mail-order catalog and send off a letter or make a phone call to place our order, we can watch our TVs and participate in the home-shopping network, or we can use the Internet. Each of these has certain virtues for speed and information content. But there is nothing about the Internet that guarantees that the purchased product will be better or more in keeping with the manufacturer's claims than mail-order or TV shopping. For some goods, the best shopping is still done in person at a store. The Internet provides another convenience just like the telephone did, but let's keep things in perspective - ***the Internet will not by its very existence make this world a better place in which to live.*** Darn it. Does that mean we will all have to take responsibility and do it on our own? Sounds kind of hard, doesn't it?

For instant and convenient response to this column over the Internet, you may reach me at silzars@ibm.net, or by dot-packets over the fax at 425/557-8983, or by audio at 425/557-8850, or by the recently improved and friendlier Post Office at 22513 S.E. 47th Place, Issaquah, WA 98029. All these methods will be considered equally good by this author and the sender will receive a response by the communication method that I will select using the faculties endowed me in Step 2. ■

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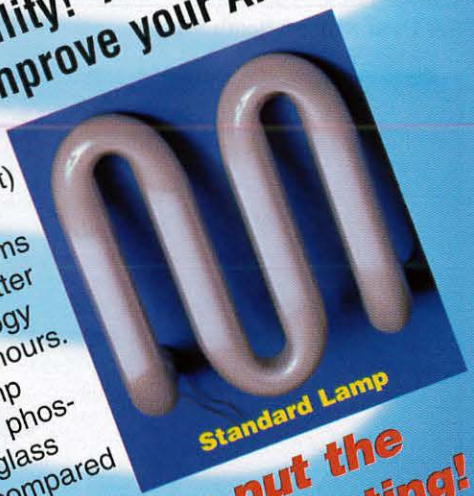

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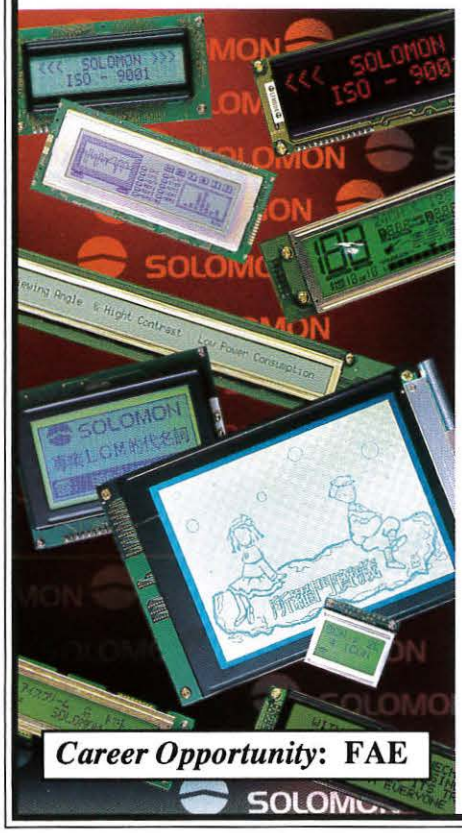

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editorial

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Akami installed its first RGB LED video display in 1995, and wound up installing four that year. Eight large displays were installed in 1996, and the company anticipated installing ten by the end of 1997, including some outside Japan.

Originally, Akami produced red-green video displays. When Nichia Chemical developed its high-luminous-efficiency blue LED in late 1993, Akami started development of an RGB display. Displays installed from July 1996 use pure green (x = 0.19, y = 0.67) gallium nitride LEDs, and those installed beginning in 1997 use a new GaAlInP red LED that is, in the company's perfect phrase, "tenderer to humans' eyes." With the new LEDs, the color primaries are very close to those on the NTSC color chart, says Akami. Akami is also proud of combining multiple LEDs in each pixel, which allows a finer pixel pitch of 3–6 mm and "remarkable improvement … on color blending from short distance." Viewing angle was also expanded in 1997 to not less than ±60° horizontally and not less than ±35° vertically.

Akami has installed RGB displays with diagonals ranging from 120 to nearly 700 in. Each of the company's "Super Vision Lisa" systems includes an image controller for both video and non-video images, and accepts signal input from cameras, TV tuners, laser discs, VCRs, and similar devices. Dot-image data such as English or Japanese characters, animation data, and scheduling data are readily managed with a personal computer. Power consumption is 25–50% less than large displays using CRTs or fluorescent lamps, and lifetime to half brightness is 3 times that of the competing technologies, Akami says.

Westerners may not be ready to confront a 30-ft. video image of Jerry Springer around each corner of a city sidewalk or each curve of a highway, but we feel differently when the image is of Cal Ripken, Jr., at Camden Yards or of Michael Jordan at any basketball facility in the country. That's an application that would bridge this particular cultural divide.

– Ken Werner

We welcome your comments and suggestions. You can reach me by e-mail at kwerner@netaxis.com, by fax at 203/855-9769, or by phone at 203/853-7069. The contents of upcoming issues of *ID* are available on the *ID* page at the SID Web site (http://www.sid.org).

european views

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The three SID chapters – with the French chapter as main contractor – have asked the EC for financial support. A further, very worthwhile goal of this proposal is to bridge the three-year gap between EuroDisplay conferences. These conferences, organized by SID and the respective national organizations of the host country, do indeed play an integrating role in the European and worldwide display community.

The next EuroDisplay conference will be held September 6–9, 1999, in Berlin. It will be preceded by the IFA, a very large exhibition that includes a show of displays, the broadcasting of images, and the processing of images. EuroDisplay '99 will be opened by a workshop on current and hot display topics, such as plastic foils for substrates or for the enhancement of picture quality. A highlight of the conference will be a performance of the Berlin Philharmonic.

The SID chapters in Eastern Europe organized a display conference in the Crimea from October 12–16, 1997. This meeting was supported by SID. As part of the support arrangement, the Proceedings of the Crimea Conference will be available at a moderate fee to SID members and other display enthusiasts. This is an opportunity to become familiar with display activity in Belarus, Russia, and the Ukraine.

Finally, attention is drawn to a forthcoming display symposium in Garmisch in the Bavarian Alps from April 29–30, 1998. It is organized by ITG, the German Society for Information Technology, and is sponsored by SID. The conference language is English. Besides enjoying spring in the Alps, participants are offered talks on flat-panel displays, their fabrication equipment, and applications. For further information, please contact:

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calendar

Display Technology

EUROMONITOR '98: The Second International Exhibition-Fair of Information Display Devices and Projection Equipment. Organizers: Russian National Association of Display Manufacturers, Distributors, and Consumers. Contact: E. G. Goushchin, President, SPS Concept Engineering, Office 902, 41 Vernadskogo av., Moscow, 117981, Russia; (095) 430-8650, 338-9582, 339-5726, e-mail: concept@aha.ru; Internet: http://www.aha.ru/~concept.
March 10-13, 1998 Moscow, Russia

The 1998 SID International Symposium, Seminar & Exhibition (SID '98). Sponsored by SID. Contact: Jay Morreale, Palisades Institute for Research Services, Inc., 201 Varick St., Suite 1006, New York, NY 10014; 212/620-3371, fax 212/620-3379, e-mail: jmorreal@newyork. palisades.org.
May 17-22, 1998 Anaheim, CA

9th International Workshop on Inorganic and Organic Electroluminescence (EL 98) and The Fourth International Conference on the Science and Technology of Display Phosphors. Sponsored by SID, PTCOE, DARPA, and the Oregon Center for Advanced Technology Education. Contact: Mark Goldfarb, Palisades Institute for Research Services, Inc., 201 Varick St., Suite 1006, New York, NY 10014; 212/620-3380, fax 212/620-3379.
Sept. 14-17, 1998 Bend, OR

The 18th International Display Research Conference (Asia Display '98). Sponsored by KPS and SID. Contact: Prof. S. Lim, Secretary General; +82-417-550-3542, fax +82-417-551-9229, e-mail: limsk@ns.dankook.ac.kr, Internet: http://tftlcd.kyunghee.ac.kr/idrc98.
Sept. 28-Oct. 1, 1998 Seoul, Korea

The 42nd Annual Meeting of the Human Factors and Ergonomics Society. Contact: HFES, P.O. Box 1369, Santa Monica, CA 90406-1369; 310/394-1811 or 310/394-9793, fax 310/394-2410.
Oct. 5-9, 1998 Chicago, IL

The Sixth Color Imaging Conference. Sponsored by IS&T and SID. Contact: IS&T, 7003 Kilworth Lane, Springfield, VA 22151; 703/642-9090, fax 703/642-9094, e-mail: info@imaging.org.
Nov. 17-20, 1998 Scottsdale, AZ

SID Conference Calendar

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- Evening Panel Discussions, an Exhibitor Reception, a Conference Luncheon, and an evening Social Event will complement the technical program.

17 MAY 98

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14 SEPTEMBER 98

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28 SEPTEMBER 98

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  - Image and Signal Processing,
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17 NOVEMBER 98

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NOVEMBER 17 – 20, 1998

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For additional information:
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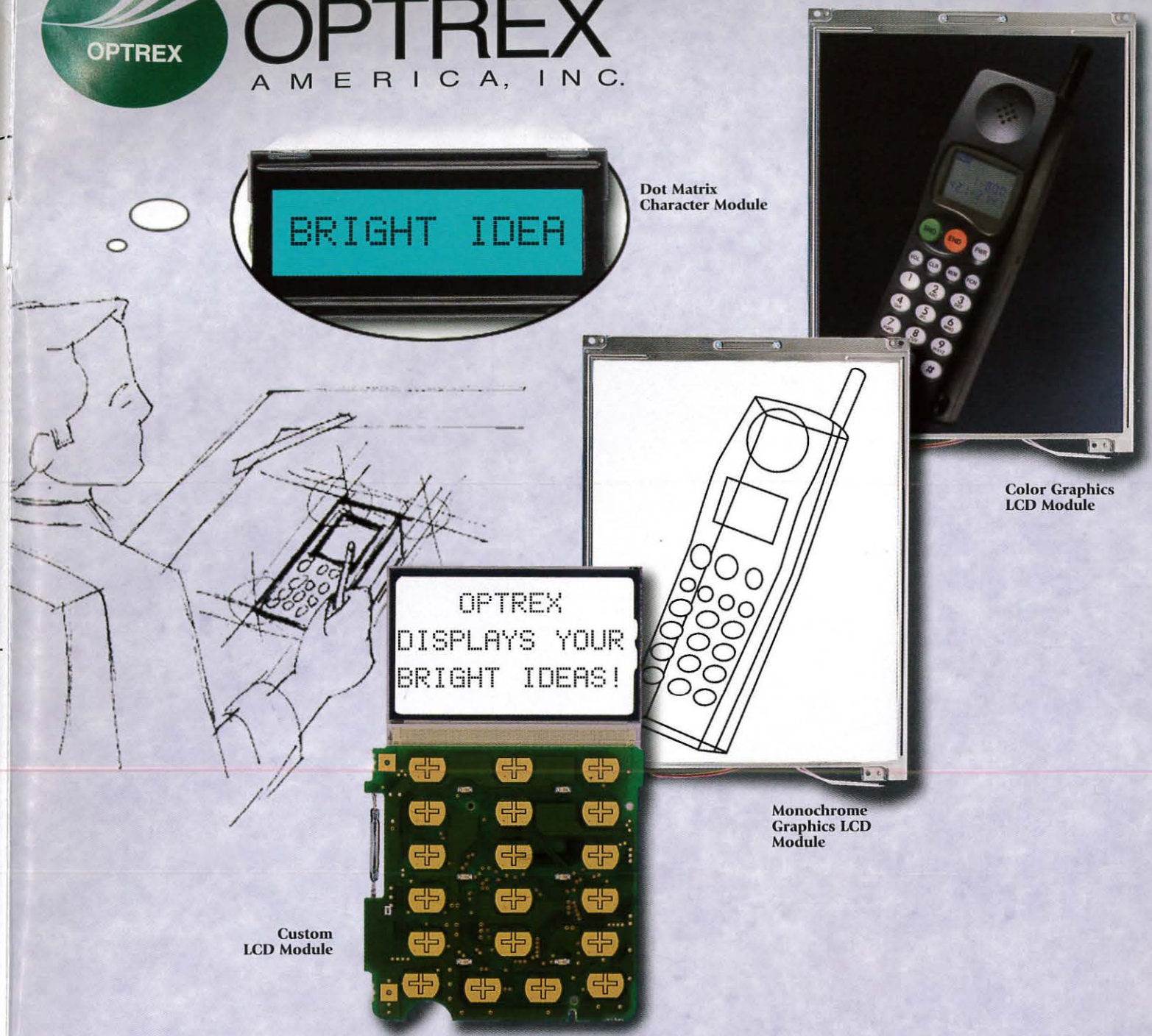

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