HDTV & THE QUEST FOR VIRTUAL REALITY©

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HDTV & THE QUEST FOR VIRTUAL REALITY©

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HDTV

Infinite Escher

I. HDTV Around the World

A. Current Production in Japan, Europe, and America

Laurin Herr

Hello, I'm Laurin Herr. Welcome to the SIGGRAPH Video Review.

This is Hi-Vision Control for Japan's public television network, NHK. Each day, one hour of HDTV is broadcast via satellite to over 100 public display screens across Japan.

In Europe, seven remote trucks comb the continent covering news, sports and special events, feeding HDTV via satellite to VIP audiences. In America there is experimental HDTV production and a growing debate about HDTV standards and applications. Broadcast is still years away.

The Little Death

Non-broadcast applications, such as critical viewing, medicine, fashion and computer graphics, are attracting more attention. This is changing the way we think about HDTV; and HDTV is changing the way we think about television. Yves Faroudja:

Yves Faroudja

The problem with HDTV is, it's got to be perfect. You see, otherwise, there's no point because the yardstick is not the old NTSC of your grandfather, because it's that old. But it is the NTSC of today, which is that. That's not bad. That's the problem. NTSC, when it is line doubled, bandwidth expanded, noise reduced, ghost reduced, looks darn good. That's the yardstick for the real HDTV.

B. HDTV Technologies

Laurin Herr
Sony: HDC-300
Sony: HDD-1000
Matsushita: Rear Screen Projector
Sarnoff Labs: Princeton Engine
Sharp: LQ4RA01
Sony: Interactive Edit Room

HDTV transcends television. It demands state of the art image sensing, image recording, image transmission, image display. It pushes the limits of computer graphics, VLSI, flat displays and workstations. These are the technologies that will carry HDTV forward.

Dale Cripps

The receiver of the future is a computer. It will always be a computer from this time forward. I think the only question that people raise about that is: will it be used as a computer, or will it be used as a television set?

II. Classical Television

A. The Evolution of Television

Laurin Herr

TV actually emerged in the 19th century, before radio, before electronics. Early television was mechanical with scanning resolutions in the dozens of lines. The breakthrough that enabled modern television was electronic image pick-ups and displays, built out of vacuum tubes.

Television was radio with pictures — broadcast from the one to the many. TV sets were bulky and the screens were small. Studio cameras were large and tethered to even larger amplifiers.

In 1953 color was squeezed into the black and white system by piggybacking three channels of red, green and blue onto a single channel. This is called composite color. The frame rate was also modified from 30 to 29.97. We still live with this compromise, called NTSC. Ampex ushered in video tape; recording in 1956.

Sony: GV-9

Like computers, video went solid state, shrinking in size and cost. Now the cameraman can roam freely, and everybody can make TV.

Joseph A. Flaherty

Development no longer really takes place at the equipment level as it did ten, fifteen, twenty years ago. Development takes place at the chip level. Given a chip, many manufacturers can make similar things in a very short time.

Laurin Herr

Video is going digital, a process that began with the time base corrector in 1972. Digital frame buffers came next. The paintbox for drawing, the ADO for image manipulation, digital special effects, the Harry for compositing, computer graphics, and digital video discs all expand the repertoire of the video artist.

Sony: DVR-10

In the late '80s, digital video tape; recorders swept into the studio. Tape keeps getting denser, cassettes smaller.

Panasonic: Digital Camcorder
Sony: CCD Microcam
Mitsubishi: AM-3501-R

In 1990, Panasonic announced the first 1/2 inch digital camcorder. And Sony showed CCD micro-cams. Only the monitor, still a large vacuum tube, continues to get bigger.

B. The Major Image Format Parameters of TV

HDTV changes television. What's changing? First of all, there is the aspect ratio, the width of the picture divided by its height.

For classical TV, the ratio is 4 x 3 or 1.33 to 1, similar to the classical cinema. But, during the '50s, in a marketing response to television, cinema aspect ratios widened.

In NTSC, there are 525 scanning lines, of which 483 are displayed. Digital standards fix the horizontal resolution at 720 pixels.

Television is moving pictures. The way we convey motion is to send many pictures per second. The number of frames per second defines the frame rate, or temporal resolution.

How TV Works

Television works by scanning the frame left to right, top to bottom, one line at a time. There is a legend that one of TV's pioneers, Philo Farnsworth, discovered raster scanning while plowing a field.

Interlace scanning, a variation on Farnsworth's idea, alternately scans all the even lines of the frame, and then all the odd lines. These are called fields, and there are two fields per frame, or 59.94 fields per second, in NTSC.

In the early days of television, the frame rate was synchronized to power lines. In America and Japan, 60 Hz., 60 fields. In Europe, 50 Hz., 50 fields. Although the European systems have less temporal resolution than NTSC, they do have more spatial resolution: 625 vs. 525 lines. The result is that the total bandwidth of the European and American systems is approximately equal — about 10 megapixels per second, or in analog terms, 4.2 MHz.

III. High Definition Television

A. The Invention of HDTV

Researchers at NHK began experiments in 1970 to develop a "television of the future". We went to Japan to talk with Dr. Takashi Fujio, who led the NHK team.

Dr. Takashi Fujio

If you look at NTSC from the perspective of developing a "television of the future", NTSC has a lot of weak points. For example, the limited range and coarseness of the color capabilities. Or the fact that deeply saturated colors make the image look blurry. There is inadequate resolution. And the aspect ratio is not appropriate for large screen display. We were aware of all these sorts of weak points. We understood them. And the solution was a new system, a new format, and development of new equipment to eliminate these problems.

B. The Advantages of HDTV

Laurin Herr

Dr. Fujio began with a re-examination of the human vision system using this test apparatus.

Dr. Takashi Fujio

The biggest challenge we faced in the beginning was to figure out what sort of aspect ratio, what sort of screen, what sort of color range was needed in order for high-definition television to evoke an emotional effect in people. Our biggest initial problem, then, was defining the design goals.

Laurin Herr

NHK's team discovered that increasing the viewing angle and enlarging the screen heightened the viewing experience. They also found that screen size affects the perception of aspect ratio — a larger screen works better, wider. The HDTV 16 x 9 or 1.77 to 1 aspect ratio is similar to wide screen cinema.

In order to improve the image while enlarging the screen, more spatial resolution is needed. Dr. Fujio confirmed that we perceive less spatial detail in moving pictures. He felt interlace enhances motion perception, without flicker.

Composite color was abandoned and replaced with RGB. The color space was enlarged.

A final improvement was the addition of stereo sound to widen the focus of visual attention.

C. The First HDTV Systems

NHK researchers turned to Japanese industry for their prototypes. The first monitor, the camera, the telecine — built in house and running 70mm film, the first 1" analog VTR, the first film recorder.

Dr. Fujio brought a working system to SMPTE in 1981. The interest of director Francis Ford Coppola gave him a big lift, but the first American to actually buy a system was Barry Rebo.

Barry Rebo — The high definition pictures are different, and I believe they're better, because they have a clarity, both in resolution and colorimetry, that's unique. Frankly, I believe it's the best color imaging system that we've found to date. I think it is better than film, in a pure sense. It may not have the aesthetic difference, or distance rather, that film has, but as an image, it is the most accurate reproduction of reality that you can get in terms of resolution and colorimetry.

D. The European and American Response

Laurin Herr — Dr. Fujio dreamt of a single, unified world standard based on his 1125/60 HDTV. But at the CCIR meeting in Dubrovnik in 1986, his dream was frustrated by the Europeans, who a month later created their own HDTV research consortium led by this man.

Ir. P. W. Bögels — If you live in a country where you have 50 Hz., and 50 Hz. is in the world (approximately 70% of the world is 50 Hz) if you want to change that in a revolution and say, "I'm going to introduce now a new system," you could disturb the market. And if you look at Europe, the European industry is mastering this market; we have more than 60-65% of this marketplace. It's of course in the interest of a competitor to disturb this market. As soon as you disturb it, you have a better chance to go into it.

But we are not very happy with these kinds of disturbances. We want to continue with what we have today. We allowed them to enter in our market. They did not the other way around. But, that is the situation, and that is, let's say, a non-technical argument.

Laurin Herr — The 1125/60 system has since been codified into what's called the SMPTE 240M standard. There are now more than 30 companies, including all the major Japanese manufacturers, building to this spec.

Companies building HDTV to SMPTE 240M standard

Chyron
Cinema Products
Compression Labs Inc.
Dynair Electronics
Dynatech Broadcast Group
Fujitsu America, Inc.
General Electric Display Division
Grass Valley Group
Gretag Displays Eidophor, Ltd.
Hitachi Denshi America, Ltd.
Hitachi Sales Corp. of America
Ikegami Electronics
Magni Systems
Mitsubishi Electronics
NEC America, Inc.
NEC Technologies, Inc.
NVision, Inc.
Panasonic Technologies, Inc.
Panavision
Pioneer Communications of America, Inc.
Quantel
Quantel, Inc.
Quasar Electronics
Rank Cintel, Inc.
Rebo Studio
Rebo Research
RGB Technologies
Sanyo North America Corp.
Sharp Electronics Corp.
Shima Seiki USA, Inc.
Sony Advanced Systems
Sony Corp. of America
Symbolics Inc.
Teknika Electronics Corp.
Telettra USA Inc.
Toshiba America Consumer Products, Inc.
Toshiba America, Inc.
U.S. JVC Corp.
Ultimatte Corp.
Utah Scientific, Inc.
Wunder and Diefenderfer

The FCC has taken the issue of HDTV broadcast under advisement and will issue a ruling in 1993.
In America, the extra time presents opportunities for new approaches. Andy Lippman represents one of these.

Andrew B. Lippman

In 1986, the NHK system was proposed as a world production standard. But it is a 60 Hz. interlace system. There is absolutely no positive benefit to the 50 Hz. world of Europe to accept a 60 Hz. production standard. It can only hurt them, especially when they can come up with one of their own.

The problem is the 1125/60 Hz system is an inherently limited system. The line rate is not necessarily the right thing to standardize at all — 60 Hz is not necessarily the right number to pick. Now, the Europeans went and did exactly the same thing for their own local turf; and that is they go with 1250/50. OK. An equally bad idea, at least in terms of the future of TV.

Now, currently these two are at loggerheads. The 60 Hz. world is not going to move to 50 Hz world, and the 50 Hz. world is not going to move to 60 Hz., as well they shouldn't. So the trick is: can we invent some sort of new signal that can bridge that gap?

E. Other HDTV Agendas

Laurin Herr

The current HDTV split roughly parallels geopolitical regions. America is the swing vote. One can also place proposals along a television continuum of increasing bandwidth. Because HDTV expands the range of TV applications, it expands the range of industries who have a stake in the matter. Their commercial agendas cut across international boundaries.

- Broadcasters
- Cable TV
- Direct Broadcast Satellite
- Regulators
- Public Interest Groups
- Manufacturers
- Film and TV
- Defense
- Telephone Companies
- Computer Graphics

Robert W. Lucky

I see the Japanese HDTV as maybe even helping the telecommunications industry in this country because if it promotes fiber to the home, it'll help us build this new infrastructure. I mean, HDTV is one reason to put a fiber into your home: you get digital-switched HDTV in the home. And if it does that for us, I'd be really happy.

Carl Machover

The classic television set is dead, and the thing we're going to get are "intelligent television sets", and those are called workstations. And unless we maintain our leadership in that area, we've had it.

F. The HDTV Image Format Discussion

Laurin Herr

The HDTV technical debate focuses on the basic parameters of television. There is broad agreement on aspect ratio and color. There is broad disagreement on scanning method, spatial resolution and frame rate.

Some HDTV resolutions produce rectangular pixels, inconvenient for computer graphics and image processing, where square pixels are the norm. Modifying 1125/60 to have 1080 visible lines would solve this problem. Likewise, increasing the horizontal resolution of 1250/50 to 2048 also squares the pixel, and 2048 is a computer-friendly number.

Getting consensus on frame rate is one of the most difficult problems in HDTV. 1125/60 and 1250/50 are mutually incompatible and hard to inter-convert. Workstation frame rates and film frame rates add further complications. Gary Demos explains:

Gary Demos

In computer graphics, we separated what we called the "update rate" of the screen from the refresh rate back in the early '70s. Well, this concept has never made it into the television industry — the separation of the update rate and the refresh rate. And the CRT viewing platform really requires a fairly high refresh rate in order to be flicker-free, which I think most people demand. The tricks in TV have been to use interlace and 60 Hz. But, I think in the computer industry there is a move up from 60 Hz. to more — 66 on the Macintosh, 70 on the Stellar, we're seeing 72 now and 75. I think 72 has a lot of merit because it is 3 x 24, and 24 is the number that films use — 24 frames a second is your favorite movie.

Prof. Dr.-Ing. Michael Hausdörfer

It is easy to discuss higher frame rates. It is easy to discuss higher bandwidth. But it is difficult to realize it, and to make it compatible, downwards compatible, to an existing system.

G. The Debate About Scanning Method

Laurin Herr

Both the 1125/60 and 1250/50 systems use interlace scanning, just like existing TV. An alternative is progressive scanning, which displays all the lines of an image sequentially. Almost all computer graphics systems today are progressively scanned.

Elliott Schlam — The workstation application is probably more demanding than HDTV. Workstations are not for entertainment; they're to get real work done. Sometimes the work is very important. You can't afford flicker; you can't afford artifacts. Progressive scan, I'm quite sure, is absolutely essential for the workstations of now and the future.

Hugo Gaggioni — We cannot have an economic basis and technical basis cameras operating at 1125/60 on progressive scan. The signal-to-noise ratio degradation would be terrible, and it's going to take us 10-15 years to make that camera work on a professional basis.

Joseph A. Flaherty — What you really want to do is start with the high line number interlaced picture, which isn't after all useless, because that is the way our TV system has in fact operated all these years. It is an interlace picture you see at home. So, unless you're terribly offended by that motion portrayal, it isn't something to worry about. This is a big step.

Then you grow into two major steps; you grow into a digital domain, where you have a digital display and digital pickup, which is a big improvement — allows a lot more image processing — and then you grow to progressive scanning. And I don't say which comes first. It depends on developments. And that will give you the 20-30 years of growth potential and headroom we need in any new system we adopt.

H. HDTV and Computers and Film

Laurin Herr — The digital revolution integrates all media: text, sound, pictures. How important is this trend for HDTV?

Yves Faroudja — You have to be able to deal with film, video disc, tape, computer graphics, fiber optics, cable, everything with the same standard. That's life. If you cannot deal with everything, it will not work. That's all there is.

Gary Demos — A simpler way of looking at the requirements for HDTV is that you want it to be film-friendly, motion-picture friendly, because motion picture people are going to have to use it and produce in it. It's got to be computer-friendly, because it's going to affect the computer industry in a big way. And it's got to be relatively friendly to existing television, because of the hundreds of millions of TV sets out there, and we don't want to throw them all away. I think those are the basic requirements in a nutshell.

Dr. Takashi Fujio
There is not just one single thing called HDTV. There are the broadband transmission technologies of fiber and satellites. There's frame memory and microelectronics. And computer graphics technologies. Our intent was to bring all of these together, and by combining them, to make something that could widely penetrate the larger communications and imaging industries, thereby recasting the role of visual information in human society, fundamentally changing the way people use pictures in communication. That was the original principle of HDTV.

IV. What You Can Buy Now on the TV Continuum

A. Improved NTSC/PAL Television

Laurin Herr
The debate goes on. But, what's here now? We went to the NAB '90 to look. And we've organized a tour for you along the Television Continuum.

Improved TV upgrades existing TV without changing the basic scanning geometry and frame rate. Its foremost proponent today is Yves Faroudja.

Yves Faroudja
For the time being, the 30 MHz. scheme does not interest me. The hybrid analog/digital scheme does not interest me. A non-compatible system does not interest me, 60 MHz. or not. They have to be digital if they are not compatible, and they have to be NTSC and they have to be today.

B. Extended Definition Television (EDTV)

Laurin Herr
Extended Definition Television, EDTV, is designed to bridge the gap between existing TV and HDTV. It uses all the tricks of Improved TV, but widens the aspect ratio and adds resolution. EDTV is downward compatible with what we have now, but requires a new TV set.

It seems everybody has an EDTV offering. NHK has two proposals. Tokyo's Nippon Television has proposed still another. D2-MAC is already in service in Europe.

The major EDTV proposal in America is ACTV, Advanced Compatible Television. It's backed by a consortium of RCA, Philips North America, NBC and Sarnoff Labs.

Mike Sherlock
Vice President, NBC Operations and Technical Services

Philips, of course, brings you the brand names of Magnavox, Philips, Philco, and Sylvania. Combine those names with RCA and GE from Thomson, and you truly have the world leaders of television manfacturers as part of our team. Between those two manufacturers, they represent almost 40% of the TV sets developed, manufactured, and sold within the United States each year. Combine the research strength of Philips Briarcliff with the expertise of the David Sarnoff Research Center. Add the perspective and the vision of the country's leading television network, NBC, and you truly have the team to beat.

Laurin Herr
RCA: Widescreen 34" Monitor

The attraction of EDTV is that production equipment is easily cobbled from current gear. Many believe it's a way to quickly get an installed base of wide screen receivers that could also receive existing TV. For some, EDTV buys time; for others, it wastes it.

C. HDTV Formats

Fully HDTV systems break with the past. They rethink all the basic TV parameters: more resolution, wider screen, better color. This means more information for the viewer.

1. Zenith Spectrum Compatible HDTV

America's only surviving television receiver manufacturer is Zenith. Their Spectrum Compatible HDTV uses a faster frame rate, 59.94 progressive scan, and a moderate increase in resolution — 1.5 times NTSC.

Zenith/Showscan: Telecine

All HD transmission involves compression, and Zenith's is novel. This computer simulation compares compressed and uncompressed images. A Showscan projector feeds a BTS camera tuned to the Zenith HD standard, driving these rear projection displays. Jerry Pearlman is president of Zenith.

Jerry K. Pearlman

Our transmission systems' benefit is that it can be broadcast on the presently blacked out channels in each market, on the taboo channels. And that it is a full-frame picture, progressively scanned, so that it really interfaces much better with the computer world as well.

• 2. Eureka 1050/50 System

Laurin Herr

We have already introduced the major contender from Europe, the Eureka1250/50 system, comparable to Japanese HDTV. The seven 1250/50 remote trucks roaming Europe are loaded with equipment, such as studio cameras, analog 1" VTR and small switchers all by BTS.

Barco: HD Monitor
Rank Cintel: MK-III HD
Angenieux: HD Lens
Quantel: Paintbox HD
Telettra: DTV-45 Video CODEC
Tektronix: 1730 HD Monitor

The small studio monitors are by Barco. The 1250/50 telecine is made by Rank Cintel. Lenses come from Angenieux. Quantel makes the paintbox. The CODEC is built by Telettra, and the test equipment is by an American company, Tektronix.

Michael Hausdörfer explains the Eureka strategy:

Prof. Dr.-Ing. Michael Hausdörfer

We have the lenses, we have the prisms, we have the tube, CCD sensors, we have the recorders. The Eureka project will give us the possibility to have a European HDTV system. This means the components coming from Europe can be used.

3. The 1125/60 System (SMPTE 240M)

Laurin Herr

1125/60, also known as SMPTE 240M, is the most mature HDTV system; the longest history, the most suppliers.

a. Cameras and lenses

After decades of research and years of product development, HDTV has matured to the point where here at NAB '90 we see 35 vendors showing a wide variety of advanced television products, from cameras to monitors, and almost everything in between.

Ikegami: EC-1125
Sony: HDC-300
BTS: KCH-1000

The first HDTV cameras were tube cameras. But CCD chip cameras are in development. Cameras are built by both Japanese and European companies; there are no American firms. Basically, anyone who can make HD cameras can make them for any standard. Prices for HD cameras are in the $140,000 range. Few have been sold to date.

Nikon: HD Lenses
Panavision: HD Lenses
Canon: P-14X16.5BHD

HD lenses are also expensive, special order items. HD camera pickups are large; they need a lot of light, and the wide screen demands superb optics. A 14:1 zoom lens costs $174,000.

b. Monitors, rear and front projection

Toshiba: P-5000-FRI
Toshiba: P32-H100

A wide range of HDTV monitors are available, from rack-mount studio displays to this 38" behemoth. Output brightness is still a challenge. Big monitors make sense for HDTV, but big monitors are also heavy, and expensive — in the $20,000 to $30,000 range.

Sony: HDIR-550
Hitachi: C110-5000R
Sony: Video Wall

Beyond the 40" range, HDTV overwhelms existing television. You really have to see it on a big rear projection screen to appreciate how good it is. Again, there are several manufacturers. Prices start at $45,000.

EIDOPHOR: 5177
HDTV Projector

Auditorium-sized pictures are achieved using front projection systems based on scaled-up versions of existing RGB technologies.

c. Tape recorders

Sony: HDD-1000

Toshiba: HV-8900
Sony: HDV-1000

The first HDTV recorders were analog. Current HDTV recorders are digital. A 63-minute 1" tape costs $1300. Recorders are in excess of $300,000. Tape heads, tape and bandwidth compression are critical in leading this race. Analog video cassette decks are already here. Digital machines are in development around the world. Further ahead, a digital HD-VCR for the home.

d. Disc and silicon recorders

Sony: HDDF-500
Sony: HDM-2830

Unlike current HD tape recorders, Sony's digital silicon recorder actually captures three full bandwidth RGB channels at 30 MHz. each. It stores 32 frames at 6 megabytes per frame.

Sony: HDL-2000

An HD laser disc player stores 15 minutes on a side, full motion or stills.

Asaca/Shibasoku:
ADS-7800 HDTV

100 picture on a side, read/write HDTV still stores extend HD applications. CD-ROM discs also exist.

e. Telecine and tape-to-film

Rank Cintel: MK-III
HD

Film-to-tape is another area where established vendors are adapting to HDTV. Rank Cintel has delivered both 1125/60 and 1250/50 telecines. Rank's flying spot scanner is easy to tune to HDTV resolutions and beyond. The only thing difficult about the Rank is the price, $650,000.

Sony: EBR

Sony's electron beam recorder transfers HDTV tape to film. The company plans to offer HD-to-film transfer services in Tokyo, London, and LA at $5,000/min. or $56,000/hr.

f. Control room equipment

This central control room at NAB'90, put together by Turner Engineering Systems to feed all the HDTV exhibitors, combined tape machines, monitors, a switching center and test gear. HD waveform monitors and pattern generators are available from several vendors.

g. Computer graphics systems

What is the HDTV future for a computer graphics workstation manufacturer? What are the synergies? A look at Symbolics may provide a clue as to how the integration with HDTV may occur, regardless of a standard.

Tom McMahon

What we're showing here is the new Symbolics XL animation system. This is the first commercially available workstation of its sort. It supports all video formats, both output and input, from NTSC up to HDTV. That includes the 240M standard and the new Zenith standard, as well. Inside this workstation is our new frame thrower videographics processor. The frame thrower processes video and graphics information in 4:4:4:4 sampling across all formats; that includes genlock for all video standards, as I mentioned, both 240M and Zenith.

What we have here is the console for the workstation. This is where an animator might create the visuals, the 3-D geometry, the dynamics information. This is the output of the frame thrower itself.

In the upper right hand corner, we have a live NTSC screen. The NTSC screen is approximately 640 pixels; the HDTV screen is approximately 1920 pixels. There are 6 screens' worth of NTSC information in a single "high def" frame.

This is the Sony silicon recorder. This frame store holds up to 32 frames of "high def" information. Once you acquire 32 frames, you can then output them as a continuous stream of 32 and one shot out to the 1" HDTV tape machine.

The Little Death

Once you have the information in this form — it's an electronic medium — you can manipulate it, edit it, composite it with live action, do color correction; or we have the option, using the Sony electron beam recorder, of going out to 35mm film.

The best thing about 1125/60 is that there's a lot of equipment available today for it; it's easily interchangeable or convertible to and from film; it's easily down-convertible to NTSC; down-convertible to PAL. It's a very nice compromise, when you look at the whole — when you look at the constraints of the entire video production industry, 1125 is the least common denominator and it solves almost everyone's problem.

V. TV & Film Production & Distribution

A. HDTV Production

Laurin Herr

Here I am with John Galt of Sony at NAB'90 in front of a HDTV blue screen studio. It's really a synthetic set, and it's amazing what you can do with this. Now, I'm in front of a model. How did we do this? Take a look.

John Galt
Ultimatte: System 6-6 HD
Sony: HDD-1000
Sony: HDS-1000T

This process, by which we're being matted into a strange environment, is called "color difference blue screen photography". But as you can see with what we've been doing here, we have done a world's first, which is an interface to a high definition visual video effects device, which allows us to track, if you like, virtual scenery, with our live camera. And, we do have the digital video effects device, we do have the matting device, we do have digital recorders now, production switchers. I think most of the tools are there now.

B. HDTV Post Production

The Gallery

HDTV is electronic and immediate. It has none of the problems associated with keys and color in NTSC. HDTV is high resolution, but doesn't have the generational loss problems, or physical instability of film. The potential is there. What's the current reality?

Dean Winkler

The image quality of a high definition, Ultimatte key really is fantastic. For someone with curly hair like me, every little strand of hair would be perfectly keyed. On the other hand, that's only good for one or two layers. The type of work that we're interested in doing, which is 50 or 60 or 100 layers, cannot be done in high definition.

Barry Rebo

If I had to make a wish list right now, I would like a high quality, moderately — doesn't have to be inexpensive — telecine film chain to go from both 35 or Super 16 to High Definition. I would then marry that with a graphic single frame animation system, such as a Harry, and then I would like to add a Digital Effects unit. If you had those three types of tools, I think you would come up with really startling images.

Laurin Herr
The Aybss

To earn a place in film special effects, HDTV must offer an advantage to places like Lucasfilm's ILM, which composites computer animation, live action and special effects using all digital systems to make scenes like these from the movie *The Abyss*. Very high definition digital posting may avoid picture degradation that comes when film and HDTV are converted back and forth. The resolutions proposed by Kodak are higher than either an original film master, the final print, or any available HDTV.

Jean-Pierre Beauviala, Chairman, Aaton

Super 16 film is a great HDTV mastering format. Image quality is more than good enough. The camera is light and portable, and unlike video, film can achieve very high frame rates. Film is also getting better; higher resolutions, and faster ASAs.

Barry Rebo

When I started, I believed high definition was really a replacement to 35mm film; that's what I was led to believe. As we started to work in it, I realized that it was very chameleon-like. It could be used as a replacement for 35mm film, but in its best application, it was unique to itself.

Dean Winkler

A high definition video system, for all its resolution and clarity, still has an electronic camera pointed at the subject. And while great effort has been made to make the luminance transfer function and colorimetry characteristics of that electronic camera equal to film, they are not the same. Film has a different look, and I believe people like the look of film. They like the grain, they like the softness, and they even like the errors of film. For some reason, people associate the look of film with class, with quality, with things that are pre-produced. People associate the look of video with news broadcasts, soap operas, and sports telecasts. And that psychological conditioning, I think, has a long way to go before it's reversed.

C. Broadcasting and Distributing HDTV

Laurin Herr: HDTV requires five times the bandwidth of existing TV. Current broadcasters, given current technology, cannot transmit HDTV. Television transmission is an issue for the regulators. The current FCC policy is called simulcast. Bruce Sidran explains:

Bruce Sidran: The concept there is that each broadcaster, if possible, would be given a second 6 MHz. channel, not necessarily contiguous with the existing channel allocation. They would broadcast a non-compatible, special HDTV standard in that channel, while continuing for some period of years in the future to supply the audience that have NTSC receivers, with the standard NTSC signal. The best thinking now as to when simulcast HDTV would be available in the home is, I would think, early 1995, perhaps mid-1995.

Laurin Herr: Direct broadcast satellite (DBS), is another way to distribute HDTV. The Japanese and Europeans are already doing this experimentally. DBS distribution works well into the home, the office or even the theater.

Ron Ratner: Well, the concept is electronic high definition theaters. The theaters will be showing first run movies, live presentations, doing auctions, concerts, sporting events, all in private country club settings, as well as your four star hotels and condominiums.

Laurin Herr: There is also cable, video cassettes and video discs, and fiber via the phone company.

Robert W. Lucky: I wish I had a fast VCR that could capture information at a high rate over the network. Like, I'd like to burst a movie into your home in one minute.

D. The Creative Angle

Laurin Herr: So much for shooting, posting and distribution. What about creative?

John Sanborn: Going back to the comparison between video and film, I think you think in pre-production, both in the way you think about a video, in terms of planning special effects, in terms of planning the manipulation of the image, but you also have to plot it out the way you plot out a film. Because it's gonna have an impact that's far greater than the impact of something in a small box.

It's gonna have eventually the impact of a larger, more kind of tantalizing screen, if it's electronic, or if it's transferred to film, it's gonna have the impact of a large screen. And that, that's a variety of subjects — from lighting, to camera movement, to the integration of effects into a story — also in terms of casting actors, and in dealing with plots, you can be overly simplistic in certain areas of film and it will play very well. You can be overly complex in methods and manipulations in video and that's okay. Those don't always translate well into high definition.

Laurin Herr
Infinite Escher

The size and aspect ratio of HD make frame composition different. The close-up is less important. You don't zoom as much. HD is harder to light. It has less sensitivity and contrast ratio. Hi-res requires better make up and scenery. You can't cut corners shooting.

Some of the most striking HD computer graphics images have come from Yoichiro Kawaguchi.

Yoichiro Kawaguchi

What has been a somewhat narrow 4 x 3 screen now becomes wider, more horizontal. Scenes are generated with various camera angles, and these must now be created with a wider, more horizontal movement...the peripheral parts we haven't been able to see 'til now. People's eyes are horizontal, so I think it makes sense.

Another point for computer graphics is that good image compositing is much easier, because we've gone digital, so we should see a lot more compositing of computer graphics with live action. I suspect that this may open a path into the movie industry for computer graphics.

VI. The Economics of HDTV

A. The Optimistic Market Projections

Laurin Herr

Many presume that HDTV will evolve like color TV did when it was introduced in America. American HD market forecasts are inconsistent and inconclusive. The most optimistic estimates have come from the Japanese ministries. But the consumer market isn't developing as fast as expected. Why?

B. The Problems Implementing a New Technology

HDTV has a chicken and egg problem. There is no transmission system, so there's nothing to watch, so there is no programming, so there's nothing to transmit. HDTV equipment is expensive, so nobody buys equipment, so nobody makes programming, so nobody buys sets, so the equipment stays expensive.

Bruce Sidran

It's too high quality to transmit over the air, so terrestrial broadcasters can't use it. And it's certainly not high enough quality for film producers to originate material in. It's really betwixt and between, and not suitable for either application. And people have realized that, and that's one of the reasons it hasn't gained widespread acceptance.

Hugo Gaggioni

I have been asked the question, "Is the consumer demanding HDTV?" I could reply by saying, "Was the consumer requesting Walkman?"

Hideichi Tamegaya

From a broadcaster's point of view, we need large screen displays to give life to the high resolution images and wonderful sound of Hi-Vision. Development of these big displays is a key requirement. But if the displays are so big they can't fit into a Japanese home, it's going to be a big problem. So, in my opinion, development of a wall-type TV, a flat panel TV, to hang on the wall is key.

C. HDTV and Computer Graphics

Laurin Herr

The Japanese have long recognized that HDTV relates to a wide range of applications. We agree. The basic concept is correct. HDTV will have a wide impact beyond the television industry.

Rebo: ReStore

HDTV's shift to niche markets makes computer graphics more important to HD and makes HD more important to computer graphics.

VII. New HDTV Applications

A. Characteristics of the New Applications

It would be a mistake to limit our thinking about HD to the traditional folk model of a TV in every living room. Early adopters will be people for whom HDTV offers an advantage. These will be primarily non-broadcast, price-insensitive niche applications where real time, high resolution, color and large screen display are important factors.

B. Real Time Critical Viewing

Critical viewing depends on a single person or small group of people examining pictures in detail and for content. Bellcore hopes to convince NASA that live HD of a shuttle launch provides better viewing for mission controllers, engineers, the media.

In medicine, doctors must make life and death decisions based on what they see. TV cameras are already used in some kinds of microsurgery. HD adds better resolution, and more color fidelity. X-rays can be input via a scanner and played back on HDTV, for high resolution medical animation. Tissue pathology is another application that depends on sharp detail and true color reproduction. Large displays make consultation easier.

Corabi: DX-1000

An American firm, Corabi, working with Ikegami and Comsat, have taken the idea of HDTV pathology another step by adding telecommunications into the system. This allows doctors in different locations to quickly exchange HDTV images, getting a valuable "second opinion" without waiting overnight.

C. Public Installations

Public displays and installations, be they trade shows and exhibitions or point of purchase, represent another application for HDTV.

Alpha Romeo, the Italian car maker, used HDTV at the Geneva Auto Show. The monitors are showing this HDTV computer animation by the French production company Ex Machina produced on the European 1250/50 standard and played back from the remote truck.

Dale Cripps — Companies that have high respect for themselves and the work that they do, cannot choose lower ways to present their products. They are going to have to choose the higher way.

Laurin Herr
Pioneer: Video Wall — Pioneer, among others, is prepared to serve this market with new types of large, bright video walls that accept HDTV input.

D. 2D Applications

Sony: Pro-MAVICA — Electronic still photography has been around for a number of years.

Nikon: HQ-1500C
Nikon: FS-1500 — HDTV still cameras and image buffers add resolution and color fidelity in a medium where detail and accuracy are crucial. Obviously, HD can also record and store the images for print out and display.

In Japan, with its long tradition of calligraphy and high quality graphic arts, top printers have been experimenting with HDTV for several years. We visited the headquarters of Dai Nippon Printing in Tokyo to see specific examples.

Tsuyoshi Teshima — I would like to explain about the relationship between printing and HDTV. Can you see this book I'm holding? The Hi-Vision picture we were just watching on the screen is now printed in this book. For a printer, the fact that a Hi-Vision picture can be used as a source image for printed materials is significant.

Laurin Herr — Here's a sample picture printed directly from NTSC. This one was printed from HDTV. The differences are striking. HDTV stills are good enough to use.

Tsuyoshi Teshima — By assembling and linking together still images in various ways, we can create Hi-Vision still image programs, as you're seeing here. How do we produce these? We take this color film, the same color film used in printing a 4 x 5 transparency. Scan it with a printing scanner. Then, by converting the scanner data to Hi-Vision data, we can put it, in digital form, into this CD-ROM. That's what is being played back on this screen here. So, for us, this is a new kind of paper, while this remains our traditional source of printed images, as always.

Laurin Herr — HDTV's aspect ratio allows display of a two-page double truck, engineering drawings, or turned sideways, this Japanese newspaper.

E. Product Design and Testing

Shima Seiki: SDS-480 SGX

HDTV paintboxes also make a great deal of sense. In the industrial heartland, Ford has demonstrated an HDTV system for *concept car* presentation, using an HD Paintbox and a large screen display.

Here, computer-generated bridges have been composited into real world photographs to previsualize the environmental impact. HD has a lot of presentation punch.

F. HDTV Programming

Infinite Escher

Even in America, where there is no distribution yet, HDTV is being produced. Who are the clients?

Barry Rebo
Infinite Escher

Our biggest market right now for our software is the Japanese television networks or industrial applications where they need software to demonstrate the hardware that they're going to bring on line. They like the idea that we take the technology that they make and we put a creative topspin on it that's different than how they would use it themselves. I would say right now that easily 50% or better of our production work ends up in Japan.

G. Two Way Videoconferencing

Laurin Herr

In February 1990, the MAST company, working with Sony and Scientific Atlanta, executed one of the world's first commercial HDTV teleconferences between its headquarters in Massachusetts and its factory in Hong Kong. This was point-to-point HDTV and it was interactive HDTV. People on opposite sides of the world came to practical decisions.

The idea behind video conferencing has always been to communicate instead of travelling to physically meet someone far away. HDTV adds enough additional picture detail, sufficiently better color and large enough screens to change the trade-off, making video conferencing much more useful.

VIII. HDTV & Telecommunications

A. Switched vs. Broadcast Video Networks

HDTV involves picture communication. As such, it must confront two realities: all communication requires some kind of network, and all networks have some limited capacity, which we call bandwidth.

The very first television was two-way, point-to-point TV, developed by Bell Labs to run on the telephone network.

Mass media success came when television adopted the network paradigm of radio broadcast, a one-to-many, one-way distribution system. However, existing broadcast networks cannot easily satisfy HDTV's great appetite for bandwidth.

Sony: HDD-1000
The Little Death

Many people quote HDTV bandwidth at 1.18 Gbits, because that is the rate recorded by Sony's digital VTR. Even this, though, is 30% compressed using 4: 2: 2 color difference encoding and chromance undersampling. Error correction is not perfect but "error concealment" techniques hide any visible flaws.

It just so happens that right now the bandwidths of the global telephone and computer networks are being increased enormously through conversion to fiber optics, opening new possibilities for HD.

B. Video Bandwidths

A single strand of fiber today carries 1.7 Gbps. Researchers at Bell Labs believe this can grow to 20 terabits per second, another factor of 10,000.

Robert W. Lucky

I have the feeling that if you went to sleep for twenty years, and then woke up, that you'd find that optical fiber comes into your home, and you had your choice of many, many digital HDTV channels. And it would be completely switched. Unfortunately, I don't know what happens in the twenty years between now and then. I know where we're going, I just don't know how we get there.

C. Video Compression

Laurin Herr

HDTV requires so much raw bandwidth that it demands compression, much of it involving digital signal processing.

Compression techniques fall into two broad classes: lossless and lossy. Lossless compression ensures that all the information in the original image is recovered when the image is decompressed. Lossy compression can be more efficient, but sometimes loses information, hopefully with little visible difference.

Big advances lie in extending what is known about compression in space to compression across time. Temporal compression exploits frame to frame continuity. Related techniques hold great promise for noise reduction, as well. Motion detection is a related compression technique. It is possible to extract movement from frame to frame, and then send only the parts of the scene that change. Compression in the frequency domain is another key technique being explored for HDTV. Scene content is analyzed to show the distribution of horizontal and vertical frequencies. A TV compression algorithm that isolates and discards certain frequencies would be lossy, but the loss might be imperceptible.

Toshiba: MUSE CODEC
Telettra: DTV-45 CODEC

Compression algorithms are implemented in hardware called a CODEC, short for *coder-decoder*. CODECs are a focus of intense worldwide research. The goal is to enable HDTV to fit into existing 6 MHz. TV channels and run on existing digital networks.

Stanley Knight
Sarnoff Labs: Princeton Engine

Tomorrow's TV's algorithms are going to be far more complex. They are going to involve motion analysis, they are going to involve compression and decompression techniques that are more complicated than we use today. And therefore, we need all the power we can muster to simulate those and look at them in real time, look at many different kinds of video, and make certain that those algorithms are truly acceptable for the viewing public.

Laurin Herr
DVS: ISP-1024

Not everybody has a 1000 processor Princeton Engine. But these German systems are designed for the same purpose: programmable test beds for digital video simulation.

Robert W. Lucky

HDTV could be over a gigabit right now, and people talk about transmitting it at 600 Mbps. But, with coding and data compression techniques, people are pretty confident we can bring it down to 150 Mbps, without any loss in quality. And that's important, because 150 Mbps is the broadband ISDN rate.

Laurin Herr

The combination of switched digital networks with HDTV will lead to a new type of telephone call: the life-size, large screen conference call.

IX. The Digital Video Telecomputer

A. The Current Merger of Video and the Desktop

One of the most important potential markets for HDTV is computer graphics. Video is already migrating from the production studio to the desktop, for animation, multimedia and scientific visualization.

D-2 Diner Video hardware is widely used in the computer industry. Conversely, computer graphics and digital electronics are increasingly integrated into the video world.

Tom McMahon I think high definition will open the door for a lot of applications that heretofore have been gridlocked because they didn't have a medium with a transmission and storages of the images they generated. For example, mapping, flybys, mission planning, failure analysis, CAD visualization, various sorts of scientific visualization — all of those applications are non-entertainment, and they all require manipulation, storage, and transmission of high resolution electronic images. We couldn't do that up until high def.

B. HDTV Display Technology

Elliott Schlam We've been making HDTV resolution displays for many years now. CRTs have been made with 2000 line and 4000 line resolution. So there's nothing unique about HDTV resolution. What's unique is putting it on a video distribution and building at costs that are comparable to TV costs.

Laurin Herr
Rebo: ReStore The advantages of a HDTV screen for computer workstations is first its size, and second, its wider aspect ratio.

Carl Machover Just as thirty years ago, the TV — commercial television — environment created a way for us to build low cost displays, I believe that the HDTV environment is the direction that we're going to get our displays from in the future.

C. HDTV Flat Panel Displays

Laurin Herr
Electro Plasma: Flat Panel Display

Many people think the solution to big displays is flat panels.

Elliott Schlam

Flat panels play a tremendous role in the HDTV environment, because most of us believe that one needs a large screen to get true HDTV. A large screen means 5' x 3' nominally. A cathode ray tube (CRT) of that size would not fit in the average home. It will also weigh about 800 pounds. So, one must get to flat panel technology, ultimately, in order to really get this large, intense market for HDTV.

Laurin Herr

Computer graphics applies a curious pressure to HDTV. It brings a tradition of software programmable pixel resolutions and frame rates. The intent of standards in the computer industry is to liberate software from hardware. Experience has shown that software must be upwardly compatible with future generations of higher performance hardware.

D. Open Architecture Television

Andrew B. Lippman

Open architecture TV is not associated with a receiver implementation. It is associated with a signal format that is scalable in both space and time, and the fact that most broadcasters and broadcast equipment manufacturers hate it with a passion means we at least must be on the right track somewhere. Because I think that part of what we're doing is take TV past that simple generation where doubling the number of scan lines is viewed as an innovation. It's viewed as a trivial change, and you know that when computers went from 500 lines to 1000 lines that was not viewed as a major innovation. That was viewed as minor step in the clarity.

Gary Demos

Even within the highest bandwidth signal, you'd like to have some flexibility. You need the higher speeds for the things that move fast. You need the higher spatial resolution for the things that stay still. You'd like to get the most you can out of that highest signal.

Bruce Sidran

People have talked about the notion of an open architecture receiver. A receiver, a TV set, that's built much more like a PC is today, where there is some sort of back plane bus, and then you can plug in different types of functionality based on your need. And that I believe, is a real — will be a real boon to consumers. There are many people who disagree with me on that.

Gary Demos — The weaknesses of the 1125/60 system, I think, cannot be fixed by minor modifications, or adjustments. I think they are essentially fundamental design problems. I think a better design could be architected by mandating the use of a frame buffer in the display devices, in the receiver. It's something we're very used to in computer graphics, but it's essentially a new idea for television.

Laurin Herr
64 MB DRAM — It's only going to get easier to put a frame buffer into a receiver or a display. Most people think this means that memory is getting cheaper and denser. That's true. But, the real strategy is to etch the memory, and the display electronics, directly on the glass of the flat panel display!

E. Everything is Going Digital

Dr. Pieter A. van Dalen — The strategic role of HDTV as I see it is that it's a cornerstone for the development of the electronics industry. If you do not own the high definition video technology, you're missing a piece of the total electronics pie, which becomes more and more a solid pie, because of what I called, the integrating effect of electronics itself.

Dr. Takashi Fujio — You will have an integrated, unified presentation device, a color imaging system, in your home. It will connect to the computer. It will connect to the satellite. It will connect to the worldwide fiber network. All accessible through your HDTV terminal. That's what the future will be!

Laurin Herr — Digital media, digital communications, digital computers. The story isn't just HDTV anymore, it's the fusion of digital technology in general. HDTV becomes a focal point. This is the essence of its dynamic.

X. HDTV and Industrial Leadership

Projectavision

High definition vision is the strategic high ground. In America, this has been that subject of fierce debate. DARPA has already funded HD research in compression and displays, like the Projectavision we're using here. But, there remain many pieces of the puzzle still to be invented.

It has been said HDTV is not primarily about pretty pictures; it's about money, power and jobs. In time, the superior HD player will come to acquire great strength in semiconductors, computers, and communication. To the extent that HDTV opens new markets, the non-HDTV player will be out of the game.

Ir. P. W. Bögels

If you don't play within this game, then of course, you give up a major issue in the future. Television is a major issue. In the world we have — consumer electronics is 200 billion gilders — $100 billion, or something like that. Half of it is related to video. Well, are you interested in that or not? It's a lot of money. And if you want to play a role in that part, well, you have to master the technology and to defend yourself, as we do.

Joseph A. Flaherty

The Japanese have undertaken a massive educational and imaginative creative buildup with investments in research looking out at ten-year horizions. Now, in America, that's what David Sarnoff used to do, and David Sarnoff isn't here anymore. And unless the American manufacturing companies wish to look at that horizon, they are simply not going to win the technological war, not only against the Japanese but against the European Economic Community, who is pouring a lot of money into this with some very brilliant engineers.

Dr. Pieter A. van Dalen

What Europe probably has not had so much of as the Japanese industry is the willingness to win. And I think at the present time we may say that we, as representatives of the European industry, have the willingness to win; we don't want to give up. And, I think, particularly in this vital part of the electronics industry, we may not give up because it is key.

Carl Machover — There are people who have already given up on the U.S. becoming a major player in HDTV because we've given up commercial TV. And I think that's a serious mistake, a dreadful mistake, because I don't think the issue is consumer entertainment. If the issue were simply consumer entertainment, then maybe we could give it away. But, I think the issue is U.S. leadership in computer technology, because I think HDTV is a major key to the modular workstation of tomorrow.

Laurin Herr — And that's HDTV. Thank you for watching the SIGGRAPH Video Review. I'm Laurin Herr.

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The Quest For Virtual Reality

AVolume of Two Dimensional Julia Sets

I. Introduction to the Desktop of the Future

A. The Digital Video Teleputer

Laurin Herr

Hello, I'm Laurin Herr. Welcome to the SIGGRAPH Video Review.

Our story today is about the workstation of the 21st century — what we call the digital video teleputer. We begin with the predictions of the experts.

Jim Clark

In the workstation of '95, you'll have digital video of varying resolutions. You'll have audio of the highest quality, systems to allow you to integrate all of these various kinds of events in a temporal way, texts — the multimedia computer will be a system for digital sound, digital video, text processing and interactive 3D image generation, and all of this integrated together in a nice interactive environment.

R. Bruce Ferguson

We see by 1995, a user who's got the same size office (so he can't have a system that's any — physically any bigger), that he's gonna have a system that's going to have hundreds of MIPS of processing power, hundreds of megaflops of processing power, and fiber optic buses, and tens of gigabytes of storage.in the $15,000 to $20,000 price range.

By the year 2000, we see the same size office, because you haven't moved yet, at the same $15,000 to $20,000 price range, having one to two thousand MIPS performance, one to two thousand megaflops of performance and a terabyte of storage.

Carl Machover

The kind of environment I think that the professional worker of all kinds can expect to see by the year 2000 is an environment which is essentially an assistant. It's an intelligent assistant, it's one that anticipates what you need. It's one that has access to data that you can partially recall. It's one that works like our mind does. I can almost think of something and with a little nudge, it comes to me. It understands my mispronunciation of words. It allows me to deal with it in the way I deal with you: I point at you, I talk to you, I gesture to you, I touch you. And that's what I need to do with my workstations.

And it needs to present back to me the information in a wide variety of forms. I need to look at information which looks realistic when I'm trying to make that decision. I need to look at information which is simplified when I need to make that kind of a decision. I need to look at static data, I need to look at monochromatic data, I need to look at real-time data, I need to look at video — I make decisions from an enormous range of senses, and the device has to give that to me.

B. Principal Features of the Future Desktop Workstation

Laurin Herr

Well what will the future digital video teleputer look like? What will it contain? How will it work?

Let's open it up. Inside, a 16 x 9 big, wide, flat, color display and a host of peripherals built in. The metrics? At least a gigabyte of memory, a gigaflop of compute, a gigabit of bandwidth — gigas everywhere. Enough to do real-time, realistic graphics on your desktop. It's networked, of course. For data, for telephone, for video. All digital, all fiber optic.

This optical crystal memory card holds a terabyte, enough for 90 minutes of digital HDTV.

This is where you do your color scanning. Color print comes out here. Of course, this is also where you do your copying and your fax.

You can interface to this baby a lot of different ways. There's a keyboard, the screen is touch sensitive, and a number of cordless peripherals. You can *talk* to this computer and it'll talk back from the stereo speakers.

A Volume of Two-Dimensional Julia Sets

Video is central to the workstation of the future. There can be a number of video formats running in any number of windows. The screen itself is HDTV-capable. Right now, we're running an NTSC animation from Dan Sandin in that window there.

Wait a minute. I think I have some video mail.

Tom DeFanti

Hi Laurin.

Laurin Herr

Oh. Hi, Tom.

Tom DeFanti

You want to check out some of these two-player stimsims I just got over the Federal SenseNet? Put on your gloves and glasses and let's go. Remember, it's in doublestim progressive mode.

Laurin Herr

Sure, Tom. Let me get ready.

You know, the workstation of the 21st century is going to be more than multimedia as we understand it now integrating text, sound, and pictures. It's going to be a platform for virtual reality.

I've got my glove on, Tom. Let me put on my HDTV displays, and we're off.

VPL: Data Glove

II. Virtual Reality

A. Definition of Virtual Reality

So, what is virtual reality? Take the concepts and techniques of 3D computer graphics. Add multisensory interactive interface devices and high resolution displays. Cook with as much compute power as you can afford, and what do you get? The ability to step through the screen into an environment.

Evans & Sutherland: ESIG-4000

A virtual environment may be real or imaginary. It can be anything you want. It exists inside your computer and inside your mind. And, you feel like you're there, wherever "there" is. The illusion is so good, there is a willing suspension of disbelief.

Interactive interface is the art of empowering a human being to physically and conceptually participate with the computer to put the person into the loop. Mankind is about to "go virtual", something which has never been done before. There's a momentous fusion occuring: digital media — video and sound, digital communications — fiber and satellites, digital computers — workstations, interactive interface — virtual reality! This a unique time in history, one of dynamic growth and change.

Fred Brooks

If I look at the different components of trying to make a virtual world look real when you look at it, the part we know best how to do is how to make it high image quality visual realism with good lighting. The so-called "rendering problem" is solved in principle. That is, for any given frame, given enough computer time, we can make it look very good. The problem of how to make the world move in real time is the hardest of the problems and how to make it move in real time in response to one's interaction, as opposed to some preplanned scenario, is very demanding on computational speed.

Jaron Lanier
VPL: DataGlove
VPL: Eye Phone

I'm wearing a DataGlove. And this is the glove that lets me reach into the virtual world and pick up imaginary objects as if they were real, see your own hand, and so forth. This device is called the Eye Phone. The Eye Phone is a head-mounted display — it's the first commercial head-mounted display. As you can see, internally to it, there are displays, and when you wear this, you find yourself inside a wide angle, color three-dimensional stereo scene that you feel inside of it. You don't feel you're looking at it from the outside, but rather, you're there. And as you turn your head, the entire scene is shifted to compensate for your head movement. And so what that means is that you create the illusion that you're moving around inside an artificial space that's standing still outside of you.

Laurin Herr
NASA Ames: VIEW

The virtual reality research group at NASA Ames works in this virtual room. Enter the virtual hand.

Virtual reality is a new form of media. It's participatory, multi-sensory, 3D, real time. You wear it. Virtual reality enables a user to mediate force at a distance. Even in outer space or in the factory across town. A worker can remotely manipulate a *real* robot arm with tele-robotics.

In virtual reality, you can connect different types of peripherals to different parts of the body. Here, head movement points the binocular camera. The user sees in his goggles what the camera sees. It's remote vision, a new form of *tele*-vision.

Virtual reality extends the desktop metaphor. These virtual control panels float in virtual space around you and may control systems anywhere. They also talk back to you.

Carl Machover

There are essentially two kinds of virtual reality: one is an attempt to make a realistic representation of a world around us. I look through my computer model and I see a model that looks very realistic. I see rounded figures, and maybe the figures do things I couldn't do in practice. But I'm not trying to create a artificial surrounding, I'm trying to simulate a real surrounding. So that's one kind of virtual reality. The other is an artifical kind of virtual reality. And that, the real reality is too complex to deal with, and therefore, I want to create a simplified reality that allows me to make decisions more rapidly.

B. The Origins of Virtual Reality

Laurin Herr

The origins of virtual reality can be traced back to two related areas: aircraft flight simulation, and aircraft flight itself.

The first of these, flight simulation, has been at the forefront of computer graphics for nearly thirty years, always pushing the state of the art in real time synthetic image generation.

The second topic involves *flying* an aircraft on instruments — that is, in the dark or in clouds, with no visible ground contact. Good flight instruments can make the difference between life and death.

Improved flight instrumentation was pioneered during a 45-year period by this man, Navy Commander George Hoover. Hoover worked with the first flight simulator, the Link trainer. He soon added the idea of visuals into the system, projecting fog onto the windscreen to make the trainer more convincing for the pilot inside.

Early planes had very simple controls. Pilots flew largely by the seat of their pants. As planes grew more sophisticated, the cockpit filled with dials and switches. The resulting information overload of the cockpit all too often lead to "pilot error". Hoover struggled to transcend this complexity. He coined a new phrase for his solution, "man-machine interface."

George Hoover

The only trouble that was apparent was the interface between the pilot and the display information that is being given to him. When you start talking to machines, you have to have a machine talking back to you, too. So it has to be a closed-loop operation. So, we called it the man-machine interface. And the problem with it was simply that, in the beginning, it started out with symbols and numbers, and in our case, it turned to pictorial.

Laurin Herr

Hoover's lifetime achievement is the command flight path display. He started with the pilot in his airplane and extracted the key clues to flying. These are: the windscreen frame of reference, an artificial horizon, and a patterned ground plane to give a sense of motion. As a guide, Hoover added a ribbon-like roadway into his virtual environment. In the upper left quadrant, a computer-generated flight leader flies the ideal path. You just have to "follow the leader." It blinks if you gain on it or fall behind.

Hoover actually flew an aircraft using this kind of display in 1983, navigating a real 3D space using only an integrated pictorial display, proving the concept of computer-mediated reality.

Evans & Sutherland: ESIG-4000

Hoover's ideas came to be embodied in the big, ground-based flight simulation systems we have today.

Silicon Graphics: PowerVision

The ability to do these kinds of simulations is already coming down to the workstation, eventually to the desktop.

III. The Evolution of Today's Workstation

A. Price Performance and Technology Trends

The virtual reality platform of the 21st century will evolve from today's workstations, today's computer peripherals, today's communication networks. We want to show you what's available now, so you can start building your own virtual reality systems right away.

Computers are getting smaller, cheaper, faster. We see this in terms of CPU MIPS as well as CPU MFLOPS. Workstations are riding this fundamental price/performance trend.

Today's computers are built around CPU architectures, like the Motorola 68000 family,

- Motorola 68000 Series
  - Apple: Macintosh
  - Apollo: DN
  - HP 300
  - Sony: NEWS
  - Tektronix

or the best selling Intel 8086 series — the latest is the 80486.

- Intel 8086 Series
  - AT&T: 6300
  - IBM: PS/2
  - IBM: PC/AT
  - HP Vectra
  - NEC
  - Tandy

Sun's SPARC chip is a reduced instruction set computer, or RISC for short.

- Sun SPARC
  - Sun
  - Fujitsu
  - Toshiba
  - Solbourne
  - Samsung
  - Taitung

The MIPS CPU is also a RISC chip and used in a variety of workstations.

- MIPS R2000, R3000
  - Silicon Graphics
  - DEC 5000
  - Evans & Sutherland: ESV
  - Stardent: Titan
  - Sony: NEWS

Intel: i860
Motorola: 96002
Texas Instruments: 34020

Some manufacturers still prefer to design their own CPU chips. Special purpose chips significantly boost available power, especially for sound and pictures, key aspects of today's multimedia and tomorrow's virtual reality. Intel's i860 chip has integrated floating point and 3D graphics processing capabilities. Motorola's 96002 "media engine" is specifically designed to process digital audio and digital video. Texas Instruments' 34020 graphics processor is driving this video game, and can be found in scores of graphics accelerators and peripherals. This is the sort of performance needed for multimedia and virtual reality.

Nick England

Virtual reality — I'd rather crash here than in the real world.

B. The Graphical User Interface

Laurin Herr

Given that the workstation vendors are all using the same or similar chips for CPU and floating point computation, how can they differentiate themselves in the competitive marketplace? This problem is aggravated by the need to support all the right standards, even if this tends to make systems look alike. The answer includes clever marketing, clever architecture, superior graphics performance and better user interfaces.

Spyglass

The success of the Apple Macintosh demonstrated the attractions of a user-friendly graphical interface.

Hewlett-Packard: UX Vectra 386

But Apple no longer has a lock on graphical user interfaces. The interface on the HP Vectra, an AT-bus MS-DOS machine running a 80386 is very similar to the Mac.

Microsoft: Windows 3.0

Microsoft Windows 3.0 brings many of the same features to the DOS market at large — a possible retrofit for more than 10 million PCs.

R. Bruce Ferguson

All graphical user interfaces are looking alike on the surface, but there's some significant differences. In the Macintosh world, the graphical user interface forces consistency upon the programmer and upon each application, so every application runs like every other application. Most of the other graphical user interfaces, such as Windows, does not force that consistency. So, you have no way of knowing between applications how they run even though on the surface, they look alike.

Mary Whitton

Someday, I'd like to see user interfaces that are as easy to use as driving a car, if you would choose that metaphor— that when we get in a car, we know where the gas pedal is, we know where the brakes are, we know where the turn signals are. We ought to be able to sit down at our workstation application and have a sense of where the menus will be, how they'll pull down, and what the buttons and applications available to us are.

Laurin Herr
Digital Equipment: X-Windows

For full-fledged workstations, windows are everywhere — X-Windows running on UNIX, in particular.

Robert F. Sproull

X-Windows is a key to ubiquity, because it supports a wide range of applications, a wider range than any previous systems have supported. There's a lot of people building quite broad classes of software for it, and that will allow on one screen, for one customer, for one computer owner, if you will, a much wider selection of software capabilities, etc. That's the ubiquity, and that's what's been growing quite nicely.
But, what, but the cost — one of the costs of that ubiquity, has been that some of these of interaction — the quality of interaction, the smoothness, the interactive techniques that we knew and loved twenty years ago, have been sacrificed.

C. New Workstations

Laurin Herr
IBM: RISC System/6000

For major computer manufacturers, the evolution of workstations to the point of "ubiquity" makes them a very attractive market — almost unavoidably so. 1990 saw IBM's reentry into the workstation arena with their RISC Series 6000 family, bridging the gap between the PS/2 and the mainframe.

IBM: RISC System/6000 POWERstation 530

This model connects directly to a mainframe channel.

IBM: RISC System/6000 POWERstation 320
IBM: RISC System/6000 POWERserver 930

These are stand-alone units with substantial memory and disk.

IBM: Xstation 120

A diskless X-terminal provides a low-cost way to put a desktop on the network.

Alias: RISC Series/6000

IBM licensed the Silicon Graphics graphics library for their new workstations, and this gives them immediate access to a large pool of existing application software.

Silicon Graphics: PowerVision

With the arrival of the new PowerVision series, Silicon Graphics continues as a fountain of real time 3D images — real time texture mapping on top of superlative 3D graphics performance. New capabilities, like depth of field and motion blur, add to the perception of realism. Gold-plating is a snap!

Jim Clark
Silicon Graphics: Personal Iris

The big progress in the next several years is not going to be pushing the high-end performance by another factor of ten, but rather going to be bringing that high-end performance — the million polygons, the textures, and the anti-aliasing, and the area averaging, and motion blur, and all of these things —first down to a $30,000 system, and then to an $8,000 system in two generations.

Laurin Herr
Digital Equipment: DEC Station 5000/200

Digital Equipment's new DECStation 5000 is based on the MIPS R3000 RISC chip. This is a competitive UNIX box and supports most industry standards. DEC's graphics accelerator uses custom VLSI and high density chip packaging to stay small. The result is substantial 3D graphics performance from a compact box.

HP/Apollo: DN-10000

Hewlett-Packard: VUE 1.0

Different operating systems, different networking systems, different evolutionary paths — how does a company cope with heterogeneous product lines? One of the most visible results of the HP/Apollo corporate merger has been creation of a common look and feel in the graphical user interface across the whole product line, effectively masking the specific hardware platform from the user.

Hewlett-Packard: HP 375 Turbo SRX

HP is also showing more graphics performance and enhanced realism with features like progressive refinement radiosity.

HP/Apollo: HP 9000 VRX

HP's newest workstation, called the HP/Apollo 9000 VRX, combines a fast 68040 CPU with an improved graphics accelerator built around multiple i860s and HP's own VLSI for shading and rendering

Sun: VX Vision Accelerator

Sun can now run SunVision, its most advanced visualization software suite, on its regular SPARCstations. Performance can be boosted with their new VX visualization accelerator.

Sun: SPARCstation SLC

Sun is also driving towards the low-end with their SPARCStation SLC. The computer itself has been squeezed into a single board and fit into the monitor housing.

Evans & Sutherland: ESV

Evans and Sutherland has thrown its hat into the workstation ring with the introduction of the ESV product family. Hardware in the workstation was specifically designed to support "native mode" PEX — PHIGS in X-windows. Other standards supported include the MOTIF graphical user interface running on top of X-windows, Network File System, Ethernet and FDDI.

Tektronix: XD-88

Tektronix has moved to broaden the applications for its XD88 workstation family by integrating image processing and digital video processing. Target markets are engineering, scientific visualization and video production.

D. Accelerating the Workstation

The traditional strategy for souping-up a workstation is to employ special purpose accelerators. These come in all shapes and sizes, targeted to various tasks. For years, it has been necessary to speed up floating point math, critical to 3D graphics, with one or more accelerator chips. But integrated CPU chip sets, like the ones in Ardent's workstations, are themselves getting powerful enough to do this without extra hardware.

Mary Whitton

The accelerator marketplace is tough because again the CPUs are increasing in power so much that we find it very difficult to stay ahead of the CPUs in performance to keep that metric at 10x or more to make it worthwhile to add the add-on boards.
The user just wants the application to go faster. And that now includes both the user interface to go fast, the data access to go fast off of disk, as well as the display to go quickly onto the screen.

R. Bruce Ferguson

What were large systems accelerators are now board accelerators, and what were board accelerators are now becoming chip accelerators. An Intel i860, which is a little tiny chip, would have occupied a half a room a few years ago. So, there is this massive trend to high computational power in accelerators and very tight packages, because that's the only way you can drive the price/performance up.

Laurin Herr
Apple: QuickDraw Accelerator

Users are demanding more color, which means more bits per pixel, which means more processing load. This was the problem Apple faced with the move to 32-bit QuickDraw. The answer? A QuickDraw accelerator for much faster scaling and scrolling of color images.

Megatek: X-Cellerator

Building accelerators for windowing systems is only economical if there is a standard with a large installed base. X-windows is such a standard.

Pixar: RenderMan
Paracomp: Swivel 3D

Rendering is another target for acceleration. Pixar's RenderMan, for example, is gaining in popularity, but even on the newest Macs, photorealism takes lots of time.

Levco: 860i

Thus, the need for accelerators. Levco gets a 25 times speed enhancement by porting RenderMan to its new i860 board for the Mac.

DuPont: MacBlitz

Accelerators can even be used to create new types of hybrid workstations. This board, called the MacBlitz from DuPont, puts a 12 MIPS Clipper co-processor inside a Macintosh, allowing a user to simply click on the Mac desktop and open a window into UNIX. The additional power is obvious here, as the Mac's CPU starts to compute a Mandelbrot image, only to be quickly outpaced by the MacBlitz.

Besides function specific, format specific, software specific and OS specific accelerators, there are also datatype specific accelerators. Boards designed to handle video data are a case in point. The drive for more power and more functionality is never-ending.

Truevision: TARGA

Truevision provides a good case study. In 1985, this AT&T spinout introduced the TARGA board. It was one of the first cards for the PC/AT to output a recordable video signal, and this helped sales enormously.

Truevision: Vista

In 1987, their next generation product, the Vista board, kept all the frame buffer and video functionality of the TARGA, but boosted performance with an on-board Texas Instruments 34010 graphics chip and 4 MB of video RAM.

Truevision: Horizon 860

In 1990, Truevision expanded its product line further with the Horizon 860 — a general purpose accelerator built around the Intel i860 with as much as 64 MB of RAM on a single board.

You may think of it, if you wish, as a rocket engine dropped into your system — it turns any PC/AT into a 27 MIP/66 MFLOP screamer. It comes complete with its own private, high speed bus — 2.1 Gbps. That's eight simultaneous channels of NTSC. Why? To avoid the 100 times slower PC/AT bus.

Sierpinski Pops His Gasket

Just where is all this taking us? If we look over the horizon, what do we see? To the user sitting at their workstation, the twin 800 MFLOP Pixel Machines generating these pictures appear to be just another accelerator running somewhere on the network.

Laurin Herr — Let's check that out. Computer, place a call to DeFanti.

Tom DeFanti — Hi, Laurin.

Laurin Herr — Tom, why do we need such powerful accelerators?

Tom DeFanti — When you're doing really computationally intensive things like ray tracing, for instance, you've got to get the stuff back fast enough to be able to iterate in your design. The Pixel Machine knocks out ray traced images like this in three minutes. Dan Sandin's piece would take 60,000 Pixel Machines operating in real time in parallel in order to do head-mounted display, HDTV, interactive virtual reality.

Lively IFS

We're going to need special accelerators for a long, long time.

E. The Integration of Digital Video

Laurin Herr — As we start to look at what used to be called peripherals, one of the first things to catch our eye is the ongoing integration of video.

It expands the creative options,.extends the range of applications and enlarges the population of potential users for both video *and* computer graphics. The advent of digital video is a logical fit.

Dean Winkler — The interface between computer graphics and the world of D1 is quite worked out. There are many devices that allow you to have an Ethernet cable on one end, and a D1 outputted video on the other end, such as an Abacus: A60 disc recorder. That's what we use. Many workstations, such as the Tektronix workstation, have a built-in D1 video card for D1 in and out. So, that's quite together. The D2 interface is a little less established, but that's okay, because once you're in D1 there's no problem converting digitally to D2.

Laurin Herr — Animation on the *desktop* requires an appropriate software package, a graphics display card that outputs legal video and, if the images are too complex to compute in real time,

Diaquest: Animaq

a controller card to automatically manage the interface to a video deck for single frame recording.

Steve Legensky — Multimedia represents a very exciting development because it will allow us to deliver all of these paint, animation, compositing, text generation, flipbook animation technologies to the desktop of marketeers and scientists and engineers. Today, everything like this is jobbed out. You have a very stratified system — low-end PC things and the high end mega-buck projects which are good enough to go on TV. I think the purpose of multimedia is to bring the quality of presentation to the operator that can afford it.

Laurin Herr — The emergence of video in a window is an important milestone for computer graphics because it completes the integration of all the different kinds of media commonly used today onto a single screen. Text, graphics, moving pictures, *and* interactivity may now be combined into a single multimedia system.

Glenn Reitmeier — We'd like to not only put video in a window — that's a good first application for video, but, in the long run, we believe that integrating video and computing is much, much more. We believe that it's giving computers the ability to process the video that they are displaying in a window, to look for objects within that video stream, to manipulate the video under interactive software control. These are the kinds of things that will create new applications.

Steve Legensky — The biggest advantage of video in a window is, if you're using an NTSC or PAL peripheral, you can avoid having a separate monitor.

F. Hypermedia and Multimedia

Laurin Herr
Avid: Avid/1 Media Composer — Here's a system that uses multiple video windows on multiple monitors to do interactive non-linear video editing. Non-linearity is a word you'll be hearing more about, because it provides a way to fuse the advantages of random access digital storage with real time video, traditionally a sequential medium. Multimedia is attracting all sorts of people.

Judson Rosebush

I've been working with computer animation for about twenty years now, but recently I've become fascinated with the possibilities of Hypermedia. What I want to do is orchestrate text, sounds, graphics, and moving pictures into a vehicle, an experience, a set of story possibilities that other people can use and explore and play with.

I put together this Hypermedia version of Issue 35 of the SIGGRAPH Video Review using just three hardware components — a Mac, a video monitor and a laser disc player, and it's all controlled using a mouse and Apple HyperCard.

Bright Star: HyperAnimator

Recently, I've started adding color images into the stacks. And I've also been exploring the idea of talking agents. You give them text, and they lip-sync it back to you.

Talking Agent

And back to you, Laurin.

Laurin Herr

Here I am live at the NCGA '90 in a Presentation Manager window running under OS/2 on a PS/2 from IBM. Hypermedia is truly coming of age.

The possible applications of hypermedia are myriad, from step-by-step training for student nurses reviewing the stages of childbirth to teaching geography and history to American schoolchildren. Hypermedia makes information more accessible, and this increases the joys of discovery
A common goal of all these hypermedia systems is to present information in an unstructured but linked multimedia format. A student interested in the American civil rights movement is able to follow his own path of discovery through complex issues, instead of passively watching TV.

Intel: DVI

This instructional program about the ruins at Pallenque combines many of the best hypermedia features. What's unique is that video playback is from a cheaper, smaller CD-ROM instead of a large laser disc. This is possible only by compressing all the data, including the video, before recording it onto theCD-ROM, and then decompressing it in real time using special purpose VLSI.

Laurin Herr
Array: AS-1

We'd like to share some of our own multimedia experience with you. This is an Array Technologies scanner. It can scan slides or flat art at resolutions from 512 to 4096 square, using piezo-electronic modulation of a video-resolution CCD chip enhanced by sophisticated image processing. It connects to a PC or a Mac and is targeted at the upscale color desktop publishing market. We used it to scan all the slides you see in this show. Then, with Photoshop software, a Vista card, and a Faroudja encoder, we output them to videotape. For video, this scanner may be overkill, but we made it work for us — and without much hassle. The capability is truly here today.

The Conquest of Form

G. New Color Printers

Hardcopy output is another piece of the multimedia puzzle. We envision a full color printer as an integral part of the system. But what's the best you can buy today?
Two of the world's largest film companies, DuPont and Kodak, have entered the market with what is called thermal dye sublimation printers.

Kodak: XL 7700

These transfer color from a donor ribbon to receiver paper by carefully controlled heating of thermal heads. Each nib on the thermal head can have 256 intensity levels, and the printing process requires either three or four cycles, one for each primary color.

DuPont: 4CAST

DuPont's 4CAST printer delivers outstanding 300 dots per inch continuous-tone four-color proofs in a new, larger 11" x 17" A3 size. Output takes about seven minutes. Getting color printing onto the desktop requires an easy-to-use interface, a small footprint, and simple maintenance. The color ribbon comes as a modular cartridge, of course.

Kodak: XL 7700

Kodak's XL 7700 printer uses the same basic technology to output either 8 1/2" x 11" or square 11" x 11" prints or transparencies in under 4 minutes at 200 dots per inch. Mass production of the new types of physical media needed by these printers is a major challenge for all the vendors.

Honeywell: COLORADO

Honeywell turned to 3M to solve its media needs. Their COLORADO imaging recorder uses a newly developed dry silver color paper to produce 8 1/2" x 11" prints like this in 30 seconds.

H. Data Storage

Pictures require massive amounts of storage. The move to color only exacerbates this by a factor of anywhere from 8 to 32 times. Higher resolutions only make it worse. Volume visualization adds yet another dimension to the problem. Faster CPUs allow us to work with bigger data sets, and these bigger data sets have to be stored somewhere.

The density of silicon-based memory, RAM, is doubling every 18 months. Magnetic revolving memories, discs, are also continuing to get denser and faster.

Optical video discs have been around for some time and offer immense image storage capacity — 54,000 still frames or 60 minutes of NTSC video. They are pressed like phonograph records, and only play back.

CD-ROM, also an optical disc, holds about 500 MB. Great for electronic publishing, but, again, read-only. The CD-ROM used in computers is a prime example of consumer technology adapted to professional applications.

A related technology, writeable/readable magneto-optical discs, are also being integrated with workstations to create image archiving and retrieval systems. Capacity is around 600 MB per side, double sided.

Panasonic: LQ-4000

A larger format rewriteable magneto-optical disc from Panasonic records real time NTSC or RGB video. Disc capacity is 30 minutes, or 54,000 frames. A high-res mode cuts capacity by 30%.

Honeywell: RSS-600

After four decades of dependable service, reel-to-reel nine track tape is being replaced by a Japanese consumer electronics innovation called the VHS cassette Integrate 600 cassettes with a robot picking arm in a "jukebox," like this one from Honeywell, and you have a 6 terabyte mass storage system in 20 square feet of floor space.

Sony: SDT-1000

Or how about this digital data storage device from Sony using even smaller 8mm video cassettes. More than 2 gigabytes per cassette at up to 15 MB per second. That's the capacity of 15 reels of 9 track tape.

Hitachi: 100-500R

If mass storage can get this kind of boost from existing TV technology, what's going to happen when HDTV hits?

I. HDTV Provides a New Wave of Peripherals

Tom McMahon

If you look at a 240M frame of information, it's 1920 by 1035 by some number of bits deep. Us computer guys like 24, sometimes 32 bits, but whatever, it's on the order of four to eight MB in a frame. We like to think of that as a packet. And you could now store in that packet almost any type of information — data, of course pictures, and the important thing to realize is that single packet could be a frame or a tile of a larger image. You can imagine taking a print image, slicing it up into some number of digital 240M packets. Sure, those packets would be put on the tape and sent off again in non-real time. But the tape machine itself offers you a transmission medium that is so dense, and in fact close to real time. If you could get, say a 4K x 4K frame of information in half a second — that's far beyond what the print guys can even dream of today!

Gary Demos

HDTV, if stored in a digital form, is a lot of data: 120 MB per second, so 10 seconds is 1.2 gigabytes; and 100 seconds is 12, and etc. and etc. That's a lot of data. The real issue there is: what kind of reliability are these data streams gonna require for HDTV? Do they require reliability suitable for a computer uses, or are we going to be content with dropping a pixel now and then and pictures as we pass them around? I think what we'll see is a wave of each. We'll see a wave of digital picture media, which is sufficiently reliable for picture use, and then a follow-on wave, which is reliable enough for computer use, with the same basic technology and media as the media is refined to higher air correction rates.

Tom McMahon

In one sense, HDTV is not important. Computers have been making thousand-line video pictures for many years now. What high def brings to the picture is a standard, a standard medium that all of the respective software and hardware vendors can design to. That means we now have a common interchange format for high resolution electronic pictures. That what high def brings to us.

Laurin Herr

Nikon HQ-1500C, FS-1500
Sony: HDC-300
Sony: EBR
Sony: HDDF-500

Besides the digital video recorder, there is the still camera for image capture, the video camera for moving picture capture, the electron beam recorder for film recording, the silicon recorder for frame storage, but at the center of all of this, there is the display.

Kipp Kramer

What we're looking for is low-cost displays. We're looking for the HDTV technology to drive down the cost of displays. What we want to see is, we want to see large screens on the desktop, flat panels because people want more and more screen size. They want to put lots of pixels on the workstation, on the desktop, and we need for low cost workstations.

Dave Trzcinski

The wider aspect ratio has advantages in that it's certainly a closer simulation to your desktop, which is what we're trying to create — a virtual desktop.

Glenn Reitmeier

I think there are some advantages to 16 x 9 displays for workstations. First of all, it gives us larger displays with more usable area. And if you look carefully at the 16 x 9 aspect ratio, you find out that it very readily accommodates engineering B-size drawings, as well as side-by-side displays of two 8 1/2" x 11" pages.

Prof. Dr.-Ing. Jose Encarnação

Once we have the HDTV, then for computer graphics, HDTV will be what raster graphics was after the storage tube period in computer graphics. We will have this TV technology as a mass production technology available for computer graphics applications because it's giving us more picture complexity, quality, detail, ergonomics, and so on. And, based on that, it means I'm convinced HDTV will come, and therefore we have in the meantime to get ourselves prepared on software tools, on interfaces, on drivers, on servers, on applications so that when the technology is there, we are prepared to use it.

IV. Display Hardware

A. CRT Computer Displays

Laurin Herr

In our vision of the future, the workstation has a very large, very flat, 16 x 9 aspect ratio display, but this is ten years away. Where are we today?

OI-NEG: TV Products

The typical workstation today has a 19" 1280 x 1024 60 Hz. non-interlace color CRT. Thisd has about seven times the performance of your home TV and about a third more bandwidth than HDTV. CRTs are a mature technology. They come in all sizes and shapes.

Hughes: MH-1463

On the small side, these micro CRTs are only a half-inch across but can show 2000 pixels on a line. Developed to be worn by fighter pilots, they work well in virtual reality head-mounted displays.

Matsushita: 19" — 2560 x 2560

Monochrome displays are easier to make in higher resolutions because there is no shadowmask and only one electron beam, unlike color.

Sony: GDM 1934

Sony showed a 19" 2048 x 1536 60 Hz. non-interlace color CRT, opening a path for workstations to move to higher resolutions. Please note that an HDTV frame could fit inside a window on this screen with progressive scan and square pixels.

Sony: DDM 280C-20/20

The current state of the art in big color monitors is this 28" diagonal 2048 x 2048 60 Hz progressively scanned beauty, also from Sony. Video bandwidth is 300 MHz. What will the ultimate monitor be?

Tei Iki

Ultimately, I think the people would like the brightness twice of this monitor, with the resolution slightly better than this one.

Laurin Herr

But not all new developments in CRTs are coming from Japan.

Zenith: 20" FTM

Zenith's flat tension mask,the FTM, is an innovation at the face of the tube that may overcome some of the limitations of the traditional shadow mask on a curved screen. The display is sharp, with blacker blacks and brighter colors.

Jerry K. Pearlman

I think that the largest short-term use for high definition CRTs is the workstation market. We've announced that we will do a 16" FTM in 1991, and a 20" FTM in 1992, and the 20" will use all the new production technologies that we need to scale it up into larger sizes, which ought to be ready just in time for HDTV in late 1993.

Marko Slusarczuk

Any technology must move through stepping stones. We are now today at 500 line resolution, essentially, on the broad application level. We are moving to 1000 line. I see no reason why we will not see 2000 and 4000 line requirements in the future.

Arthur Firester

We think we can look ahead to televisions for HDTV-type resolution, which approach 3000 x 5000 resolution elements in full color.

Alexander P. Pentland If you look at traditional workspaces — painters, designers and the like — you find they're organized always in the same way. There's a little intense workspace, where you do your drawing and whatnot, and then, surrounding that, there's a large desktop where you put things that you don't need right at the moment, context materials, and beyond that, there's usually a large wall, or something like that, a post board where you put all the things that you don't need very often, but you need to look at in order to provide reference for what you're doing.

And, a large display will get you — the current displays are good for this little workspace. If you had a display that was this large, the size of most, sort of, tables — you could do desktop stuff right. But, you need something that's the size of the whole wall to get that final context thing that replaces post boards.

Laurin Herr So how big a display do we really want?

Carl Machover What we're looking for is 6' x 4', 18' x 10' —

Laurin Herr I've got it. We're going to need flat panels. How close are we?

B. Flat Panel Displays

Elliott Schlam The state of the art in color is that in active matrix liquid crystal, it's been vividly demonstrated, and all three (red, blue, green) colors. In plasma, it's been demonstrated but not in vivid colors, and there's still a lot of work to be done in that area. In electro-luminescent, two of the prime colors have been demonstrated sufficiently well. There's still a brightness issue on the third color, blue, which we believe within the next year or two, will be resolved. Again, these are demonstrations, they are not manufacturability proofs.

Hitachi: 10" TFT LCD
Matsushita: Color 17" Plasma
Thomson: THX 948
Electro Plasma: RS512-1024
Toshiba: Flat Color Display
Hitachi: TM26D01C
Hitachi: TFT 640x200
Sharp: Display
Sharp: LQ4RA01
Sharp: LM10P10
Electro Plasma: EPI-1728

Electro-luminescence has demonstrated yields in excess of 70%. Plasma technology has demonstrated fairly high yields. The active matrix liquid crystal is in a 10% ballpark. Yield is the problem and that relates to cost. You need to be able to manufacture these things at high yields in order to sell them into a marketplace that will accept them.

Size is another issue again. Size is a serious, serious problem. In plasma technology and AC plasma technology, it's been shown that one can make a display a meter on a side. In active matrix liquid crystal, the largest displays built have been 14" on a diagonal. In electroluminescence, the largest sizes built have been 18" on a diagonal. Making one isn't good enough — you have to be able to make many, many hundreds of thousands and millions, and I don't think any one technology necessarily has an unsurmountable lead at this point.

Planar Systems: EL75121 14M
Sharp: LJ0244U33
Sharp: LM10P10
Matsushita: MD480L640PG2
Toshiba: TV
Toshiba ST-LCD
Hitachi: Cockpit Display
Hitachi: LCD LMG9020ZZFC
Hitachi: 10" TFT LCD

The billions of dollars that are going into flat panel technology are going there because it provides a leverage to the information industry as a whole. The Japanese or no one else wants to sell an inexpensive, one percent markup — ultimately — flat panel display, when they can sell a computer system or an HDTV system. So, building that display with value added, with scanning converters, with memory, with other features, has to be the wave of the future, to substantiate the billions of dollars that are going into manufacturing flat panel displays right now.

The Politics of Pleasure

V. Data Highways

A. Digital Computer Networks and Fiber Optics

Laurin Herr

Bandwidth, the amount of information that can move through a system, is a serious constraint on the development of an information society in general, and a digital video teleputer in particular.

Hewlett-Packard: HP-VRX
Sony: GDM 1934
DuPont: GIP

Faster CPUs have voracious appetites for data that have to be fed. Higher resolution displays have to be updated. Multimedia involves moving large image files in and out of disks. More color means more bits per picture. Real time video in a window requires very fast data flowthrough. HDTV will need five to six times more.

Jim Clark In ten years, we've had the CPU performance of processors outstrip the networking performance of the computers they go in by factors of almost 1000 in ten years. We're still stuck with an Ethernet standard, a 10 MB standard. FDDI says, "Well, let's go and multiply that by a factor of ten," but that's not nearly enough.

R. Bruce Ferguson What we need are very low-cost, high-speed fiber optic buses. And today, that only exists in a few research laboratories around the world. But, there are many companies, including DuPont, who are rapidly pushing to make that a low-cost reality. So, within two or three years, high-speed fiber optic bus connections will be readily available at very low cost.

Laurin Herr Telephone trunk line bandwidth, local area network bandwidth, workstation bus bandwidth — they're all climbing. They are all going to fiber optics.

Robert W. Lucky The current fiber systems are 1.7 gigabits. In the research laboratories, we are going 16 gigabits, and that capability is doubling approximately every year. So, that maybe another year it'll be 32 gigabits. And there's room for another factor, we believe, of a thousand in improvement because there's that much bandwidth left in the optical spectrum on the fiber. So, ultimately, we believe a fiber could carry maybe 20 terabits per second on a single fiber.

Laurin Herr This experimental system from a consortium of companies led by Bellcore allows me to use this PC to route my live video image from here in Atlanta to Los Angeles and back. The system employs a switched digital fiber optic network running at 45 Mbps.

B. Digital Image Compression

Compression is essential to putting video on a network, even a fiber optic one, using what the phone company calls DS3 channels, the fastest they sell. Bellcore's experimental system we just saw uses a Telettra compression scheme that delivers acceptable moving pictures at 20 Mbps. At 45 Mbps, the compressed images are visually indistinguishable from the originals.

German researchers have taken a progressive image build-up approach. The higher the bandwidth of the network, the better the image in a given length of time. This permits a flexible trade-off of cost, speed and image quality.

(NOTE: The bandwidth of the first cycle is 64 Kbps. The second image was at 2 MBps. The third image was at 140 MBps.)

C-Cube: J-Peg

C-Cube Microsystems has already introduced a single-chip image compressor that reduces bandwidth by 20:1, without visible degradation in quality. The new chip uses a pipeline architecture performing more than 10 billion operations per second. Four chips running in parallel can handle HDTV.

(NOTE: The original bandwidth was 2.8 MBps. The compressed bandwidth was 1.8 MBps).

In the industrial age, nations traditionally invested in roads and bridges, but "freight" in the information age will not be physical goods — it will be data. Image compression and faster networks are both needed to build a digital communications infrastructure for the 21st century. We need data highways.

Larry Smarr

What is critical to the next phase in increasing the nation's productivity is to be able to get greater communication across all channels between scientists, regardless of where they are. We must eliminate distance as being important. That means we have to get the visual channel, the audio channel, the various computer channels, the scientific visualization channels all in one conversation.

Rich Riesenfeld

Design is no longer an individual activity. Complex designs involve groups, they involve entire companies, they involve corporations where you have geographically distributed efforts of design. Increasingly, we're seeing that the risk of a new design — a new airplane, a new automobile — is so large scale that a single company can neither muster their resources financially, or human resources, to undertake such a design. So you're seeing consortium collaborative design, across companies, and transnationally in fact.

This means that people have to communicate intimately, very detailed geometric, visual examples of their work across vast distances. And in order to achieve this, networking is the critical component.

VI. The Journey to Virtual Reality

A. Extending 2D Peripherals

Laurin Herr

Interface devices have been a challenge for interactive computer graphics from the very beginning. Many of the tools used to control 2D windowing environments are evolving these days, adding functions, going cordless, getting less cumbersome.

The mouse, taken for granted today, started with this handmade prototype in the mid '60s.

Practical Solutions: Cordless Mouse

Now, there are cordless versions.

Evolution Technologies: Pen Mouse

and a pen-mouse — it behaves like a mouse, but you hold it like a pen.

Microtouch: UnMouse

Here's a touch pad to replace the mouse entirely with a finger.

This is a keyboard joystick — you manipulate with your index finger while you type.

Wacom: Cordless Digitizer

This stylus is sensitive to downward pressure — the harder you push, the wider the line.

Numonics: ZedPEN Plus

Even more sophisticated drawing tools are being introduced for the graphic artist. In addition to pressure, sensors in this new pen detect rotation and tilt relative to the drawing surface. The result is a full six degrees of freedom, with the pen point "anchored" to the drawing plane.

B. 3D Peripherals and the Data Glove

CIS Graphics: Geometry Ball

Holding a ball in your hand is a very natural thing to do, allowing another form of 3D control device.

SimGraphics: Flying Mouse

Here's a new hybrid device, the flying mouse. It works like a mouse on the desktop, but it's engineered to fit into the hand and move in 3-space. It incorporates a 3D position sensor called a Polhemus that can track location and orientation in space.

AT&T: Data Glove
SimGraphics: Data Glove
Loma Linda: Data Glove

The peripheral you hear the most about today is the glove, an interface you can wear. The glove most used by researchers is made by VPL and introduced in 1987. A glove makes possible entirely new types of applications. By sensing gestures, a computer can help the speech impaired to talk.

Mattel: Power Glove

VPL has also implemented its technology into a low cost, low performance glove for video games.

Exos: Exos Glove

At the high end, this Exos glove developed for researchers at M.I.T. is much more precise, and much more expensive.

Tod Machover

Basically, the very slightest movement of each finger — and I mean really slight — is picked up by the computer, and that means that if I wanted to keep my hands steady and get a very slight change in color just by going like that, I could do it. But it also means that if I wanted to have my whole orchestra change sound and I wanted to do it by rippling my hand progressively, it would be something that this glove would have the resolution and the speed to pick up, and so we built a system to do that.

Laurin Herr

More commonly, the data glove is used to interactively control computer-generated virtual environments. Researchers at Bell Labs have used it for virtual CAD systems. They have also added another dimension of control with voice commands.

Alexander P. Pentland

People have twenty or thirty years, at least, history, of interacting with the real world. They have strong intuitions about how real objects act, how they behave, and how they can be used to build other things. So what we're trying to do is capitalize on all those intuitions that they have — things that might have been built in by evolution, even, and the way to do that is to simulate the important perceptual aspects of real materials in this design environment.

The ability to do this intuitive modeling — very efficient building of models — is important with virtual reality because there have to be things in the virtual reality. In fact, the sort of simple things that you see today aren't all that interesting for doing anything. What you'd like to do is populate them with lots of stuff and make them interesting.

Laurin Herr
Mira: Hyperspace Modeler

Cyberware: 3D Digitizer
SimGraphics: BodyBuilder

In order to create a virtual reality, you need virtual objects. One way is to create models using a 3D digitizer.

Another is to scan objects dimensionally. Cyberware has extended their 3D scanner to add color to the surfaces. Ergonomic design enters new dimensions with virtual humanoids modelled in virtual space. Once you've built the body you need, you can use it to simulate whatever you want, even astronauts repairing a space station that hasn't yet been constructed.

C. Force Feedback Peripherals

David Zeltzer
M.I.T. Media Lab.: Force Output Joystick

U.N.C.: Force Feedback Arm

This is a three-axis force output joystick. Not only can users push objects around in the virtual environment, but these objects can now push back.

Force output allows the user to experience the forces that the dynamic simulation is computing. This is very important in many kinds of control tasks and many kinds of problem-solving tasks — when you literally have to feel around in a problem domain to find a local minima or a local maximum. Force output also helps a great deal when you're controlling a device or a vehicle. Force output helps you to understand what it is that the vehicle or the device is doing at the moment.

Fred Brooks

The force feedback arm is expiration of a new mode of display using outrageously complicated and expensive equipment, but what we're trying to learn there is how much can the force display add to the visual display. And the experiments so far indicate that the chemists can determine the nature of the best docking much more effectively with force feedback than with the best visual systems we can build. So this has promise for enabling the chemists to determine new drugs for working in specific sites where they understand the shape and electrical forces around the site.

Laurin Herr

U.N.C.: Treadmill
VPL: Bodysuit

Architects can explore virtual buildings before they are built, experiencing the design in three dimensions as they move through the halls, around the corners, up the stairs. At the University of North Carolina at Chapel Hill, a treadmill senses forward motion. Left-right turning is controlled with some bicycle handlebars. It may be simple, but it works. For the more adventurous, there is the body suit.

Carlo Séquin

I sometimes have the feeling that at this current state of the art in 3D graphics tools, we're a little bit too enamored with technology and gadgets, and if we find a more complicated device, we would rather use that. We see people using data gloves when a mouse would be perfectly adequate. And you see people using mice when a simple keystroke on the keyboard would be adequate. So, I guess I would like to get the message across: keep it as simple as possible. The simplest tool is the best.

Fred Brooks
U.N.C.: Chapel Hill Helmet

We need to use three-dimensional joysticks, three-dimensional pointing devices, stereo glasses — we need to start out by realizing we are working with three-dimensional objects and the user wants to manipulate them in a natural way by pushing and pulling and twisting, and not by moving a mouse around on a 2D surface.

D. Head Mounted Displays

Laurin Herr

Head-mounted visual displays are another key piece of gear for the virtual reality interface. Chapel Hill researchers have been working on head mounted displays that use liquid crystal flat TVs and either Polhemus 3-space trackers or optical sensors to achieve an integrated pictorial feedback system.

Reflection Technologies: Private Eye

This is the Private Eye It's a head-mounted display I can wear to bring my computer screen right up close.

Artists are also exploring virtual reality. This live performer is playing with a virtual instrument. He's untethered. There is no physical connector. He can just as easily play with a ball.

E. Shared Virtual Realities

Shared virtual realities occur when two or more participants enter a shared virtual space. Here, artist Myron Kruger plays with a virtual friend. Both are untethered; the system works using motion detection to sense the location of the players.
In this multiparty simulation, participants can be in the tank, on the ground, or in the air. Each player sees what the others are doing.

Michael J. Zyda What we really need is to start focusing on what I call 3D icons. How do we build low-polygon count three-dimensional skins that work in our visual simulation systems and give people the notion that yes, that is a particular kind of tank?

R. Bruce Ferguson It is impossible within the vision of the next decade of computational power to do total synthesis of the real world, because the real world is too complex. The only way you can merge the real world with simulation is a merging of the digital video with the digital computations.

Laurin Herr Virtual reality not only lets you step into virtual environments, you can even say goodbye to your friends across the network with new realism.

Tom DeFanti Hi, Laurin.

Laurin Herr Oh. Hi, Tom.

Tom DeFanti How'd you like to try out our new force feedback gloves?

Laurin Herr How about a virtual handshake?

Tom DeFanti OK.

Laurin Herr Bye.

Tom DeFanti Bye.

F. Telepresence

Robert W. Lucky I love the idea of telepresence, you know, the idea that I'm somewhere I'm not, that I extend all my senses, that I have this robot that can feel at a distance, and I can move my head around. Then, I think, I can send my robot to a meeting and he can sit there and look around at the other people at the meeting. I think I turn my head and there's another robot sitting beside me. I think, this is really stupid.

Fred Brooks The holdback up until now has largely been the computational power not to deliver the images, but in fact to maintain the models in the virtual world underneath the images, and we are just at the hairy edge of being able to do virtual worlds model maintenance for worlds that are complex enough to be interesting, and not quite there except in some very limited case for worlds that are complicated enough to be useful.

Robert W. Lucky	We're ever searching for that greater presence or reality, and HDTV is the next step in the evolutionary chain. I mean, after that, you got 3D television, and then you start being able to move your head around and things like that, and eventually you're somewhere you're not.
Laurin Herr	That's virtual reality. Thank you for watching the SIGGRAPH Video Review. I'm Laurin Herr.

SPEAKERS' BIOGRAPHIES

Ir. P. W. Bögels

Peter W. Bögels, born in Holland, received his M.S. degree in 1964 from the Technische Hogeschool of Eindhoven, Holland, joining Philips that year. Until 1970, he worked on the pre-development of video and audio recorders in Eindhoven. From 1970 to 1973, he was manager of the development group Audio Philips S.A. in Flers, France. In 1973, he started managing the laser disc systems development group in N.V. Philips, Eindhoven, becoming director of the Audio Division responsible for development and technology five years later. In 1986, he became president of the Directorate EU95 HDTV and is currently director of the C.E. Division N.V. Philips. He received the Eduard Rhein Prize in September, 1988.

Frederick Phillips Brooks, Jr.

Frederick Brooks is Keenan Professor of Computer Science at the University of North Carolina at Chapel Hill, where he founded the computer science department in 1964 and was its chairman for two decades. Prior to coming to Chapel Hill, he worked for IBM for eight years, during which time he was a development manager for the IBM System/360. Dr. Brooks received his Ph.D. in applied mathematics (computer science) from Harvard University in 1956.

He currently serves on the National Science Board and IBM's Science Advisory Committee. Dr. Brooks received the Distinguished Service Award of the Association for Computing Machinery in 1987 and the National Medal of Technology in 1985. He is the author of *The Mythical Man-Month: Essays of Software Engineering*, as well as numerous other books and technical papers.

Dr. James H. Clark

Dr. Jim Clark is the founder and chairman of the board of Silicon Graphics, Inc. The focus of his work in recent years has been to develop hardware and software for advanced special-purpose graphics and CAD Systems. He holds the patent for Silicon Graphics' Geometry Engine™.

Dr. Clark has worked as a systems programmer and a consultant. He also taught electrical engineering at Stanford University, where he led the VLSI research team that developed the Geometry Engine™.

In 1970, he was awarded the annual Gold Medal by the Research Society of America in physics. In 1984, he received the Annual Computer Graphics Achievement Award, and in 1988, the Arthur Young Company and *Venture* magazine Entrepreneur of the Year.

Dr. Clark received his Ph.D. from the University of Utah in computer science, and his M.S. in physics from the University of New Orleans.

Dale Cripps

Dale Cripps attended Portland State and Fullerton State, where he received a degree in business administration. In 1965, he founded Cripps Associates, a consulting and industrial marketing firm specializing in the aerospace and defense industries. He began publishing the *HDTV Newsletter* in 1986, and has recently sponsored international conferences on HDTV. In 1989, he co-founded the non-profit First International Academy, Institute and Foundation for HDTV Arts and Sciences to further research, honor merit, and promote the value of HDTV in general.

Mr. Cripps is currently involved in The Trades Channel, a business-to-business direct satellite broadcast TV system to serve video information to American manufacturing facilities, and the World Wide Cinema Delivery, a motion picture and entertainment delivery service to multiple viewer venues in HDTV format, which should be launched in 1993. Mr. Cripps is a member of the Society of Motion Picture and TV Engineers, and participated within the SMPTE HDTV standards committee.

Gary Demos

Gary Demos is the founder and president/chief executive officer of DemoGraFX. Mr. Demos began his work with computer graphics while a student at the California Institute of Technology (Eng. Applied Science, 1971). For the past twenty years, he has been working with high resolution computer graphics imaging onto film. He has also produced for digital video. He was the founder of Digital Productions, which used a Cray supercomputer to produce motion picture and computer imagery. He also founded Whitney/Demos Productions in 1986, where he used a massively parallel Connection Machine.

Mr. Demos has been involved in the software and hardware development that supported numerous motion pictures, including *Futureworld*, *Looker*, *Tron*, *The Last Starfighter*, *2010*, and *Labyrinth*.

Prof. Dr.-Ing. Jose L. Encarnação

Jose L. Encarnação was born in Portugal and has been living in the Federal Republic of Germany since 1959. He is professor of computer science at the Technical University of Darmstadt, head of the Interactive Graphics Research Group, chairman of the board of the Computer Graphics Center, and director of the Fraunhofer Computer Graphics Research Group in Darmstadt. Prof. Encarnação is the founder of EUROGRAPHICS, the European Association for Computer Graphics. In addition, he is on the executive board of the German Computer Society (1985 to 1990) and has also been chairman of its Technical Committee for Computer Graphics since 1983. Prof. Encarnação is a member of the supervisory board of the Deutsche Informatik Akademie (German Academy of Computer Science) and of the scientific advisory board of the CMD, a large German research institute on mathematics and computer science in Birlinghoven/Boun. Prof. Encarnação chaired the DIN activities in the area of Graphics-Standardization, from which GKS and follow-up graphics standards evolved.

Prof. Encarnação holds a diploma and a doctorate in electrical engineering from the Technical University of Berlin. He is the author of a large number of books, proceedings, and articles in internationally-reviewed journals. He is a member of the editorial board of several professional journals, including *IEEE, CG&A, Computer Graphics Forum, Visual Computer and Computer-Aided Geometric Design*, and is the editor-in-chief of Pergamon Press' *Computer & Graphics*. In addition, he is managing editor of the technical book series *Computer Graphics-Systems and Applications*, which is published in English by Springer-Verlag.

Prof. Encarnação is the West German representative at the International Federation for Information Processing TC 5 (Computers in Industry). He is a member of ACM SIGGRAPH, the German Computer Society, and the Association of German Electrical Engineers. Besides several honors, he was awarded with the German Federal Service Cross in 1983 and the Karl-Heinz-Beckurts Award for outstanding technical scientific achievements in 1989.

Yves C. Faroudja

Yves C. Faroudja is the president of Faroudja Laboratories, Inc. and Faroudja Research, both of Sunnyvale, California. After his graduation with an MSEE degree from the École Supérieure d'Électricité in Paris, Mr. Faroudja worked at ITT Research Laboratories in France and at NATO in Italy as a research engineer. While working in Europe prior to 1965, Mr. Faroudja participated in three engineering firsts: the development of the first tide-power plant, the first transistorized Doppler radar, and the first laser activated on that continent.

Since arriving in the San Francisco area, Mr. Faroudja's efforts have been fully dedicated to the advancement of video technology. Faroudja Laboratories, founded in 1981, has been instrumental in improving video enhancement, noise reduction, and NTSC encoding and decoding techniques. Many of these processes have been licensed to manufacturers of 3/4", SuperVHS, HQ-VHS, and 8 mm video recorders. In 1988, Faroudja Research was founded in order to complete the development of SuperNTSC™, an advanced TV system. Mr. Faroudja holds more than 25 U.S. and foreign patents in the field of TV engineering.

Mr. Faroudja is a fellow of SMPTE and a member of IEEE, NAB, ATSC, and AAEESE. He also participates in the work on ATV of the SS/WP1 Advisory Committee to the FCC. Mr. Faroudja has been honored with the Monitor Award for excellence in engineering and in 1987 received the SMPTE David Sarnoff Gold Medal Award for his contributions in optimizing NTSC performances.

Arthur H. Firester

Arthur H. Firester is director of the Applied Physics and Advanced Displays Laboratory at the David Sarnoff Research Center (formerly RCA Laboratory) at Princeton, New Jersey. His most recent research focus has been applied mathematics and physics focused on physical system simulation and electron optics design, and software and database engineering. His past research interests, both participatorial and managerial, have included optical spectroscopy; holography; lasers and nonlinear optics; optical recording; display device production, engineering and instrumentation; amorphous silicon solar cells-research, fabrication, and application; microwave materials, devices, applications, and systems; and flat display technologies.

Dr. Firester has received four RCA Laboratories Outstanding Achievement Awards, is the author of numerous scientific papers, holds more than twenty American patents, and is a member of Sigma Xi, the American Physical Society, the Optical Society of America, the Society for Information Displays, and the Institute of Electrical and Electronics Engineers.

He received the B.A. degree *cum laude* with honors in physics from Brandeis University in 1962, and his M.A. (1964) and Ph.D. (1967) degrees in physics from Princeton University.

R. Bruce Ferguson

Bruce Ferguson is the group business manager of industrial and visualization systems in electronic imaging of the DuPont Company's Imaging Systems Department. This position comes after a number of years during which he worked in the company's Atomic Energy Division at the Savannah River Plant near Aiken, South Carolina, where he concentrated on robotics, artificial intelligence, and scientific computing.

Mr. Ferguson graduated from Wofford College with a bachelor's degree in chemistry in 1968. He received his master's degree in analytical chemistry in 1970 from Clemson University. He is a member of IEEE.

Joseph A. Flaherty

Mr. Flaherty is vice president and general manager of engineering and development at CBS, which he joined in 1957 as a TV design engineer. He is responsible for all TV and radio engineering and development activities for CBS Inc., including planning and coordinating the development of new equipment, and for the design and installation of all technical facilities.

Mr. Flaherty received his degree in physics from the University of Rockhurst, Kansas City, Missouri, in 1952. He is a fellow and one of the governors of SMPTE. In addition, Mr. Flaherty is a fellow of the Institution of Electrical Engineers (IEE) and a chartered engineer of the United Kingdom. He is a fellow of the Royal TV Society (U.K.), an honorary member of the Society Fernseh-und Kinotechnischen Gesellschaft (Germany), a member of the Societé des Électriciens, des Électroniciens et des Radioélectriciens (SEE), (France), and one of the four international honorary members of the Institute of TV Engineers (Japan).

Mr. Flaherty is chairman of the Planning Subcommittee of the FCC's Advisory Committee on Advanced TV Service, a member of the Executive Committee of the Montreux International TV symposium, a member of the Executive Committee of the Advanced TV Systems Committee, a member of the Board of Directors of the Advanced TV Test Center, and a member of the USIA Advisory Committee on TV Telecommunications.

Since 1974, Mr. Flaherty has received four Emmy awards for developments in television engineering. In 1979, he received the Montreux Achievement Gold Medal for the development of the concept and the operational implementation of electronic news gathering. He has also received the National Association of Broadcaster's Engineering Award and SMPTE's Progress Medal Award.

The French government has conferred on Mr. Flaherty both the Legion of Honor and the Order of Arts and Letters. In 1989, Rockhurst College in Kansas City, Missouri awarded Mr. Flaherty an honorary Doctorate of Science degree.

Takashi Fujio

Takashi Fujio spent over thirty years with the Science and Technical Research Laboratories of NHK (Japan Broadcasting Corporation), working on research into the transmission of color TV signals and HDTV systems. In 1986, he retired from NHK and entered the Matsushita Electric Industrial Co. as director of the HDTV Development Center.

Dr. Fujio holds nearly 70 patents and utility models relating to HDTV system and TV transmission systems. He received the Achievement Award from the Institute of TV Engineers of Japan in 1979, and SMPTE's David Sarnoff Gold Medal Award in 1981. In 1983, his distinguished service in HDTV research and development, along with his continuous efforts to develop a worldwide HDTV standard, were highly recognized by the Ministry of Science and Technology (MITI) of Japan.

He received a doctor's degree in electrical engineering in 1967 from the University of Tokyo's Institute of Technology. His thesis was on signal decoding and image reproduction of color TV.

Hugo P. Gaggioni

Hugo Gaggioni is a manager of High Definition Video Systems with Sony Advanced Systems. His work involves examining applications of advanced technologies like HDTV, video communications, and B-ISDN. Prior to joining Sony, he was a member of technical staff of the Visual Communications Research District at Bell Communications Research, studying new compression algorithms for the digital transmission of HDTV and standard video signals, as well as in high-resolution graphics and video terminals.

He received his B.Sc. in telecommunications and a M.Sc. in electrical engineering from Essex University, Colchester, England, and a M.Sc. in systems engineering from the University of Pennsylvania. He also holds a professional engineering degree from Columbia University.

He is a vice-chairman of the Working Party 4, System Standard of the Systems Subcommittee of the Advanced TV Advisory Group to the FCC. He serves as vice-chairman of the HDTV analysis group, T4-S1, of the A.T.S.C. He is also chairman of the SMPTE Ad Hoc Group on Digital Representation of the 1125/60 (SMPTE-240M) HDTV standard.

John Galt

John Galt is director of production services for Sony Advanced Systems in Los Angeles. He is presently involved in establishing a Sony high definition facility on the Columbia Studios Lot in Culver City. This will include the commercial operation of the first high definition electron beam recorder in North America.

Before joining Sony, Mr. Galt was president of Northernlight & Picture Corp., and was co-producer and director of photography on Canadian Broadcasting Corp.'s *Chasing Rainbows*, the world's first drama series to be captured in high definition video.

Originally trained in his native Scotland as a photographer, Mr. Galt has also worked as a production designer, lighting designer, and technical consultant on numerous television programs.

Dr. Michael Hausdörfer

Dr. Michael Hausdörfer, a native of Germany, has been the head of the advanced development department of Fernseh GmbH, in Darmstadt, since 1973. His current focus is digital and analog video signal processing for studio applications. He joined the company in 1967 as a project engineer investigating low-light level pickup tubes (SEC) and their application in color TV cameras.

In 1980-1981, he participated in the standardization process of the component digital video standard as a member of the SMPTE task force of component digital coding. At present, he is responsible for an extensive program on the development of experimental equipment for High Definition TV.

Dr. Hausdörfer received his Dipl.-Ing. degree in 1959 in communication engineering, and his Dr.-Ing. degree in 1965, both from the Technical University of Aachen.

Dr. Hausdörfer is a member of the American IEEE, the SMPTE, and FKTG (Fernseh-und Kinotechnische Gesellschaft). Since 1973, he has been lecturing on *The Basics of TV* at the Technical University of Darmstadt. In 1988, Dr. Michael Hausdörfer was appointed honorary professor at the Technical University of Darmstadt, Germany. In the same year he was appointed chairman of the studio equipment group 3 of the Eureka HDTV-Project, EU 95.

Laurin Herr

Laurin Herr has worked in the computer field since the mid-1960's and has consulted to Japanese, European, and American companies since the late 1970's. He founded Pacific Interface in 1980 as an international consulting company, developing an extensive network of professional contacts in Japan and elsewhere through his work on industrial study missions, international conferences, special events, industry and market research projects, and other consulting assignments.

In 1989, Herr produced and directed *Volume Visualization: State of the Art*, Special Issue 44 of the SIGGRAPH Video Review (SVR). This was preceded in 1988 by the 160-minute report, *Visualizaiton: State of the Art*, Special Issue 30 of the SVR and its update, Issue 35. Prior to his affiliation with the SIGGRAPH Video Review, his tapes were published by Frost & Sullivan. He made two video reports on computer graphics with Raul Zaritsky in 1986 and 1987.

Mr. Herr has served as the official liaison with Japan for ACM SIGGRAPH since 1982 and was appointed to the International Relations Committee of the National Computer Graphics Association (NCGA) in 1987.

Mr. Herr received a Bachelor of Arts degree in government from Cornell University in 1972. He pursued additional studies in Japanese language, history, and politics at Cornell, and Sophia University in Tokyo.

George W. Hoover, Cmdr. U.S.N. (Ret.)

Since his retirement from the U.S. Navy in 1958, Cmdr. George Hoover has been an independent consultant to government and industry, focusing on issues relating to aerospace. His active career as a Navy aviator spanned every class of Naval aircraft, from biplanes to jets. He has flown over 100 types and models of aircraft, and holds Navy helicopter designation No. 10.

Cmdr. Hoover is internationally known for his work in developing advanced displays and controls in aircraft cockpits. He designed and developed the first operational flight trainer in 1944 with Mr. Ed Link, and pioneered many techniques for creating illusions for simulation through the use of audio/visual technologies.

He was stationed at Pearl Harbor in 1941 when the Japanese attacked. Here he designed an automatic navigation display, which is believed to be the first computer graphics system ever created. In 1960, he initiated a program with General Electric to develop a digital display called Contact Analog and the Highway in the Sky. In 1988, this same concept, which is now called the Command Flight Path Display, was successfully flown in two flight tests and one simulator program, which proved the validity of the original concept.

Cmdr. Hoover is credited with initiating and managing Project Orbiter, the first official space program in the U.S., with Dr. Wernher von Braun, which resulted in the first U.S. earth satellite, Explorer One. Upon retirement from the Navy, he received a Legion of Merit from the President for his achievements in advancing the effectiveness of aircraft instrumentation and for initiating Project Orbiter. He received the Space Flight Award from the American Astronautical Society at its third annual meeting on Dec. 7, 1956 for initiation and management of Project Orbiter.

Cmdr. Hoover was selected as "Laureate for Electronics for 1989" by *Aviation Week and Space Technology* for his lifelong dedication to improving pilot effectiveness and safety through such innovations as integrated pictorial cockpit displays. He received the British Interplanetary Society Bronze Medal for Astronautics Achievement in 1971.

For several years Cmdr. Hoover served as a consultant to the Smithsonian Institute. He produced and developed the conceptual design for the Sea/Air Operations Exhibit in the National Air and Space Museum. He has published or presented over 100 articles, including a contribution in 1949 on aircraft cockpits for the *Encyclopedia Americana* , and space cockpits for the *Handbook of Astronautical Engineering* , published by McGraw Hill in 1961.

Cmdr. Hoover graduated from the University of Nebraska with a B.S. in physics in 1951, completing the course in two years.

Tei Iki

Mr. Iki has been with Sony since 1973, holding various positions in the CRT and display areas. At present, he is based in San Diego as president of Sony Display Systems of America, a unit responsible for non-consumer displays. Prior to Sony, Mr. Iki was with Tektronix in the early 1960's.

He has taught various display-related courses, most notably a course at UCLA on color CRTs.

Tei Iki has a B.A. in chemistry/physics from the University of California at Berkeley. He has also done graduate work at Portland State University.

Yoichiro Kawaguchi

Yoichiro Kawaguchi is an instructor in the art department of Nippon Electronics College. Mr. Kawaguchi was educated at the Kyushu Institute of Design and did graduate work in Tokyo University's Department of Art Education. His work appeared at SIGGRAPH throughout the 1980's, as well as at numerous conferences in South America, Canada, Europe and Australia. He received the Most Excellent Artist award at EUROGRAPHICS '84; the Grand-Prix, PARIGRAPH '87 (creation); the Grand-Prix, Nouvelles Images REALLON '87; and the first prize at IMAGES du FUTUR '87, '88.

He is a member of ACM SIGGRAPH, the Japan Society for Science of Design and the Japan Society of Image Arts and Science.

Stanley P. Knight

Mr. Knight is the head of the Parallel Computing Research Group of the Information Sciences Research Laboratory of the David Sarnoff Research Center. A holder of five U.S. patents, he has worked at Sarnoff on various research assignments, including RF circuit design and system development, thick-film planar technology for use in television tuners, and IF and automated test-set design. He has also been involved with the development of Direct Broadcast Satellite for home terminals, and the development of parallel processing hardware for real-time system simulations.

He received a BSEE degree from the University of Kentucky in 1961, and a MSEE in 1969 from the Newark College of Engineering. Author of numerous technical publications, he has received the IR100 Award (1969), and the RCA Laboratories Outstanding Achievement Awards in 1967, 1975 and 1981. He is a member of ACM, IEEE, SMPTE, and was the chairman of the Joint RCA-Hitachi Frame Store Task Force from 1985 to 1987.

Kipp Kramer

Kipp Kramer is the engineering manager of the Video Products Development Group at Sun Microsystems in Mountain View, California. His team is responsible for developing video processing cards for Sun's desktop workstations. Prior to Sun, he was manager of engineering for Fortel, where he led a team developing digital time base correctors and color correctors for the television broadcast industry.

Mr. Kramer received degrees in electrical engineering from North Carolina State University in 1974 and 1976.

Jaron Lanier

Jaron Lanier is a computer scientist, businessman, and composer. He is the chief executive officer of VPL Research Inc, a Silicon Valley research and development company that he founded in 1984. VPL is the developer of the first commercially available virtual reality system as well as the Power Glove (licensed to Mattel); Swivel 3D, the popular Macintosh 3D tool (licensed to Paracomp, Inc.); and other well-known products.

Mr. Lanier's work has been featured in numerous books, on national TV, and in articles, including the *New York Times*, the *Wall Street Journal*, and the cover of *Scientific American* twice. He is best known in the scientific community as a designer of computer programming languages. He has also been a political activist, a designer of video games, and a composer of TV sound tracks. He lives in Palo Alto, California with hundreds of musical instruments.

Stephen M. Legensky

Stephen M. Legensky is president of Intelligent Light, a world leader in products for visualization. Steve holds a Bachelor of Engineering and Master of Science Degrees from the Stevens Institute of Technology and has worked in both hardware and software for computer graphics since 1973.

Andrew B. Lippman

Andy Lippman has spent the past 23 years at M.I.T. in capacities ranging from undergraduate to associate professor. He is currently associate director of the Media Laboratory and is directly responsible for research programs in the lab addressing the future of TV, movies, consumer entertainment systems, and multi-media workstations. In recent years, his work has included development of high definition TV systems for production and distribution, techniques to contain feature-length movies on compact audio discs, interactive technologies for videotape and disc, and home information systems that literally compose TV programs on-the-fly as they are viewed. He has participated in congressional and international discussions on communications, American competitiveness, and the future of TV.

In the past, he directed the Architecture Machine Group and gained some notoriety for the development of an early interactive videodisc system, the Movie-Map, which enabled viewers to pre-experience a trip to Aspen, Colorado via a video personal computer. Later work included the *Movie Manual*, an electronic book written individually for each reader as it was being read, and research programs in teleconferencing, news information, and personalized publishing. He has been published widely and made over one hundred presentations, for technical and lay audiences, on interactivity, high definition TV, personal communications, and entertainment in the next century.

Robert W. Lucky

Robert W. Lucky, executive director of the Communications Sciences Research Division at AT&T Bell Laboratories, has been with the company since graduating from Purdue University. He received a B.S. degree in electrical engineering in 1957, and the M.S. and Ph.D. degrees in 1959 and 1961. His initial work at Bell Labs was to study ways of sending digital information over telephone lines. The best known outcome of this work was his invention of the adaptive equalizer, a technique for correcting distortion in telephone signals that is used in all high-speed data transmission today. The textbook on data communications that he co-authored became the most cited reference in the communications field over the period of a decade.

Dr. Lucky is a fellow of the IEEE, where he has served as editor of the *Proceedings*, and is a member of the National Academy of Engineering. He has been on the advisory boards or committees of five universities and of the National Science Foundation, and was Chairman of the Scientific Advisory Board (SAB) of the U. S. Air Force from 1986 to 1989. In May 1988, Dr. Lucky was awarded an honorary Doctorate of Engineering from Purdue University.

He is a consulting editor for a series of books on communications through Plenum Press. In 1989, St. Martin's Press published his book, *Silicon Dreams*, a semi-technical discussion of the information age.

Carl Machover

Carl Machover is president of Machover Associates Corporation, a consultancy providing a broad range of management, engineering, marketing, and financial services to computer graphics users, suppliers, and investors.

Mr. Machover is an adjunct professor of computer graphics at Rensselaer Polytechnic Institute, and on the technical advisory board of The Boston Film and Video Foundation. He has served as the president of the NCGA and the Society for Information Display, and was formerly executive vice president of Information Displays Inc.

In 1988, Mr. Machover was elected to the FAMLI Computer Hall of Fame and was awarded the Orthogonal Medal by North Carolina State. He was the first elected "Chief Old Timer" of the Computer Graphics Pioneers.

He has written numerous articles on computer graphics and is on the editorial boards of *IEEE's Computer Graphics and Applications*, *Computers and Graphics*, and *Visual Computer*. He is also chairman of the editorial board of the *S. Klein Newsletter*. He has recently published *The C-4 Handbook*, Tab Publishers.

Mr. Machover graduated as an electrical engineer from Rensselaer Polytechnic Institute. He and his wife, Wilma, are also the parents of three creative children.

Tod Machover

Tod Machover is active in many forms of new music from orchestral to computer-generated, chamber to operatic. After studies at the Juilliard School with Elliott Carter and Roger Sessions, he spent 1978-1985 in Paris at Pierre Boulez's IRCAM institute, serving for five years as its director of musical research. Since 1985, he has worked at the M.I.T. Media Laboratory, where he is associate professor of music and media, as well as director of the Experimental Media Facility.

Mr. Machover's music has been widely performed throughout the world and has been awarded numerous prizes and honors from such organizations as the Koussevitzky Foundation, the Fromm Foundation, the American Institute of Arts and Letters, the National Endowment for the Arts, the Kennedy Center, and the French Culture Ministry. His opera *VALIS* received a new production at Tokyo's Bunkamura Theater in January 1990, and the recording of the work (Bridge BCD 9007) was recently named a "best of the year" by the *New York Times*.

Mr. Machover is currently working on a series of three pieces for "hyper"-string instruments: for cellist Yo-Yo Ma, the St. Paul Chamber Orchestra, and a viola concerto for Kim Kashkashian. In addition, he is working on several new opera projects, including one with director Peter Sellars.

Tom McMahon

Tom McMahon, founder of Symbolics' Graphics Division, has served as its general manager and director of R&D since 1982. In addition to his administrative responsibilities of marketing, managing and planning, his design responsibilities have included most of the graphics hardware system, architecture of the graphics software system, parts of the main 3600 CPU family and peripherals, and general digital and analog engineering.

Prior to that time he was a member of the technical staff at Information International Inc., responsible for design of the Digital Film Printer, high resolution color and gray scale raster display systems, very high speed calligraphic display systems, digital audio hardware, film recording and scanning systems, and various arithmetic processors.

He is a founding member of the Information International Motion Picture Project, a state of the art computer animation facility. He was also the founder (in 1980) of Future Logic, a contract consulting firm which focused on the development of biomedical applications of microprocessor technology. Notable was the first working prototype of a subcutaneous programmable insulin system injection system using a semi-custom microprocessor. This system has passed FDA trials and is now in production.

In the mid-1970's he co-founded Pertron Controls Corp., which developed a line of computerized industrial controllers for the welding and auto body industry. He was responsible for analog and digital design as well as mechanical drafting and test engineering.

Mr. McMahon received his BSEE from the California State University at Northridge.

Jerry K. Pearlman

Jerry K. Pearlman is chairman, president, and chief executive officer of Zenith Electronics Corp., the only independent American color TV and picture tube manufacturer. Pearlman joined Zenith in the early 1970's as controller. He also directed the Heath Company and Zenith Data Systems subsidiaries, beginning in 1979. Prior to joining Zenith, Pearlman was a director and vice president of finance of the Behring Corporation in Florida. From 1962 to 1970, he worked for Ford Motor Co., where he held a variety of managerial posts.

Pearlman is a director of First Chicago Corp., the Evanston Hospital Corp., and Stone Container Corp. He is a member of the Board of Trustees of Chicago's Museum of Science and Industry and the Board of Trustees at Northwestern University, where he also serves on the advisory board of the Kellogg Graduate School of Management. Pearlman is also a member of the Board of Trustees of the Committee for Economic Development.

Pearlman graduated *cum laude* in 1960 from the Woodrow Wilson School of Public and International Affairs at Princeton University. He earned a MBA degree with high distinction from the Harvard Business School in 1962 and was named a Baker Scholar.

Alex P. Pentland, Ph.D.

Alex Paul Pentland received his Ph.D. from M.I.T. in 1982, and that same year began work at SRI International's Artificial Intelligence Center in California. He was appointed industrial lecturer in Stanford University's Computer Science Department in 1983, winning the Distinguished Lecturer Award in 1986. In 1987, he was appointed associate professor of computer, information, and design technology at M.I.T.'s Media Laboratory, and was given the NEC Computer and Communications Career Development Chair in 1988.

He has done research in artificial intelligence, machine vision, human vision, and computer graphics. In 1984, he won the Best Paper prize from the American Association for Artificial Intelligence for his research into the problems of texture and shape perception. His last book was entitled *From Pixels to Predicates*, published by Ablex, and he is currently working on one entitled *The Vision Machine*, to be published by Bradford Book, M.I.T. Press.

Ron Ratner

Ron Ratner has been president, chief executive officer, and a director of Club Theatre Network (CTN) since 1988, when he introduced High Definition Television as part of the business plan, including HDTV electronic production facilities. CTN has since become one of the fastest growing high definition TV companies in existence today, and has become a public company. Prior to Club Theatre Network, Mr. Ratner was president and director of Acuvision Systems, Inc., a high-technology public company engaged in the development of a computerized exercise machine for the eyes.

Mr. Ratner received his higher education from Pratt University and New York University.

Barry Rebo

Barry Rebo is president and chief executive officer of REBO High Definition Studio, New York, the pioneer in high definition production in America. Founded in the summer of 1986 as the first American company to purchase HD equipment, REBO Studio has produced in excess of seventy commercials, short features, live concerts, music videos, and animations as well as a full-length theatrical motion picture. REBO High Definition Studio is the winner of many prestigious awards in the video and film industries, including the best narrative short at the 1989 Cannes International Film Festival.

Glenn A. Reitmeier

Glen Reitmeier is the group head, Interactive Multi-Media Systems Research, of the Consumer Electronics and Information Sciences Division of the David Sarnoff Research Center. His work focuses on adaptive digital signal processing algorithm development, multi-dimensional signal processing, systems engineering, and hardware and software development.

Among his research assignments at Sarnoff, Mr. Reitmeier has led the Sarnoff-Sun-TI team in developing a high-resolution video workstation for DARPA, as well as headed projects relating to the development of all-digital HDTV, including hierarchical data compression and digital transmission. He has received RCA Laboratories' Outstanding Achievement Awards in 1979, 1981 and 1983.

From 1980 to 1989, Mr. Reitmeier was an adjunct faculty member in the Department of Electrical Engineering at Villanova University, where he received his B.E.E. *summa cum laude* in 1977. He received his M.S.E. in 1979 from the University of Pennsylvania's Moore School of Electrical Engineering. He is the author or co-author of 16 papers and presentations and the holder of 34 U.S. patents.

Richard Riesenfeld

Dr. Riesenfeld is a professor of computer science and adjunct professor of mechanical engineering at the University of Utah. He also co-heads the Computer Aided Geometric Design Group, which has been investigating a broad spectrum of research problems in computer graphics, geometric modeling, and manufacturing within an integrated experimental testbed system motivated by the unifying principles of spline theory.

Dr. Riesenfeld received his Ph.D. in computer science in 1973 and his M.S in mathematics in 1969 from.Syracuse University. In 1966, he received his A.B.in mathematics from Princeton University. In 1988 he was awarded the University of Utah Distinguished Research Award, and in 1987, the First Annual Utah State Governor's Award for Science and Technology.

Judson Rosebush

Judson Rosebush is a producer and director of computer animation, an author, and media theorist. He graduated from the College of Wooster in 1969 and received an M.S. from Syracuse University in 1970. He has worked in radio and television broadcasting, sound and video production, and print. He completed his first computer animations in 1970 and founded Digital Effects Inc. in New York, the company which virtually introduced computer animation to the commercial marketplace. He has exhibited computer-generated drawings and films in numerous museum shows and his computer drawings have been reproduced in hundreds of magazines and books. He is skilled at computer programming and system design as well as the graphic arts.

Rosebush is the co-author of *Computer Graphics for Designers and Artists*, published in 1986 by Van Nostrand Reinhold Co., and is currently writing a book on computer animation. Other credits include work for major advertising agencies and networks, scenes for feature films such as *Tron*, and lectures at computer graphics conferences worldwide. He currently produces and directs a wide variety of special effects work for film and video, consults and lectures on animation, aids in software and facility planning, and writes text as well as software. Typical projects during the past year have included co-authoring a one-hour television program on volume visualization, writing *The Proceduralist Manifesto*, a statement on computer art published in *Leonardo*, publishing a tutorial on using APL for computer graphics notation, and programming a HyperCard controlled videodisc system.

John Sanborn

Since the late 1970's, artist John Sanborn has been world known for his innovative, experimental, and popular creations in the field of video art. Sanborn's award-winning work, ranging from commercial vehicles to video installations to live multi-media events, emphasizes his unique point of view, which fuses technology and art, and in his own words, "expresses ideas in an off-beat, surreal way".

His work includes collaborations with Mary Perillo, his partner in Sanborn, Perillo and Co.; Robert Ashley (*Perfect Lives*), Twyla Tharp (*Scrapbook*), Dean Winkler (*Luminare*), and The Residents (*The Eyes Scream*), Molissa Fenley (*Metabolism* and *Geography*) Lee Breuer and Bob Telson (*Sister Suzie Cinema)*, Charles Moulton (*Fractured Variations* and *Visual Shuffle*), David Van Tieghem (*Galaxy)*, David Gordon (*Duet* for *Great Performances* with Mikhail Baryshnikov), and Philip Glass (*ACT III*). Sanborn has created work for all six seasons of the PBS series *Alive from Off Center*, including *Words on Fire*.

In the realm of high definition video, Sanborn and Perillo have produced *Cause and Effect* (with REBO High Definition Studios), which has been exhibited worldwide; *Infinite Escher*, a commission from the Sony Corp. to create a work in HDVS including Hi-Vision computer graphics, based on the life and works of M.C. Escher; and *Memories of New Orleans*, an HDVS musical/narrative produced by REBO Studio for NHK-TV.

Elliott Schlam

Dr. Elliott Schlam is an internationally recognized authority on the information display industry. His consulting practice specializes in the business and technical development of display and related products, high definition TV, and military systems.

During his tenure as a division director for the U.S. Army, Dr. Schlam was responsible for all aspects of their extensive display programs including research and development, technology insertion, systems integration and manufacturing methods. He is largely responsible for the currently prominent use of flat panel displays in a wide variety of military systems. He was a spokesman for the use of displays throughout the armed services, serving on DOD's prestigious Advisory Group on Electron Division.

Dr. Schlam also served as the vice president of sales and marketing for a small flat panel display manufacturing company. During this time, he directed a streamlining and focusing of the company's technical and business activities into high payoff areas. He was responsible for millions of dollars of sales of the company's emerging products.

He is a fellow of the Society of Information Display and has been elected to Who's Who in the East, Who's Who in Technology Today, American Men and Women of Science and Who's Who in Optical Science and Technology. Dr. Schlam earned the Ph.D., M.E.E., and B.E.E. from New York University and the M.S. in Management Science from Fairleigh Dickinson University.

Carlo Séquin

Carlo Séquin is a professor of computer science at the University of California at Berkeley, where he joined the faculty in the EECS Department in 1977. In the early 1980's, jointly with D. Patterson, he introduced the RISC concept to the world of microcomputers. From 1970 to 1976, he worked at Bell Telephone Laboratories at Murray Hill, New Jersey on the design and investigation of charge-coupled devices for imaging and signal processing applications.

He received his Ph.D degree in experimental physics from the University of Basel, Switzerland in 1969. His subsequent work at the Institute of Applied Physics in Basel concerned interface physics of MOS transistors and problems of applied electronics in the field of cybernetic models.

His research interests now lie in the fields of computer graphics and computer aided design tools for CADAM as well as for the design of integrated circuits. He is particularly interested in the issues that transcend individual tools, such as consistent and efficient data representations and good user interfaces. Dr. Séquin is a member of ACM, a fellow of the IEEE, and has been elected to the Swiss Academy of Engineering Sciences.

Bruce Sidran

Bruce Sidran is currently district manager, Planning for Advanced Video Services, for Bell Communications Research. In this role, he is responsible for directing Bellcore's internal and external activities related to broadband ISDN (BISDN) video technology and services, with a focus on advanced TV (ATV) applications. As part of this responsibility, he managed Bellcore's Advanced Laboratory for Interactive Video Experiments (ALIVE).

Mr. Sidran serves the FCC's Advisory Committee on Advanced TV as vice-chairman of Systems Subcommittee Working Party 4 (System Standards) and chairman of the Task Force on Report Drafting. He is also vice-chairman of CCIR's Interim Working Party 11/9, Harmonization of High Definition TV Standards Between Broadcast and Non-broadcast Applications.

He is a member of IEEE, SMPTE, ACM, and SIGGRAPH.

Marko M. G. Slusarczuk

Marko M. G. Slusarczuk is the program manager of the high definition display technology program at the Defense Advanced Research Projects Agency (DARPA). He comes to DARPA from the Institute for Defense Analyses (IDA), where he was one of the co-founders of the Computer and Software Engineering Division and served as the assistant division director. He has also been a consultant, entrepreneur and has practiced law in Washington, D.C.

Dr. Slusarczuk graduated in 1974 from M.I.T. with a Bachelor of Science in electrical engineering and in 1979 with a Doctor of Science in materials science. He was also awarded a Juris Doctor *cum laude* in 1982 by the Boston College Law School. He is a member of the District of Columbia Bar. Dr. Slusarczuk has been active in the computer law section of the District of Columbia Bar and in the M.I.T. Educational Council.

Dr. Larry Smarr

Larry Smarr is professor of physics and astronomy at the University of Illinois at Urbana-Champaign and the director of the National Center for Supercomputing Applications (NCSA). Smarr received his Ph.D. from the University of Texas at Austin. He has conducted research at Stanford and Texas and taught at Princeton and Yale universities.

Robert Sproull

Dr. Sproull is vice president of Sutherland, Sproull, and Associates, Inc., and adjunct professor of computer science at Carnegie-Mellon University. Sutherland, Sproull, and Associates specializes in consulting, research, and development, and advising venture capital investors. For the past few years, Sproull and Ivan Sutherland have been pursuing new designs and design techniques for asynchronous systems.

Prior to joining SSA, he was an associate professor at CMU and a research scientist at the Xerox Palo Alto Research Center (1972-1977), where his work involved the design of hardware and software for page-imaging systems that prepare high-resolution images for printing on laser printers. He now serves on the Technical Advisory Council of R. R. Donnelley and Sons, the largest commercial printer in the United States.

Dr. Sproull's other interests are in computer graphics, the design of large hardware/software systems, and electronic publishing. He has worked on real-time display hardware, line-drawing and hidden-surface algorithms, device-independent graphics packages, display system design, and network graphics. He is co-author with William Newman of a computer graphics textbook.

He received a Ph.D. degree in computer science from Stanford University in 1977, and an A.B. in physics from Harvard College in 1968.

Hideichi Tamegaya

Mr. Tamegaya is the deputy director of the Hi-Vision Special Project at NHK (Japan Broadcasting Corporation). He has been involved in the use of computer graphics in broadcasting from the introduction of the technology, to system development, to program production.

Mr. Tamegaya was responsible for the world's first HDTV "graphic anchorperson," who appeared in NHK's 1984 production, *Warning from the 21st Century.* This was made possible by applying human simulation technology in cooperation with M.I.T.'s Media Laboratory.

He has been involved in numerous HDTV events, including a 3-hop satellite broadcast; an HDTV co-production drama with BBC; and closed circuit world boxing championship events. He was the HDTV technical coordinator for German film producer Wim Wender's *Until the End of the World* and for Peter Greenaway's *Prospero's Book.*

Mr. Tamegaya graduated in 1966 with a B.S. from Tokyo Electric Engineering College's Electric Communications Engineering Department.

Tsuyoshi Teshima

Since 1968, Mr. Teshima has been with Dai Nippon Printing, where he has served over the years as general manager of the Communications Art Department, and head of planning and development of electronic publishing using new media such as CD-ROM, optical disks, and HDTV. In 1987, he introduced Hi-vision Graphics as a still image art work.

Recently, he took charge of the development of the "HI-VISION GALLERY" in the Gifu Museum of Fine Arts under the NHK Group. In 1990, he began overseeing the "HI-VISION GALLERY" Software for Art Museum in Machida. He was also appointed general manager of the Multi-Media Communication Center.

In 1966, Mr. Teshima graduated from the Department of Literature in Keio University.

David Trzcinski

David L. Trzcinski is manager for Display and Graphics Peripherals, in the Graphics Technology Division of Hewlett-Packard Company's Workstation Group in Chelmsford, Massachusetts.

At present, he is on the workstation committee of the Society of Information Display, and IEEE and NAS's committee on high resolution systems (COHRS), which is working to develop industry architecture standards. for high res systems.

He holds a BSEE from the State University of New York at Buffalo.

Dr. Pieter A. van Dalen

Dr. van Dalen is the chief operating officer and president of BTS Broadcast Television Systems GmbH, Darmstadt, West Germany, a joint venture of Bosch and Philips.

For the past two decades, he was with Philips in various capacities ranging from research in the Philips Research Laboratories, to product and marketing manager in the Philips Medical System Division, to consultant and manager of North American Philips in Shelton, Connecticut. His most recent position with Philips was as managing director in charge of worldwide commercial activities of the I&E Division, in Eindhoven, The Netherlands.

From 1966-1967, Dr. van Dalen was a post-doctoral research fellow of the Faculté de Sciences, Université de Paris, France. In the early 1960's is was an assistant research instructor at Michigan State University, East Lansing.

Mary C. Whitton

Mary C. Whitton is the marketing director of the Visualization Products Group of the Graphics Development of Sun Microsystems, Inc., located in Research Triangle Park, North Carolina. She came to Sun Microsystems, Inc. through their acquisition of Trancept Systems Inc., where she was one of the founders and vice president of sales/marketing. Prior to Trancept, she was a founder of another start-up, Ikonas Graphics Systems, later acquired by Adage, Inc., where she was involved in engineering and sales/marketing.

While earning a Master of Science in electrical engineering from North Carolina State University, Ms. Whitton built hardware for the display of curved surfaces. She is a frequent invited speaker at graphics industry conferences, where her solid understanding of technology and a wide variety of display intensive applications make her comments interesting to both engineering and marketing audiences.

Dean Winkler

Dean Winkler is currently vice president, director of creative services at Post Perfect, Inc., a major electronic special effects facility located in New York City. Winkler is also a computer/video artist, and has created over 5 1/2 hours of video art that have been shown internationally. Winkler's interests span art and engineering.

Mr. Winkler received a bachelor of science and master's degrees from Rensselaer Polytechnic Institute. He is a holder of a U.S. patent, has been recipient of numerous awards in the TV industry, and lectures frequently in the United States and abroad.

Dr. David Zeltzer

Dr. David Zeltzer is associate professor of computer graphics in the Media Arts and Sciences Section at M.I.T. Since September 1984, Dr. Zeltzer has been the director of the Computer Graphics and Animation Group at the M.I.T. Media Laboratory. The efforts of this group are aimed at developing a graphical simulation environment that integrates robotics, artificial intelligence and computer graphics technologies to provide a powerful visualization tool for learning, simulation and design. In addition to work in computer animation, his research interests include biological and artificial motor control systems, robotics, and human interface design.

Dr. Zeltzer joined the faculty at M.I.T. in 1984 after receiving his M.S. and Ph.D degrees in Computer and Information Science from Ohio State University in 1979 and 1984, respectively. He was awarded the B.S. in mathematics *magna cum laude* from Southern Oregon State College in June 1978. While at Ohio State, Prof. Zeltzer was a research assistant at the Computer Graphics Research Group. His work there centered on modeling the kinematics of the human figure, and investigating goal-directed animation of human movement.

He has produced animated sequences portraying a human skeleton walking over level and uneven terrain that have been shown at numerous computer graphics conferences and widely published. He is a frequent speaker at computer graphics symposia and workshops.

Michael J. Zyda

Michael J. Zyda is an associate professor of computer science at the Naval Postgraduate School, Monterey, California., where he has been since 1984. Prof. Zyda was the chair of the 1990 Symposium on Interactive 3D Graphics, held at Snowbird, Utah.

His active research centers around the production of inexpensive, real-time 3D visual simulation systems and graphics workstation performance measurements. In addition to academic duties, Prof. Zyda has served as a consultant with over fifteen different companies throughout Japan.

Prof. Zyda received a B.A. in bioengineering from the University of California at San Diego in La Jolla in 1976, where he was part of an undergraduate research group, the Senses Bureau. He went on to receive an M.S. in computer science/neurocybernetics from the University of Massachusetts at Amherst in 1978 and a D.Sc. in computer science from Washington University in St. Louis, Missouri in 1984.

IMAGE CREDITS
(in order of appearance in the program)

HDTV

Infinite Escher
Escher Works Provided by Masahara Kohga
The Boy: Sean Ono Lennon
Directed by John Sanborn, Mary Perillo, Dean Winkler
Music composed by Riuichi Sakamoto
Art Consultant Nam June Paik
Project Originated by Hiroe Ishii
Screenplay by Michael Kaplan, John Levenstein
Based on a story by John Sanborn
HD production at REBO Studio
Post Production facility: REBO Studio

1990 Gorbachev visit to Germany
BTS Broadcast Television Systems GmbH

President George Bush at NAB'90
Turner Engineering Systems

Critical Viewing: NASA Shuttle Launch
Bellcore

Microsurgery
Hi-Vision Promotion Center, Japan

MAST Fashion Teleconference
Sony Corporation
Scientific Atlanta

The Little Death
Symbolics, Inc.
Director,Writer, Character Developer, Animator, Background Painting::
Matt Elson
Producer, Writer and Butterfly Animator, Render Form Manager
Marc Scarparro
Technical Director, Music Director, Project Research and Development
Larry Stead
Music and Sound FX Composed and Performed on the Synthesizer by:
Haze Greenfield

DBS Satellite
FR3-TV
Paris, France

Mechanical Scanning Disk
1927
David Sarnoff Research Center

Felix used as model before RCA/NBC experimental TV camera
1927
David Sarnoff Research Center

Felix on TV
1927
David Sarnoff Research Center

Dr. Zworkin holding display tube
1929
David Sarnoff Research Center

Dr. Zworkin holding vacuum tube
1929
David Sarnoff Research Center

1936 Olympics TV broadcast
BTS Broadcast Television Systems GmbH

1930s BTS TV
BTS Broadcast Television Systems GmbH

Early Television Set
1939
David Sarnoff Research Center

Ampex Quad Machine
1956
Ampex Corp.

Demo Reel 1990
Post Perfect

Thomson Electronics Commercial
Ex Machina

Field Being Plowed
Ford New Holland

How TV Works
Sandin, Morton, and DeFanti
1972 - EVL
University of Illinois/Chicago

Powerline
Judson Rosebush
Digital Effects

Horsetrack NTSC vs. HD
FR3-TV
Paris, France

Road Atlanta 1988 & 1989
Carbonara & Korpi
Department of Communications Studies
Baylor University

First HDTV Monitor
1975
Dr. Takashi Fujio

First HDTV Camera
1980
Dr. Takashi Fujio

First 70MM Telecine
1980
Dr. Takashi Fujio

First 1" Analog VTR
1980
Dr. Takashi Fujio

First 35mm Laser Film Recorder
1980
Dr. Takashi Fujio

T. Fujio, F. Coppola, J. Flaherty
1981
Dr. Takashi Fujio

Projector
Judson Rosebush

Interlace Scan vs. Progressive Scan
FR3
Paris, France

D2-MAC Control Room
FR3
Paris, France

Remote 1250/50 HDTV Studio Truck
BTS

The Gallery
Experimental Test of Miniature Sets
REBO Studio

The Abyss
©1989 Lucasfilm Ltd.
©1989 20th Century Fox
courtesy of Industrial Light and Magic

Film/Digital Process Diagram
Eastman Kodak Co.

Water Drop
Judson Rosebush
Digital Effects

DBS Satellite
FR3
Paris France

New York Town
NHK Enterprises
REBO Studio

Bumble Bee
Ex Machina

HDCG
Yoichiro Kawaguchi

HDTV Mandala
Dr. Kotaro Wakui
New Electronics Media Division
Dentsu Inc.

Microsurgery
Hi-Vision Promotion Center, Japan

Input Scanner
Hi-Vision Promotion Center, Japan

B&W Playback of X-Rays
Hi-Vision Promotion Center, Japan

Tissue Pathology Microscope
Hi-Vision Promotion Center, Japan

Alfa Romeo Animation
Ex Machina

This is Hi-Vision
NHK

Bridge Simulation
Hi Vision Promotion Center, Japan

Early Long Distance TV Demonstration
1927
AT&T Bell Laboratories

General David Sarnoff announces B&W TV at NY World's Fair
1939
David Sarnoff Research Center

The Cerritos Project
GTE

PIPES Demo
National Bureau of Standards (N.I.S.T.)

DCT Mandala
David Sarnoff Research Center

Teleconference Room with Video Wall
(artist's rendering)
AT&T Bell Laboratories

D-2 Diner
Presented by Abekas Video System and Sony Broadcast Products
Produced by: Post Effects
Produced by: Mike Fayette
Directed by: Don Hoeg and Mike Fayette
Production Designed by: Don Hoeg
Motion Control Camera & Lighting by: Patrick Byrne
Edited by: Arturo Cubacub
Joe Langefeld

Mapping
DuPont

Flybys
GE Aerospace

Failure Analysis
Failure Analysis

CAD *Visualization*
Evans & Sutherland

Scientific Visualization
Intelligent Light

Vortex-3 Animation
The Visual Engineering Laboratory
Artist-in-Residence in Engineering Program
Penn State University in cooperation with
Design Mirage, Inc., State College, PA.
On screen graphics by Dave Haughwaut

IMAGE CREDITS
(in order of appearance in the program)

VIRTUAL REALITY

Eye
SunVision Demo
Sun Microsystems

A Volume of Two Dimensional Julia Sets
Computer Animation: Dan Sandin
Original Music Laurie Spiegel
Algorithms and Ray Tracer: John Hart
Mathematical Research: Lou Kauffman
Visual Leadership: Tom Defanti
© copyright 1990

DataGlove Demo
VPL Research

Flight Simulation
ESIG-4000
Evans & Sutherland

Vortex-4 Animation
The Visual Engineering Laboratory
Artist-in-Residence in Engineering Program
Penn State University in cooperation with
Design Mirage, Inc., State College, PA.
On screen graphics by Dave Haughwaut

View: The Virtual Workstation
NASA Ames Research Laboratory

Command Flight Path Display
5 images
George W. Hoover
(The CFPD has been carefully covered by copyrights, and patents being processed)

Flight Simulation
General Electric Aerospace

Cockpit
George W. Hoover

Command Flight Path Display Images
George W. Hoover

Command Flight Path Display Images
George W. Hoover

Modern Instrument Panels in Jet Fighter
George W. Hoover

LINK Trainers
George W. Hoover

Improved LINK Trainer
George W. Hoover

Earliest Instrument Panels & Flight Controls
George W. Hoover

Modern Instrument Panels in Jet Fighter
George W. Hoover

Command Flight Path Display Images
George W. Hoover

Flight Simulation
ESIG-4000
Evans & Sutherland

Watch Animation
Alias

PowerVision Images
Silicon Graphics

DN10000 Images
HP/Apollo

Progressive Radiosity Refinement
Hewlett Packard

Cathedral
Hewlett Packard

Steel Mill
Hewlett Packard

ESV Images
Evans & Sutherland

Old Glory
Stardent Computer

Targa Animations
Xaos/Truvison
Intelligent Light

Vista Animation
Truvision

Sierpinski Blows His Gasket
Fractal Modeling and Rendering: John Hart
Physical Based Modeling: Sumit Das
Systems Guru: Irving Moy
Visual Advice: Daniel J. Sandin
© copyright 1990 John C. Hart Sumit Das

Lively IFS
Animation by: Gordon Lescinsky Alias
Sound by Chris: V. Baerson
Special Thanks to: Dan Sandin, Irving Moy & Becky Ruether

Post Perfect Demo Reel
1990 Post Perfect

Animaq Animation
Diaquest Inc.

Labor & Delivery
College of Nursing & Health
University of Cincinnati

GTV
A Geographic Perspective on American History
Lucasfilm Learning
National Geographic

Martin Luther King
ABC News Interactive

Palenque
DVI Intel

The Conquest of Form
William Latham
IBM UK Scientific Centre

Thermal Dye Transfer
Dupont

XL7700 Animation
Eastman Kodak Co.

CG Animation
FhG
Technical University of Darmstadt

The Politics of Pleasure: Papilloma Virus
Computer Animation By:
Stephan Meyers: EVL $(Art)^n$
Donna Cox: NCSA $(Art)^n$
Ellen Sandor: $(Art)^n$, EVL
Music: "A Slip of the Tongue" The Art of Noise
Produced at the Electronic Visualization Laboratory
at the University of Illinois at Chicago
Thomas A. DeFanti and Daniel J. Sandin Co-Directors
Maxine Brown, Assistant Director
In Conjunction with:
$(Art)^n$
Ellen Sandor, Director
& The National Center for Supercomputing Applications
Larry Smarr, Director
© Donna Cox, Stephan Meyers & Ellen Sandor 1990

Lively IFS
Animation by: Gordon Lescinsky Alias
Sound by Chris: V. Baerson
Special Thanks to: Dan Sandin, Irving Moy & Becky Ruether

Cars & Planes Montage
PowerVision: Silicon Graphics
VRX: Hewlett Packard
Alias

Hi-Vision Image
Hi-Vision Promotion Center

Data Transmission
Bellcore

Data Tansmission
FhG
Technical University of Darmstadt

C-Cube Compression Demonstation
C-Cube Microsystems

Prototype Mouse
Douglas Englebart

Keyboard Joystick
Ted Selker
IBM

Data Glove
AT&T Bell Laboratories

Data Glove
SimGraphics Engineering Corporation

Data Glove
Loma Linda Medical Center

Tod Machover in Concert
Fuji-TV

Spline Pulling
David Weimer
AT&T Bell Labs

Thingworld & Fitting
Alexander Pentland

3D Color Digitizer
Cyberware Laboratoy Inc.

Body Builder
SimGraphics

ESV
Evans & Sutherland

Space Station Freedom
Intelligent Light

ESV Images
Evans & Sutherland

DataSuit
VPL Laboratories

Virtual Piano and Ball
FhG
Technical University of Darmstadt

Videoplace Interactions
Myron Krueger
Artificial Reality

Zydaville
Michael Zyda
Naval Postgraduate School

Apple Computer, Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010

Product: Color QuickDraw 32 Bits

Features:

- Operates on 68020 or 68030 based Macintosh personal computers
- Has been extended from 8 bit/pixel to 16 or 32 bit/pixel mode, allowing thousand: millions of colors to be displayed
- 32 bit QuickDraw allows manipulation of 24 bit images with many color paint packages. 24 bits are used for color 12 bits are used for attributes like transparenc
- Major enhancements include approximation of color of 16 or 24 bits at lower re: via dithering, compression in file format, more gray levels in gray scale model
- Recommended memory is 2 MB of RAM. To see the full range of colors possible party manufacturers 16-,24-,32 bit video card is required. It is possible to manipul high quality color images without a video card.

Array Technologies
7730 Pardee Lane
Oakland CA 94621
415-633-3000

Product: AS-1

Optical Resolution:	1700 line pairs maximum
Image Resolution:	Software selectable 4,096,2,048,1,024,512
Aspect Ratio:	Specified by operator
Addressable Resolution:	8,000 maximum
Lens:	Micro-Nikkor 55mm standard Other lenses optional
Precise Geometric Repeatability:	Better than +-1/10 pixel
Smearing:	Guaranteed less than -100dB
Dynamic Range:	Up to 12 bits/4,096 intensity levels R,G,B or grayscale
Image Accumulation:	Up to 32 scans can be accumulated and averaged for increased dynamic range.
Image Capture Sensor:	Transverse sense line array of photodiodes - 331,000 active elements.
Digital Signal Processor:	Western Electric DSP 32
Image Processing Functions:	Cropping, color correction, pan and zoom unsharp masking, input and output gamma correction, half tone generation.
Software File Formats:	TIFF 24,48 TGA,.VST Encapsulated Postscript CT2T DDES Other, please inquire
Array Technologies Software:	-Hardware control functions library -Complete library of "C" subroutines to capture, process and output images Complete, easy to use, interface menus
Hardware Interfaces:	Board on AT bus, GPIB (IEEE-488),SCSI. Extended performance interface unit

ASACA/SHIBASOKU Corp. of America
12509 Beatrice St.,
Los Angeles, CA 90066
TEL: (213) 827-7144

Product: ADS-7800 Videodisc Player

<u>High Speed MO Disk Drive Specification</u>

Recording Media:	130mm glass substrate original format removable disk cartridges
Disk Capacity:	1)User Area/Side: 600Mbytes/side 2)User Area/Disk: 1.2Gbytes/disk
Eff.data trans. rate:	12Mbytes/second(0.5 sec. for 1 hdtv still image)
Ave. Access time :	120ms
Ave.Access and display time:	0.62 seconds
Disk Rotation Speed:	3000 rpm
Sector data Length:	40 kbytes
Optical Head config.	two parallel heads each with four beams

<u>HDTV Video Processor Specification</u>

HDTV Format (BTA Standards)	1) Image Size: 1920x1035 pixels 2) Horizontal Lines: 1125 lines 3) Frame Frequency:30 Hz 4) Scan Ratio: 2:1 5) Horizontal Line Frequency: 33.75 kHz 6) Sampling Frequency: 74.25 MHz
Input Signals:	1) Analog HDTV Signals:RGB or Y/Pr/Pb, SYNC or HD, and VD 2) Digital Signal: CCD color image scanner square lattice sampling
Output Signal:	1) Analog HDTV signals: RGB and Y/Pr/Pb, SYNC or HD, and VD 2) Digital Signal: color printer square lattice sampling
Image Memory:	1) Standard: three plane 2048x2048 pixel 8-bit 2) Optional: 2048x4096 or 4096x4096
D/A Display Buffer:	Real time data transfer from image memory
VME Bus:	IEEE P1014/D1.2 (A32/D32) standards
CPU:	1) Hardware: MPU M68020(20MHz), FPCP 68881 (Optional) 2) Software: supports OS/9 (68020 CPU)
Expansion Board Slots:	Two slots for VME Bus external computer interface board and/or user applications

Autodesk, Inc.
2320 Marinship Way
Sausalito, CA 94965
(415) 332-2344

Product: Cyberspace

Features:

Hardware:

Head Mounted display:

Contains two color LCD displays that project a stereoscopic image to each eye. Special op provide a wide field of view and a comfortable viewing distance. The image occupies an area vision larger than that of regular glass, surrounding the user's view with computer gener graphics. Head mount also contains a head tracking device which correlates head moveme with displayed scene. The combination of head movement and wide field of view creates a compelling illusion of being in virtual environment.

Dataglove:

Tracks movement and position of the fingers. This permits natural grasping and gesturi within the virtual environment.

3D Joystick:

Either a joystick or a steering wheel to permit flying in the virtual space.

Software:

Will include techniques for incorporating and changing physical models of gravity, fricti movement and collision,tools for hierarchical composition of objects and scenes and techn to support multiple interacting users.

Avid Technology, Inc.
3 Burlington Woods
Burlington, MA 01803
(617) 221-6789

Product: Avid/1 Media Composer

Advanced Technology:

- Fast 32-bit 68030 CPU
- Up to 4.2 GB disk capacity
  Digital Image Compression
  Real time 30 FPS capture
  Real time 30 FPS playback
  Stereo, CD-quality sound
  32-bit videographics coprocessor
  24 bit DSP audio coprocessor

Editing Features:

- Familiar source/record monitors
- Film-style splicing
- Video-style insert editing
- Assemble editing
- Sync-point editing
- Sophisticated transition editing
- 1000+ events
- Frame-accurate
  Intermix-drop/non-drop time code

Digitizing Features:

- Real time, direct to disk
- Capture video and stereo audio
- Variable frame rate,I-30 FPS
- Compensation for 3-2 pulldown

Timeline Display:

- Timebar mode
- Head frame mode
- Head/Tail mode
- Frame mode
- Edit by rearranging elements
  Vertical/horizontal sizing
- Adjust picture size

Bins:

- View by head frame
- View by keyframe
- View by name
- Multi-column sorting
  Selection using multiple criteria
- Rearrange columns
- User defined properties

Audio Defined Features:
- Audio scan with no pitch change
  Multi channel mixing
- Equalization

Output Features:
- CMX-compatible EDL output
- Optional 5 1/4" floppy drive
- Outputs film cutlist
- Accurate video EDL from film
- Real-time workprint output
- Frame-accurate CD sound

Deck Controller Features:
- Control of serial or parallel decks
- Auto-assembly of finished programs
- A-and B-mode assembly

BARCO Inc.
1000 Cobb Place Blvd.,
Bldg. 100
Kennesaw, GA 30144
TEL: (404) 590-7900

Product: HD-Monitors

Sizes Available::	20", 26", 30", 40" (diagonal) CRT
Type:	Dot screen delta gun Black matrix
Pitch:	0.34mm
Aspect Ratio:	5/3
Deflection Angle:	90
Custom Design	
Scanning Systems:	Any scanning system resulting in a horizontal scan frequency of up to 33.750 kHz
Scanning Linearity:	+-1% of the picture height
Synchronization:	Line Blanking: typical 5 usec. Vertical Blanking: 700 usec. AFC time constant: fast 0.67 msec. slow 2.50 msec.
RGB Performance:	Frequency Response: 15 KHz to 30 MHz +-0.5 dB Black level stability: 1% Clamping: back porch clamping is standard: Sync pulse tip clamping selectable by jumper on the sync board.

BTS
(Broadcast Television Systems, Inc)
P.O. Box 30816
Salt Lake City, UT 84130-0816
TEL: (801) 972-8000

Model: KCH 1000 Camera Channel

Dimensions: (mm)
Camera Head(excluding lens): Height 440, Width 310, Length 565
Camera Control Unit: Height 195, Width 518, Length 500
Weights: (approx.)
Camera Head (excluding lens): 33kg
Camera Control Unit: 30 kg
Video:

Scanning standard alternatives:	1250 lines, 50 fields, 2:1
	1125 lines, 60 fields, 2:1
	1050 lines, 59.94 fields, 2:1
	626 lines, 50 frames, 1:1
	525 lines, 59.94 frames, 1:1

Aspect Ratio 16:9
Other standards on request
Sensitivity
Plumbicon 30 mm tubes
800 Lux, 74 ft.cd.,F4.0 gain 0 dB
70 Lux, 65 ft.cd.,F2.0 gain +9 dB
Santicon 25 mm tubes
1000 Lux, 93ft.cd.,F2.8 gain 0 dB
100 Lux, 9.3 ft.cd.,F1.5 gain +9 dB
16:9,89.9% reflectance, 3200 K, in the green channel
Resolution
50% at 600 TV lines, 16:9
1200 TV lines limiting resolution
(CTF in picture center, aperture and contour off, RCA P200 test pattern, measured in the green channel)
Registration
0.02% (Zone 1)
Video Output Signals
1 x RGB video, 0.7 Vp-p, 75 Ohm
1 x RGB + Sync, 1 Vp-p, 75 Ohm
1 x YCrCb video (Y+Sync)
0.7/1Vp-p, 75 Ohm
1 x Y video + Sync, 1 Vp-p, 75 Ohm

Input-Signals(loop through)
1 x Sync reference (tri-level)
1 x Return video
1 x Teleprompter

Canon U.S.A., Inc.
1 Canon Plaza
Lake Success, NY 11042-1113
TEL: (516) 488-6700

Product: P14 X 16.5B HD (F1.4)

Specifications:

Application:	For HD 1 1/4 tube cameras
Zoom Ratio:	14x
Image Format:	18.65 x 10.49 mm dia 21.4 mm
Range of focal length:	16.5mm- 231mm
Maximum Relative Aperture:	1:1.4 at 16.5 -180 mm 1:1.8 at 231 mm
Angular Field of View:	58.9 x 35.3 degrees at 16.5 mm 4.62 x 2.6 degree at 231 mm
Minimum Object Distance:	0.75 m
Object dimension at MOD:	110.8x62.3cm at 16.5mm 4.62 x 2.6cm at 231 mm
Size:	340(W) x 397(H) x 659.5(L) mm
Weight:	41 kg

CIS Graphics Inc.
285 Littleton Rd., P.O. Box 695
Westford, MA 01886
(508) 692-9599

Product: Geometry Ball Series 3-D

Key Features:

-family compatibility
-variety of operational modes
-programmable function keys
-pick button control
-emulation mode operations
-selection of software protocols
-variable baud rates
-extensive user interface library

Technical Specifications

Sensor: -optically working force/torque sensor

Corabi International Telemetrics, Inc.
890 South Pickett St.
Alexandria, VA 22304
TEL: (703) 823-4753

Product: DX1000

Features:

- System in its simplest form has a receiving workstation, a workstation and a communication link.
-Transmitting work station consists of high resolution video camera attached to a motorized light microscope.
- Image from camera is broadcasted via broadband satellite, microwave or cable depending upon the distance between primary and consulting physicians.
- Consulting physicians sits at the receiving workstation where he can manipulate the microscope by using a proprietary robotic keypad which is linked to the microscope stage through the computers included in the workstations. Both physicians may talk over the phone line installed in the workstation.
- Corabi systems Micromapper tracks examination of slide accurately and allows a replication of data at a late time.
- Corabi systems Robotic Optical Network operating system software includes an auto scanning feature to ensure a complete review of every tissue specimen on the glass slide.
- A high speed thermal color printer at primary site provides archiving capacity. Ultimately there will be provision for optical disk storage system.

Diaquest Inc.
1440 San Pablo Ave.
Berkeley, CA 94702
(415) 526-7073

Product: DQ-Animaq Macintosh Animation Controller

Key Features:

Frame accurate animation
Frame accurate digitizing
Multiple software interfaces
Rotoscoping & special effects
Serial & Parallel VTR Control
On Board sync generator
SMPTE/EBU Timecode generator
Desktop and Broadcast Models

Digital Equipment Corp.
146 Main St.
Maynard, MA 01754
(508) 493-5111

Product: DECstation 5000/200

Specifications:

General

CPU	R3000/R3010 (FPU)
Clockspeed	25 MHz
MIPS	24 MIPS (Dhrystone V 1.1)
FPU	3.7 MFLOPS Linpack,double precision
TURBOchannel	23 Mbytes/sec burst rate
SCSI bus	6 Mbytes/sec transfer rate
Ethernet	10 Mbit/sec
Data Types	VAX-compatible integer format

Graphics Performance

	CX	PX	PXG	PXG Turbo
2D Vectors/sec	130,000	300,000	300,000	400,000
2D area fill, Mpixel/sec	22	55	55	110
3D Vectors/sec	10,000	70,000	300,000	400,000
3D polygons/sec	10,000	20,000	65,000	100,000
Resolution	1024x864	1280x1024	1280x1024	1280x1024
Color Planes	8	8	8/24	24
Z buffer			(Optional) 24	24 Planes

Du Pont Company, Imaging Systems Dept.
600 Eagle Run Rd.
Newark, DE 19702
(302) 733-9670

Product: MacBlitz

Features:

- Unix V.3.0 with some Berkeley Extension
- Application portability
- Communication services include TCP/IP, and EtherTalk
- Multi-User
- Multi-tasking
- Concurrent processing for simultaneous running of both Macintosh and UNIX applications.
- Dedicated application server with no operating system
- Instant portability of X Window application
- R System Library to simplify interfaces to TCP/IP or Macintosh TCP
- Direct interface to TCP/IP
- Psuedo device interface
- Supports C, Pascal, FORTRAN-77 and Ada
- Uses Du Pont FileShare, an AppleTalk Protocol for Unix, to allow MacBlitz to be an AppleShare file server.

Du Pont Company, Imaging Systems Dept.
600 Eagle Run Rd.
Newark, DE 19702
(302) 733-9670

Product: 4CAST Digital Color Imager

Specifications:

Dimensions:	34(W) x 31(D) x47(H)"
Hardware Components:	Proofer Cabinet housing 180 mb disc drive and PC with built in B&W monitor and keyboard.
Recording Method:	Dye Sublimation thermal transfer.
Recording resolution:	300 dpi
Color output:	Y,M,C,K dyes (S.W.O.P. or Eurostandard).
Gradation Level:	256 Levels per pixel
Proofing Material:	4CAST dye ribbon 4CAST receiver paper
Output Size:	11.9" x 12.4" 11.9" x 17.3"

Interface Capabilities:

For Color Prepress Systems:	Scitex Handshake and Visionary Hell Chromalink, crosfield lightspeed, 9 track tape.
Personal Computers:	TGA, TIFF, PICT, Ethernet,SCSI
Macintosh II, IIx, IIcx:	POSTSCRIPT, TIFF
Unix Workstations:	TIFF, Pict, TGA, Sun Raster,Bitmapped

EIDOPHOR Ltd.
Althardstraße 70
CH-8105 Regensdorf/
Zurich, Switzerland
TEL: (01) 842-1111

Product: Eidophor 5177

Weights::	Projector: 540 kg Electronics: 140 kg Rectifier: 270 kg
Luminous flux (central lumens with fully modulated white field)	3300 lumens minimum at 1125/60 2200 lumens mimimum at 1250/50
Resolution	850 lines horizontal by 620 vertical (RGB Input)
Aspect Ratio (width/height)	16:9
Vertical Projection Angle	+10 to -20
Contrast Range (dark field/white field)	Better than 1:100
Geometric distortion	Better than 0.5% of picture height in a circle of a diameter of 0.8 picture height Better than 1% of picture height in rest of picture
Scanning Rates	Vertical 45-75 Hz Horizontal 15-34 kHz
Signal inputs	2 video channels RGB, 1 test channel (monochrome), composite or noncomposite 0.5-1.4V p-p(white positive) Composite sync (negative) or horizontal and vertical drive 0.5-4V p-p
Video Amplifier	Bandwidth 50 MHz (3db), overall gamma 2.2
Projection optics	Anamorphic projection lenses 320/240 mm, min. throw distance 9.5 m
Power Requirements	Projector: 200-240V, +/-7,5%, 50/60 Hz, 3kVA, single phase Rectifier: 220/380V, +/- -10%, 50/60 Hz, 9.9kVA, triple phase

Electro Plasma, Inc.
4400 Martin-Moline Rd.
Millbury, OH 43447
TEL: (419) 255-5197

Product: 512/1024

Size:

Active Display Area:	8.52" x 17.05"
Screen Size:	11.65" x 20.25" x 1.8" (w/ Bezel)
Resolution:	512 x 1024
Dot Pitch:	60 dpi
Weight:	26#
Characters:	51 Lines/160 Char (8000 5x7 characters.)

Optional Interface:

Infrared Touch: Combined with Infrared Touch Frame it provides user programmability touch sensitivity "softkeys" and expanded capability of touch screen.

RS3 Video Interface: Allows user to drive plasma display at video rates with TTL monochrome input (interlace or noninterlace). Also contains touch detection circuitr applications requiring video update rates and touch capability.

Evans & Sutherland
580 Arapeen Dr.
Salt Lake City, UT 84108
(801) 582-5847

Product: ESV series of RISC/Unix workstation

Features:
- CPU based on MIPS R3000 RISC microprocessor running at 25 MHz
- CPU performance :20 MIPS
- Processor :RISC
- Unix environment (System V5 with BSD extensions)
- PSX (PS 300 application emulator)
- VME bus support for third party hardware
- C, Fortran, Pascal
- Floating points performance 4 MFLOPS (at double precision)
  8 MFLOPS (at single precision)
- Memory (min/max): 8/128 MB
- Hard Disk (min/max): 141 MB/ 2.4 GB
- Display size: 19 inches
- Resolution: 1280 x 1024
- Colors: 16.7 M
- Color Bit planes: 48
- Z-Buffer:24
- Range of graphics performance:(9 system configuration available)
  3D Vectors per second: from 277K to 1000K
  Polygons per second: from 19K to 100K
- Stereo viewing option
- Desk side cabinet with 14 circuit card bay

Evans & Sutherland
580 Arapeen Dr.
Salt Lake City, UT 84108
(801) 582-5847

Product: ESIG-4000

Specification:

Update/Refresh rate:	60 Hz or 50 Hz standard
Resolution:	250K to over 1.5M pixel per channel
Displayed Surfaces at 60 Hz	
Per channel:	1500 to 10000 available
System:	up to 24000 per Environment processor
Display Format:	Raster 2:1 vertical interlace standard
Display Devices:	Software programmable to a variety of display devices
Colors:	4096 entry color table
Feature Texture:	up to 384 high resolution maps (128x128) Programmable map resolution from 16x16 to 512x512
Global Texture:	For Texturing terrain topology separate from feature texture Full color texture, for complete RGB freedom Up to 20 MIPS level, for texel size down to fractions of a meter
General Purpose Computer:	Internal VME 68K based

Evans & Sutherland
580 Arapeen Dr.
Salt Lake City, UT 84108
(801) 582-5847

Product: PS 390

Features:

General

- Anti-aliased dynamic wireframe and static shaded images on single color raster display.
- Graphics commands interpreted locally by Graphics Control Processor
- 127 selectable hardware generated line texture

Control Unit

Graphics Control Processor
- Dedicated MC68000 (10 MHz)
- Local handling of interactive devices
- Host communications
- Stand alone diagnostic capability

Mass Memory

Provides storage for graphical commands to perform a wide variety of graphics performance
- Expandable to 4 megabytes of dual ported memory

Display Processor
- Proprietary bit-slice microprocessor

High speed processing of data primitives and matrix transformation
- 32 bit precision floating point transformation
- Transformations expressed as 4 x 4 matrices
- Viewporting capabilities

Shadowfax Technology
- Produces calligraphic quality lines on raster display
- High speed custom VLSI circuitry
- Performs depth cueing as standard feature

Display Characteristics

Color Raster Display
- 19" diagonal display (11"x15" usable area)
- 1024 x 864 60Hz non interlaced
- RGB raster monitor

24 bit planes double buffered (8 each for R,G and B)
- 16.7 million colors
- 8192 x 6912 addressability

Finlux Inc.
20395 Pacifica Dr., Ste. 109
Cupertino, CA 95014
(408) 725-1972

Product: MD 640.400

Screen Size: 4.8"(H) x 7.68"(W)

Physical Dimension: 6.24"x9"x0.72"(D) IS 1.38"WITH MOUNTED POWER UNIT
Weight: 17.1 OZ

Resolution (Pixel): H.(MIL)8.5xW.(MIL)8.5
Dot Pitch: H.(MIL)xW.(MIL)12

Hewlett-Packard Co.
3000 Hanover St.
Palo Alto, CA 94304
(415) 857-1501

Product: HP 9000 375 SRX Turbo Workstation

Features:

Spe ifications

Central Processor	32 bit 50 MHz MC68030
Floating Point	50 MHz MC68882 standard
Memory	8 Mbytes to 32 Mbytes ECC RAM
Standard I/O	HO-HIL, RS-232C, HP-IB, SCSI, AUDIO
Optional	Parallel, High Speed HP-IB
Graphics Subsystem	High Performance 3D (1280 x 1024) 16"/19"

Mass Storage Options

External Magneto Digital Audio Tape Drive capacity 1.3 Gbytes per medium, HP-IB winchester hard disks from 80 to 660 Mbytes formatted capacity per mechanism

Performance

Transformations/sec	900,000
Polyline/sec	238,000
Polygons/sec(Triangles)	41,000
Polygons/sec(Quad.)	13,500

Hitachi America, Ltd., Electron Tube Division
300 North Martingale Rd., Ste. 600
Schaumburg, IL 60173
(708) 517-1144

Product: LMG9020ZZFC

Specifications:

Size:	Display Area	231(W) x (175(H)
	Overall DImensions	300 x 234 x 17
	Weight	1800 gms
Resolution:		1024 x 768
		Dot Pitch 0.22 x 0.22
Colors:		Black and White film
Features:		+5V Single Power Supply type
		New Gray type
		Non Glare type
		with backlight (CFL)

Hitachi America, Ltd., Electron Tube Division
300 North Martingale Rd., Ste. 600
Schaumburg, IL 60173
(708) 517-1144

Product: TM16D01HC

Screen Size: 6.3" DISPLAY

Physic l Dimension: 166mm long x187mm Wide x 5mm thick
interface thickness 21.3mm excluding the backlight unit

Weigh 390 GMS

Resolu ion (Pixel): 640x(200x3)

Hitachi America, Ltd.
Electron Tube Division
300 North Martingale Rd., Ste. 600
Schaumburg, IL 60173
(708) 517-1144

Product: C110-5000R 110" HD Rear Projection Display

Features:

Aspect ratio:	16:9
Screen:	110" Rear projection

Specification:

Dimensions:	2800 x 2500 x 2700 mm
Resolution:	
Horizontal:	1000 TV Lines
Vertical:	750 TV Lines
Scanning Frequency:	
Horizontal:	24-35 KHz
Vertical:	40-120 Hz
Brightness:	140 cd/square meter
Contrast ratio:	140:1 or more

Hitachi America, Ltd., Electron Tube Division
300 North Martingale Rd., Ste. 600
Schaumburg, IL 60173
(708) 517-1144

Product: TM26 D01 VC 10.4" Display

Size: Effective display area:	211.2(W) x 158.4(H)
Extern l Dimensions:	285(W) x 217(H) x 5(D)
	(size excluding backlight)
Resolu ·on:	(640 x 3) x 480
	Dot arrangement is vertical
Color:	8
Featur s:	High Contrast Ratios 100:1
	Fast response time tr=40ms,tf=60ms
	Wide viewing angles I 60 (TYP)
	Low power consumption 1W
	Easy Interfacing

Honeywell Inc., Test Instruments Division Hdqtrs.
P.O. Box 5227
Denver, CO 80217

Product: Honeywell Colorado Color Imaging Recorder

Specifications:

Colors Produced:	32,768
Resolution:	300 dpi
Speed:	
* Page Recorder:	30 sec (1st A-size color print) 15 sec (for each successive print)
* Medical Recorder:	25 and 50 mm/sec (color strip charts) 25,50,75 and 100mm/sec. (monochrome strip charts) 30 sec (6x8 inch color prints)
Cost per print:	
* Page recorder:	$1.5 (A-sizecolor print)
* Medical recorder:	$1.12 per foot (color strip chart) $0.75 (6x8 inch color prints)
Imaging Medium:	3M dry silver color paper and transparencies.
Interfaces:	Hi resolution video, SCSI & Centronics
Exposure	Single pass
Unit Dimension:	17.5 inch wide 8.75 inch tall 23 inch deep
Unit Weight	60 pounds
Price:	Less than $10,500 (with substantial OEM discounts available)

Availability: July 1990

Honeywell Inc., Test Instruments Division Hdqtrs.
P.O. Box 5227
Denver, CO 80217

Product: RSS-600 Rotary Storage System

Specifi ations:

Function

Capacity	Greater than 3 Terabytes
Drives	Upto 5 VLDS drives
Access time	8 seconds to a cassette
Load/Unload Time	16 seconds (worst case)
Data Transfer Rate	4 Megabytes/sec/drive
Interface	
Robotics	RS 232C
VLDS	SCSI
RSS-600	Ethernet

Environmental

Temperature	5-40 degree centigrade operating
Humidity	80% noncondensing

Physical

Size	71 x 40 x 78 inches
Weight loaded	2000 lbs
Power line	115 Vac 2 kVA

Media

High quality T-120 videocassettes

HP/Apollo Computer Inc.
330 Billerica Rd.
Chelmsford, MA 01824
(508) 256-6600

Product: DN10000 Personal SuperComputer

Features:
- Multi-Processor Available
- Parallel Instruction Execution
- 64-bit Architecture
- Data flow compiler
- Custom floating point
- Dual cache
- Interleaved memory (16 - way)
- High Speed Bus (160 Mb/sec)
- Disk Striping
- Scan Path Technology

Specifications:

CPU's:	1 to 4
CPU Clock rate:	20 MHz
Integer Processor:	Semi- Custom
Floating Point Processor:	Custom
System Bus:	64 bit
Bus Bandwidth:	160 Mb/sec
Memory:	8-128 Mbytes
Cache:	192Kb/CPU
Buses:	VME HI-Perf. X-Bus PC/AT Bus

Performance:

Number of CPU:	1
Throughput, relative to VAX 11/780:	15-30 X
Dhrystones:	27000
Whetstones, Single Prec:	18500K
Whetstones Double Prec:	17000k
MFLOPS (single):	10.2 Mflops
MFLOPS (double):	6.0 Mflops

Hughes Display Products Corp.
550 Mt. Pleasant Ave.
Dover, NJ 07801
(201) 328-1400

Product: MH1463 Cathode Ray Tube

Opera ing Conditions:	
Anode	8.5kV
Focus	1.1 to 1.35kV
Grid 2	400 to 700 V
Grid 1	-60Vdc
Cathode	0 V
Filament	
Voltage	6.3Vdc
Current	95mA
Displa Parameters:	
Line Width(raster mode)	50% amplitude
Center	1.0 mil @ 600 fL
Edge	1.5 mil
Brightness	
Nominal	600 fL
Maximum	1500 fL
Modulation	<20 V @ 600 fL
Raster size	
Horizontal	.4 in (10.16 mm)
Vertical	.4 in (10.16 mm)
Line WIdth(stroke mode)	50% amplitude
Center,4000in/sec 60Hz	1.2 mil
Edge	1.5 mil
Line Brightness	2500 fL
Optic l Characteristics:	
Viewing area	.445 in (11.3mm)
Faceplate	
Type	Fiber Optic
Configuration	Plano/concave
Size	.555 in (14 mm)
Phosphor Type (other types available)	P43
Mech ical Characteristics:	
Screen Size,including shield	.670 in (17 mm) or 744 in (18.9 mm)
Overall length	2.75 in (69.9 mm)
Flying lead length	8 in (203 mm)
Weight, excluding leads	1.6 0z (45 g) or 1.7 oz (48 g)

IBM Corp.
1133 Westchester Ave.
White Plains, NY 10601
(914) 642-3000

Product: IBM model 730 POWERstation of RISC 6000

Specifications:	
Packaging:	Deskside
Processor:	
Type:	IBM POWER Architecture
Clock:	25 MHz
Performance	34.5 MIPS, 10.9 MFLOPS, 990,000 3D Vectors/sec
System Memory:	16Mbytes/128 Mbytes max6
Expansion Slots:	6
Supported Functions:	Integrated floating point processor Native I/O Board 32 bit Micro Channel Bus 1280x1024 monochrome & color graphics SCSI adapter
Supported Graphics Adapter:	Gray Scale Graphics Adapter Color Graphics Display Adapter High Performance 8 bit 3D Color Graphics Adapter High Performance 24 bit 3D color graphics Processor Supergraphics Processor Subsystem
Communication Support:	Asynchronous EIA-232D, EIA-422A and MIL-spec 188. 4-and 16Mbit per second IBM Token Ring Ethernet (thick & thin) X.25 Interface Co-processor/2 3270 Connection Adapter Optical channel adapter
Diskette Drives:	3.5 inch 5.25 inch
Fixed disk storage:	355 Mbytes/2.5 Gbytes max.

IBM Corp.
1133 Westchester Ave.
White Plains, NY 10601
(914) 642-3000

Product: IBM model 320 POWERstation of RISC 6000

Specifications:	
Packaging:	Desktop/side
Processor:	
Type:	IBM POWER Architecture
Clock:	20 MHz
Performance Benchmark:	27.5 MIPS, 7.4 MFLOPS,
System Memory:	8 Mbytes/32 Mbytes max.
Expansion Slots:	4
Supported Functions:	Integrated floating point processor Native I/O Board 32 bit Micro Channel Bus 1280x1024 monochrome & color graphics SCSI adapter
Supported Graphics Adapter:	Gray Scale Graphics Adapter Color Graphics Display Adapter High Performance 8 bit 3D Color Graphics Adapter High Performance 24 bit 3D color graphics Processor
Communication Support:	asynchronous EIA-232D, EIA-422A and MIL-spec 188. 4-and 16Mbit per second IBM Token Ring Ethernet (thick & thin) X.25 Interface Co-processor/2 3270 Connection Adapter
Diskette Drives:	3.5 inch 5.25 inch (Option)
Fixed disk storage:	120 Mbytes/640 Mbytes max.

IBM Corp.
1133 Westchester Ave.
White Plains, NY 10601
(914) 642-3000

Product: X Station 120

Specifications:	
Packaging:	Desktop
Processor:	
Type:	TMS34010
Clock:	50 MHz
System Memory:	512kbytes/8.5 Mbytes max.
Expansion Slots:	1
Supported Functions:	Native I/O Board 1280x1024 monochrome & color graphics
Communication Support:	4-and 16Mbit per second IBM Token Ring Ethernet (thick & thin)

IBM Thomas J. Watson Research Center
P.O. Box 218
Yorktown Heights, NY 10598

Product: 14" LCD Screen

Features

-14 inch LCD display containing 1.5 million color dots
-uses thin film transistor(TFT) technology
-produces 16 bright and clear colors
-screen very readable even in strong ambient light
-readable from acute angles and is good for potential laptop applications
-work being done to increase number of simultaneous color and lower cost

Ikegami Electronics (U.S.A.), Inc.
37 Brook Ave.
Maywood, NJ 07607
TEL: (201) 368-9171

Model:: EC-1125 High Definition Television Camera

Specifications:

Dimensions:	
Camera Head:	164 x 405 x 300 mm
Weight	approx. 15 kg (w/o view finder and lenses)
Control Unit:	260 x 920 x 450 mm
Signal specs:	
Scan Lines:	1125
Interlacing:	2:1
Horizontal Scan frequency:	33.75kHz
Vertical Frequency:	60 Hz
Performance:	
Frequency response:	
	60Hz - 27MHz: +/-0.5dB
	<60Hz - >27MHz: Drooping Characteristic
S/N ratio:	
	Irregular Noise: 47 dB p-p/rms or more
	Synchronous Noise: 60 dB p-p/rms
Resolution:	800 TV lines

Intel Corp.
3065 Bowers Ave.
Santa Clara, CA 95052-8131
(408) 765-8080

Product: Digital Video Interactive Technology

Characteristics:

Storage Medium:	CD-ROM hard disk, other digital devices in future
Media Size:	5 1/4" CD-ROMS, half-height CD-ROM & hard disks
Platforms:	AT now, others under consideration including consumer versions
Motion Video:	72 min. full screen, full motion, approx. VCR quality 256 x 240 res.
Audio:	Up to 40 hours upto 2 output channel
Video Stills:	Up to 40,000 max res of 1024 x 512
Frame Buffer, Graphics overlay:	Yes
Video Manipulation:	High Speed hardware accelerated software driven
Compression required:	Yes
Audio/Video Editing:	Yes

Intel Corp.
3065 Bowers Ave.
Santa Clara, CA 95052-8131
(408) 765-8080

Product: i860 CPU

Features:
- 64 bit external data bus
- 128 bit internal data path
- 64 bit internal instruction path
- 64 bit floating point operations
- up to 2 instructions and 3 operation per clock
- multiple execution units on chip
- scalability
- 1 gigabyte/second at 40 Mhz
- Integer RISC core
- Floating point adder
- 3-D graphics unit
- Eight KB data cache
- Four KB instruction cache
- Memory management unit

Eastman Kodak Co.
343 State St.
Rochester, NY 14650
(716) 724-4000

Product: Kodak XL 7700

General Specifications:

Dimension:

Rack Mounted:	14H x 19W x 22.5" D
Table Top Mounted:	15H x 20W x 24" D
Weight:	Approx. 115 lbs
Computer Interface:	IEEE 488 and SCSI

Printing Specification:

Printing Method:	Thermal Dye Sublimation Transfer
Output Options:	Reflection Prints, transparencies
Output Sizes:	8.5 x 11", 11 x 11" w/.5" border
Resolution:	200 pixels/inch, 8 pixels/mm
Density Range:	.07 - 2.5 (reflection density)
	.05 - 2.7 (transmission density)
Digital Data Size:	
8.5 x 11":	1536 x 2048 pixel array
11 x 11" :	2048 x 2048 pixel array
Print Times:	
Color:	3.5 mins
Black & White:	1.6 mins
Prints/Cartridge:	
Color:	100
Black & White:	300
Prints/Tray :	100

Levco Co.
6181 Cornerstone Ct. East
Suite 101
San Diego, CA 92121
619-457-2001

Product: Levco 860i Card

Specifications:

Hardware:

- 40 MHz Intel i860 RISC processor based Motherboard
- 2, 8, or 32 megs of RAM (standard 8 megs)
- SCSI port on the Motherboard
- 2 serial ports
- 64 bit data path
  80 megaflops single precision floating point
- Throughput of 33 VAX MIPS
- One NuBus slot installation

Performance:

Benchmark

Dhrystone:	Version 2.1- 80.8	
	Version 1.1- 87.1	
Whetstone:	Single Precision-	30.8
	Double Precision-	24.0
Sustained MIPS		33
Peak MIPS		40
Dhrystone MIPS		49.5
MFLOPS Peak	Single-	60
	Double-	80

Application Software:

Levco Renderman: Card will be used as accelerator for image processing.

MacroMind, Inc.
410 Townsend, Ste. 408
San Francisco, CA 94107
(415) 442-0200

Product: MacroMind Director

Features:

Auto Animate:
Allows quick creation of animated bullet or barcharts, zooming text, scrolling banners, or credits and other text effects.

Overview Window:
Links together standard Macintosh and Macromind Director files into a multimedia production. Addition of clip animation, auto animation, transitions on top of MacPaint and PICT backgrounds.

Paint Window:
Color program which includes customizable airbrush, gradient effects, color tiles, and brushes for blend, cycle, smudge, smear and reveal.

Cast Window:
Multimedia database for managing and retrieving graphics, text, palettes, sampled sound, and animation sequences.

Import:
Imports scrapbooks, palettes,sound and PICT, MacPaint and PICS file from any Macintosh program.

System Configuration:
Apple Macintosh Plus,SE, SE/30, IIcx, II and IIx. Hard drive recommended. System 6.0.2 or greater. For B&W 1 Mb RAM and Color 2 Mb RAM.

Matsushita Electric Corporation of America
(MECA)
One Panasonic Way
Secaucus, NJ
O 201-348-7000

Product: Matsushita 33" Monitor

Features:
- Diagonal display 33"
- Aspect ratio 16 x 9
- Displays A2 size
- 64 levels of grey

Megatek Corp.
9645 Scranton Rd.
San Diego, CA 92121
(619) 455-5590

Product: Megatek X-Cellerator /9U

Features:
- A complete X11 development and execution environment for Sun-3 and Sun-4 workstation
- Uses TI 34020 as a graphic coprocessor
- Configured with up to 7 megabytes of local memory
- Each board provides 64 x 64 bitmapped three color hardware cursor
- Supports OPEN LOOK graphical user interface
- 1280 x 1024 @ 60 Hz or 1152 x 900 @ 66 Hz
- 8 bit color
- 3 Mbytes of Local memory
- Optimized X server
- Sun 3/100, 3/200, 4/100, 4/200 and 4/300 support
- Color performance
  - Characters @ 62K/sec
  - Pix BLTs @ 12M/sec
  - Fills @ 24M/sec
  - Vectors @ 103K/sec

Microsoft Corp.
16011 NE 36th Way, Box 97017
Redmond, WA 98073-9717
(206) 882-8080

Product: Windows Version 3.0

Specifications:

Personal Computers using the Intel 286,386 or higher processor.
- MS-DOS or PC-DOS operating system version 3.1 or higher
- 640K conventional memory minimum, 640k conventional and 256k extended memory recommended.
- One 5.25" (1.2 MB) disk drive and a hard disk, or one 3.5"(720k) disk drive and hard drive.
- CGA, EGA, VGA, 8514/A, or Hercules graphics card, or compatible video graphics adapter and appropriate monitor (EGA or higher recommended)

Options:

Microsoft Mouse or compatible pointing device.
- Hayes or compatible modem for communication.

Mitsubishi Electric Sales America, Inc.
800 Cottontail Lane
Somerset, N.J. 08873
TEL: (201) 563-9889

Product: AM-3501R 35" Monitor

Specifications:

CRT:	
Size:	35" viewable inches
Mask Pitch:	0.92 at center,1.13 at center
Panel:	Tinted faceplate
Scanning Frequency:	
Horizontal:	15-35 KHz
Vertical:	40-70 Hz
Composite Video/Audio:	
Inputs:	1.0 Vp-p NTSC 75 ohms
Output:	1.0 Vp-p NTSC 75 ohms (through)x1
	1.0 Vp-p NTSC 75 ohms (switched)x1
RGB:	Compatibility with IBM PGC/EGA/CGA/MDA and Monochrome Hercules graphics board
TTL Input:	Positive 8,16 or 64 color
Seperate sync:	+/- HD, +/- VD
Composite sync:	+/- Hd/VD
Dimensions	
	35 1/4" x 29 7/10" x 23 1/2"
	Weight: 110 kg

Motorola Inc.
Microprocessor Products Group
6501 William Cannon Dr. West
Austin, TX 78735-8598

Product: 96002 Media Engine

Application:

3D, shaded, color graphics and animation
Compact disc-quality sound
Photo realistic imaging
Color laser printing
Number crunching and simulation

Specifications:

750,000 transistors
- 1 micron geometry
- 223 pins- pin grid array package
- Low power consumption (CMOS)
- Eight 32- bit buses (266 million bytes/second information bandwidth
- At 33 MHz 165 million operations/second peak
- At 33 MHz 50 MFLOPS peak
- At 33 Mhz 16.5 MIPS

NIKON Inc.
623 Stewart Ave.
Garden City, N.Y. 11530
TEL: (516) 222-0200

Product: Lenses for HDTV

Specifications:

Model: F-HD converter TM-A1
- Enables use of 35mm SLR Nikkor lenses for telephoto or close-up use.
- 90 x 90 x 53.5 mm
- 290 g

Model: Close-up lens for R7 f=210mm
Maximum magnification of 0.44, field of view at
- 126 x 126 x 30 mm
- 510 g

Model: Close-up lens for R7 f=380mm
- maximum magnification of 0.29, field of view at max. magnification 48 x 28 mm
- 134 x 134 x 26 mm
- 800g

NIKON Inc.
623 Stewart Ave.
Garden City, N.Y. 11530
TEL: (516) 222-0200

Product: FS-1500 Frame Storage

Specification:

Dimension:	425 x 150 x 350
Weight:	17 kg
Memory capacity:	1920 x 1035 pixel of 3 colors x 8 bit
Sampling Frequency:	74.25 MHz
Quantization:	8 bits
Effective lines/frame:	1035
Effective samples/line:	1920

NIKON Inc.
623 Stewart Ave.
Garden City, N.Y. 11530
TEL: (516) 222-0200

Product: HQ-1500C Still Camera

Specifications:

Dimension:	
Head:	177 x 126 x 200 mm
CCU:	425 x 150 x 350 mm
Image pickup tube:	1" MS "SATICON"
Lens mount:	Nikon F mount (lenses are optional)
Scanning system:	1,125 lines, 2:1 interlace
Aspect ratio:	16:9
Sync signal:	HDTV 1125/60 (BTA S-001) standard
White Balance:	Automatic/Manual
Resolution:	1500 TV lines at center
Sensitivity:	2000 lux, F4 (3200 k)
Signal/Noise ratio:	More than 40 dB

Numonics Corp.
101 Commerce Dr.
Montgomeryville, PA 18936
(215) 362-2766

Product: ZedPen plus

Typical Uses:	Raster Paint systems, Animation, 2D & 3D CAD, Signature Recognition, Broadcast/Audio Visual Image Rendering, Publishing & Presentation Graphics.

Specifications:

Performance:

Levels of Pressure:	512 or 128
Levels of Height:	128
Proximity of Height:	25 mm (1 inch) nom.
Start Loading:	Programmable (50 g typical)
Maximum Loading:	Programmable (500 g typical)
Tip Displacement:	1.2 mm nominal
Tilt Error:	+/-0.6 mm typical
Working Proximity:	25 mm (1 inch nominal)

Physical:

Stylus Case:	Stainless Steel Barrel
Length:	145 mm
Grip Diameter:	11 mm
Center of Gravity:	70 mm from Tip
Weight:	25 g
Tip Radius:	0.7mm
Tip Impact Loading:	10 Kg max.

Digitizer:

Type:	Active area A3, 432mm x 30 mm Also avail. as A2 and A4.
Work Surface:	High Impact acrylic zero friction.
(x,y) Accuracy:	+/-.25 mm/.001 inch.
(x,y) Resolution:	Selectable to .0025mm
Interface:	Serial EIA RS-232 C/V 24

Panasonic Co.
1 Panasonic Way
Secaucus, NJ 07094
TEL: (201) 348-7000

Product:: AQ-11

Dimensions:	4 9/16"(W) x 9 5/8"(H) x 6 1/8"(D) (103 x 245 x 155mm)
Weight:	5.5 lbs(2.5kg)
Camera Head:	
Pick-up Device:	
Type:	Interline transfer 2/3" CCD image sensor(3)
Pick-up Element:	754(H) x 487(V)
Optical system:	F1.4 prism with quart filter
Sensitivity:	(89.9% reflection)
Standard:	2,000 lux (at F/5.6)
Min. illumination:	10 lux (at F1.4 +24dB)
Shutter Speed:	1/100, 1/125, 1/250, 1/500, 1/1000, 1/2000 sec
Optical Filter:	3200 K, 5600 K, +1/4ND, 5600 K, 5600 K + 1/16 ND
Lens Mount:	Special bayonet type
Signal-to-Noise Ratio:	60dB (typical)
Horizontal Resolution:	More than 700 TV lines (at center)
Registration:	less than 0.05% all zones (excluding lens distortion)
Hightlight Compression:	600%
Gain:	0, +9, +24dB
Digital Processing Sampling Frequency:	14.3 MHz/28.6MHz
Viewfinder	
Picture Tube:	1.5" monochrome
Control:	Variable: Bright, Contrast, Peaking SW: Tally, ZEbra, Character
Resolution:	550 TV lines
Power Requirement:	12V DC
Power Consumption:	2.5W
Weight:	1.1 lbs (500 gms)

Panasonic Co.
1 Panasonic Way
Secaucus, NJ 07094
TEL: (201) 348-7000

Product:: AQ-20

Dimensions:	4 9/16"(W) x 9 5/8"(H) x 6 1/8"(D) (103 x 245 x 155mm)
Weight:	5.5 lbs (2.5kg)
Camera Head	
Type:	Frame interline transfer 2/3" CCD image sensor (3)
Pick-up element:	754(H) x 487(V)
Optical System:	F1.4 prism with quartz filter
Sensitivity:(89.9% reflection)	
Standard:	2,000 lux (at F/5.6, electronic shutter off)
Min. Illumination:	15 lux (atF1.4, +18 dB)
Shutter Speed:	1/100, 1/125, 1/250, 1/500, 1/1000, 1/2000 sec.
Optical Filter:	Dual Concentric filter wheels ND:100%, 1/4ND, 1/16ND,Star Filter CC:3200 K,4700 K,5600 K, 6300 K
Lens Mount:	Special filter type
Signal-to-Noise Ratio:	Typical 62dB
Horizontal Res.:	More than 750 TV lines (at center)
Registration:	less than 0.05% all zones (excluding lens distortion)
Hightlight Compression:	600%
Gain:	0, +9, +18 dB
Digital Processing	
Sampling Frequency:	14.3 MHz/28.6 MHz

Panasonic Co.
1 Panasonic Way
Secaucus, NJ 07094
(201) 348-7000

Product: PV-40 Palmcorder

Specifications:

Video Recording System:	4 Rotary heads, helical scanning system
Television System:	EIA standard; NTSC color signal
Tape Format:	Tape width 1/2inch
Pick-Up Device:	One integral color filter Charged Coupled Device
Lens:	8:1 Zoom Lens Auto Zoom lens Auto focus system F 1.8 f:6mm
Electronic View Finder:	Monochrome 2/3" CRT built in
Dimension:	3 3/4" x 5 1/8" x 5 3/4" Weight 1.7 lb w/o battery

Paracomp, Inc
123 Townsend Street
San Franciso, CA 94107
415-543-3848

Paracomp

Features:

Anti-aliasing smooths jagged edges for higher quality graphics and video output.

Optimized Color Palette allows greater control over range and contrast of colors and shadows.

Importing (via the clipboard) allows any paint, draw or scanned image to be used as a template for designing 3D objects, or as a background image.

Project Object Image renders 2D graphics or textures, such as wood grain or marble, onto 3D surfaces.

Command Language creates a text-based script to bring in data from external sources and develop specific applications.

Simultaneous viewing of objects in rendering modes: wireframe, hidden line, outline shade, shade, and contour.

Cushioned rulers and grids provide accurate measurement for precision model-making.

Skin Object feature creates a new object from a series of linked cross-sections of any size or shape.

Adjustable light sources provide advanced shading and also cast shadows.

Two program versions are available for single megabyte Macintoshes and Macs with two or more megabytes.

Output:

PostScript Halftones for color separations.
Encapsulated Postscript, and PICT and PICT2 for Paint-and-Draw type formats.
Text for Excel to generate bill of materials.

System Requirements & Compatibility:

Minimum: 1 meg Macintosh Plus, SE or II
Color support with 256 color board on Macintosh II
Supports Multifinder
Compatible with Laserwriter and Postscript compatible printers.

Pioneer Communications of America, Inc.
600 East Crescent Ave.
Upper Saddle River, NJ 07458-1827
(201) 327-6400

Product: Cube Hi Vision

Features:

- High degree of brightness of 350 lamberts.

- Cube can project Hi-Vision on an area of 12 40 inch screens. Height to width ratio of each screen is 3:4, which is 9:16 for 12 screens. The 9:16 ratio is just right for Hi-Vision.

- Either 6 or 12 screens can be used, maintaining the same image quality using multi-converter.

- Projection area can be expanded to 24 or 48 screens.

- Cube is superior to older system in terms of brightness, screen size and especially in terms of cost.

Planar Systems, Inc.
1400 Northwest Compton Dr.
Beaverton, OR 97006
(503) 690-1100

Product: EL751214MS 1024 x 864 Pixel Organization

Specifications:

Physical Size:	16.5"x 13.9"x1.38"
Active Area:	13.6" x 11.5"
Weight:	6.6 lbs
Power Supply:	14.3" x 12.9" x 1.3"
Resolution:	1024 x 864 pixels
Pixel Size:	0.0093" x 0.0093"
Pixel Pitch:	0.0133" x 0.0133"
Viewing Angle:	>120 degrees
Brightness:	18 fl typical
Color:	Yellow 585 nm typical
Power:	85 watts typical
Video Sync:	60 Hz

Polhemus, Inc.
P.O. Box 560
Colchester, VT 05446
(802) 655-3159

Product: 3Space Tracker

Specifications:

Physical Size:

System Electronic Unit	11.6"(L)x12.5"(W)x5"(H) 114.0 Oz
Source	2.4"(L)x1.4"(W)x1.4"(H) 3.5 Oz
Sensor	0.9"(L)x1.1"(W)x0.6"(H) 0.8 Oz

Position Coverage: The system will provide the specified accuracy when the sensors are located within 30" of the sources. Operation up to 60" is possible with reduced accuracy.

Angular Coverage: The sensors are all attitude.

Static Accuracy: 0.1" RMS for the X, Y, or the Z sensor position and 1/2 degree RMS for sensor orientation.

Resolution: Min. 0.046",0.1 degree (@ 30" range)
Ave. 0.023" (@ 15" range)
Max. .0006" (@ 4"range)

Update Rate: One sensor: 60 per second
Two Sensors: 30 per second
Three sensors: 20 per second
Four sensors: 15 per second

Interfaces: Parallel, or RS-232C with selectable baud rate of 300, 1200, 2400, 4800, 9600, and19,200; ASCII or binary format.

Polhemus, Inc.
P.O. Box 560
Colchester, VT 05446
(802) 655-3159

Product: 3Space Digitizer

Specifications:

Physical Size:	Model Table 23.5"(L)x23.5"(W)x40"(H) Weight 80 lbs.
Position Coverage:	Models upto size 18x18x10" can be digitizes with specified accuracy. Models up to 60" can be digitized with reduced accuracy.
Angular Coverage:	The stylus is all attitude.
Static Accuracy:	0.032" RMS for the X, Y, or the Z stylus position and1/2 degree RMS for stylus orientation. When used as a hybrid tracker, accuracies are as per tracker specification.
Resolution:	Min. 0.031", 0.1 degree (at extremes). Max. .008" (at table centre)
Update Rate:	60 updates per second
Operating Mode:	Run, point, track.
Data Output: Identification:	User definable- including status, keypad, or foot switch key X,Y,Z coordinates of stylus tip, directional cosines or Euler angle orientation of the stylus.
Interfaces:	Parallel, or RS-232C with selectable baud rate of 300,1200, 2400, 4800, 9600, and 19,200; ASCII or binary format.

Polhemus, Inc.
P.O. Box 560
Colchester, VT 05446
(802) 655-3159

Product: 3Space Isotrak

Specifications:

Physical Size:

System Electronic Unit	12.25"(L)x9.12"(W)x2.88"(H) 95.0 Oz
Source	2.4"(L)x1.4"(W)x1.4"(H) 3.5 Oz
Sensor	0.9"(L)x1.1"(W)x0.6"(H) 0.8 Oz

Position Coverage: The system will provide the specified accuracy when the sensors are located within 30" of the sources.
Operation up to 60" is possible with reduced accuracy.

Angular Coverage: The sensors are all attitude.

Static Accuracy: 0.13" RMS for the X, Y, or the Z sensor position from 4-15"source to sensor seperation.
From 15-30" positional accuracy degrades linearly to 25" RMS for the X, Y, or the Z sensor position at 30".
Angular 0.85 degree RMS to 30".

Resolution:

Normal Mode: Min. 0.184",0.35 degree (@ 30" range)
Ave. 0.092" (@ 15" range)
Max. .025" (@ 4"range)
Output at 58 updates/second at 19.2 k baud,
Binary format.

Quite Mode: (Selectable by host command) Angular and positional resolution is improved by a factor of 3 over Normal Mode resolution. Output is at 28 updates/second at 19.2 k baud.

Interfaces: Parallel, or RS-232C with selectable baud rate of 300,1200, 2400, 4800, 9600, and 19,200; ASCII or binary format.

Projectavision, Inc.
310 East 46th St., Ste. 21-A
New York, NY 10017
(212) 867-8888

Model:: Projectavision

Features:

- NTSC, HDTV projection system with no screen requirements, video input from projector.
- Liquid crystal technology
- Accepts input from a variety of sources
- Projectors are very compact, light weight, relatively inexpensive, high contrast, wide color range, extremely high brightness, continuous tone image without lines or dots.

Quantel Inc.
655 Washington Blvd.
Stamford, CT 06901
(203) 348-4104

Product: Paintbox HD

Features:

- Paintbox HD is designed to bring the graphics capability of Paintbox to High Definition, without any compromise to fast and easy use of operating system and range of facilities.
- Paintbox HD is compatible with SMPTE 240M, Eureka and 1050 high definition standards.
- Images can be directly transferred digitally between Paintbox HD and both Paintbox and Graphic Paintbox.
- Paintbox HD's Pictureport open interface allows integration with complementary third party high definition devices such as 3D systems.

Rank Cintel Inc.
13340 Saticoy St., Unit F
North Hollywood, CA 91605
TEL: (818) 765-7265

Product:: High Definition MKIII Telecine

Film Format::	35mm 4 perforation academy, widescreen and cinemascope.
Film Speed::	24 and 30 fps by switch selection and other adjustments.
Input:	AC power as MKIIIC. Mixed Sync Tri-level +-0.3 Vpp
Output:	Analogue non-composite R,G,b, 0.7 Vpp 75 Ohms.
Color Channel:	Master Gain Master Gamma (R,G,B only) Master Lift
Color Correction:	Differential joysticks for lift, gamma and gain.
RGB Tracking:	Better than 1%
Resolution:	Not more 3dB down at 20 Mhz at centre of the assuming no film losses.
HAV/VAC:	16MHz 0dB to +12 dB boost
Masking:	As MKIIIC
Signal/Noise:	Red 36 dB Green 42 dB Blue 32 dB RMS noise with respect to 0.7 Vpp

REBO High Definition Studio
530 West 25th St.
New York, NY 10001
TEL: (212) 989-9466

Model: ReStore

Features:

- 1920 x 1035 pixels
- 32 bit channel (includes alpha channel)
- Two seperate frame buffer
- Internal digital image mixing
- Color correction
- Real time image capture

Specifications:

Video I/O:	1125/60HDTV signal (SMPTE240M)
Video Bandwidth:	30 MHz per channel (R,G,B,alpha)
Sync I/O:	Tri-Level
Sampling Frequency:	74.25 MHz
Quantization:	8 bits per channel
Memory Size:	16 Mbytes
Frame Size:	1920 x 1035 pixels
S/N ratio:	>50 dB
Host Computer Interface:	NuBus
Video connector:	BNC type

Reflection Technology, Inc.
240 Bear Hill Rd.
Waltham, MA 02154
(617) 890-5905

Product: Private Eye

Specifications:

Physical Size:	1.2" high x 1.3" deep x 3.5" long; 2.25 oz
Power Requirements:	5 Volts D.C. Display uses 1/3watts Can be battery powered.
Image Produced:	Sharp red image on black background. Displays 720 x 280 pixel, 25 lines with 80 columns or bit mapped image. Image focal point can be adjusted by the user to be between 9" and infinity.
Interfaces:	Available interfaces include a high speed serial cable interface, an IBM PC bus interface, an custom integrated circuit which can handle all the interfacing tasks in a host device. Special purpose interfaces can also be provided.

Sharp Electronics Corp., Microelectronics Division
Sharp Plaza
Mahwah, NJ 07430-2135
(201) 529-8757

Product: LJ024U33 EL Display Unit

Physical Specifications:

Outline Dimensions:	310(W) x 238(H) x 15(D)mm
Resolution:	1024 X 768
Effective Display:	255.9 x 191.9mm
Dot Pitch:	0.25 x 0.25 mm
Dot Pitch Ratio:	1:1
Dot Size:	0.19 x 0.18mm
Weight:	1050 gm

Sharp Electronics Corp., Microelectronics Division
Sharp Plaza
Mahwah, NJ 07430-2135
(201) 529-8757

Product: LM10P10

Specifications:

Outline Dimension:	312 x 230 x 18.5mm
Weight:	1300 gms
Resolution:	1024 x 768
Dot Pitch:	0.22 x 0.22mm
Panel:	Triple Super Twisted Nematic
Color:	Black and White
Back Light:	Cold Cathode Fluorescent Tube (Edge lighting type)
Structure:	Transmissive

Sharp Electronics Corp.,
Microelectronics Division
Sharp Plaza
Mahwah, NJ 07430-2135
TEL: (201) 529-8757

Product: LQ4RA01 TFT LCD Screen

Physical Dimensions:

Display Format:	479(W)x234(H) dots
Active Area:	81.9(W)x61.8(H) mm
Screen Size:	4 inches diagonal
Dot Pitch:	0.071(W)x0.264(H) mm
Dot Configuration:	R.G.B Delta Configuration
Outline Dimension:	110.2(W)x85.8(H)x2.7(D)mm
Weight:	170+/-10gms

Features: Dual mode type (NTSC(M) and PAL(B.G))
234V x 479H dots(total 112,086 dots)
High quality full color rendition with back light source incorporated.
Viewing angle 6 o'clock direction.

Shima Seiki
22 Abeel Road
Cranbury, N.J. 08512
TEL: (609) 655-4788

Product: SDS 480 SGX

Size:	
Standard:	
Standard table	W2,430 x D1,390 x H1,366
High Definition:	
Standard table:	W2,430 x D1,390 x H1,365
Elec.-pow. table:	W2,115 x D1,320 x H1,385-1,515
Screen:	High definition
CRT:	28"raster scan
Screen Display	1125 60 fields/second
System:	Interface
Display Scanning:	1024,1035
Frame Memory Area:	1832x1024,1832x1045,1920x1024,1920x1035
Screen size:	620 x 372(mm)
Zoom Pan:	1-32 times
Number of colors available for simultaneous display:	Full Color Mode:16.7 million colors Color Table Mode:256 colors
Display Clipping:	1024 x 1024
Options:	Color Image Scanner, Drum Scanner,35mm Film Scanner, Internal Disk, Juke Box, MT (compatible with pre-press system), Digital Film Recorder (QCR), Color Ink Jet Printer, Color Thermal Printer.

Silicon Graphics
2011 North Shoreline Blvd.
Mountain View, CA 94043
(415) 960-1980

Product: POWERVISION System

Features:

- 1,2,4 or 8 25 MHz or 33 MHz CPU's
- 8 MB ECC Standard Density Memory
- IO2 I/O Processor
- Ethernet port
- SCSI Channel
- 4,8 or 16 RS232 Ports
- Power Store Drive Drawers
- IRIX
- Graphics Backplane (6 VME slots)
- VGX Graphics Subsystem (4 boards)
- Standard 19" rack mount enclosure
- 1/4", 1/2" or 8mm tape backup devices
- Front access card storage
- Upto 36.7 GB disk unformatted
- POWER Meter CPU monitor

Silicon Graphics
2011 North Shoreline Blvd.
Mountain View, CA 94043
(415) 960-1980

Product: Personal IRIS

Specifications:

Standard Features:

CPU:
4D/20 Processor: 12.5 MHz 32 bit RISC CPU w/12.5 MHz floating point coprocessor, cache 8KB data, 16KB instruction, 10 mips, 0.9 mflops
4D/25 processor: 20 MHz 32 bit RISC CPU with 20 MHz floating point coprocessor, Cache 32KB data, 64KB instruction, 16 mips, 1.6 mflops.

Memory Storage: 8 MB DRAM, Internal 190 MB, 344 MB, or 700 MB formatted 5.25"

Display: RGB color monitor, 60 Hz non interlaced 19" 1280 x 1024 resolution or 14" 1024 x 768 resolution.

Graphics:
Entry Models: 8 color bitplanes plus 2 additional bitplanes for window ID plus 2 additional bitplanes for overlay/underlay (total of 12 bit planes)
Super Models: 24 color bitplanes plus 4 for window ID plus 4 additional for overlay/underlay, plus 24 bit Z buffer (total 56 bits/pixel)

Performance:
90,000 3D Vectors/second
5,000 four sided polygons/sec

Color Range:
Color map mode- 256 color displayable (Entry) 4096 displayable (Super). RGB mode 16.7 million colors displayable (Super)

Communication:
Ethernet port with TCP/IP
2 RS 232 serial port, 1 parallel port, one single wide double high VME slot.

SimGraphics Engineering Corp.
1137 Huntington Rd.
South Pasadena, CA 91030
(213) 255-0900

Product: BodyBuilder

Features:

- A tool for specifying and constructing anthropometrically correct human body geometry and postures.
- Displays models in wireframe, or as flat shaded or Gouraud shaded solids with realtime update.
- Generates adult male and female geometry for all percentile ranges with anthropometry based on aerospace medical research data.
- User need to specify only the gender, and height and weight percentile, to create an anthropometrically proportioned model.
- Allows manipulation of the model either by direct 3D manipulation or joint-limb spreadship, or posture library.
- Imports ancillary 3D geometry from other CAD system for accurate positioning of body model.
- Body models can be saved in MOVIE.BYU, IGES and GEOMOD formats.

Versions for Silicon Graphics IRIS and Hewlett Packard SRX graphics workstations are available.

SimGraphics Engineering Corp.
1137 Huntington Rd.
South Pasadena, CA 91030
(213) 255-0900

Product: Flying Mouse

Features:

- Mouse like operation. In 2D it is point and click. In 3D it is place and grab.
- Automatic 2D/3D mode transition. Lifting device from desk allows users to switch from 2D to 3D.
- Selectable degrees of freedom give the user control of cursor movement and complex function input in 3D.
- System Compatibility for standard 2D mouse function allows it to be used in 2d mode on all existing codes.
- Rich software library available.

3D Sensing System Specification:
A Polhemus 3Space-Isotrack-6 degree of freedom tracking system is incorporated in the flying mouse. Polhemus system uses a magnetic detection system to determine position and orientation.

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: Sony SDT-1000

Specifications:

Tape Format:

Recording Geometry:	Helical Scan with read after write
Recording Format:	Digital with Error Correcting Code
Capacity:	2.3 GB per tape, formatted

Performance:

Tape Read Rate:	250 KB/ second sustained; 1.5MB/ second burst
Tape Write Pate:	250 KB/ second sustained; 1.5MB/ second burst
Time to Read 2 GB:	133 minutes
Time to Write 2 GB:	133 minutes
File Search Speed:	10 minutes read/write speed
Time to Rewind Tape:	2 minutes

Reliability:

Non-recoverable Error Rate:	Less than one in 10 thirteenths bits read

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: HDDF-500 Digital Frame Recorder

General:	
Signal Standard	SMPTE 240M 1125 line, 2:1 interlace, 60 Hz 1035 active lines
Dimensions	(16 3/4 x 9 1/2 x 21 7/8")
Weight	33kg (72 lb 12 oz)
Video:	
Sampling Rate	74.25 Mhz in each RGB channel
Quantization	8 bit/sample
Capture	8 to 32 frames or 16 to 64 fields(RGB)
Display	Frame or Field (Selectable)
Memory Content	1920(h) x 1040(V) pixel per frame(RGB) 2 megabyte per frame each channel
Frequency Response	0-27 MHz:+-0.5 db 0-30 MHz:-1.5 db +-0.5db
K Factor	less than 1% (HDTV) 2T-66ns HAD)
Tilt	less then 1% (Horizontal and Vertical)
S/N Ratio	more than 56 db
Sync Jitter	less than 2ns
Input/Output Signal:	
Input	
Analog	G,B,R: IVP-P+-2db (7.5 ohms BNC per channel)
Digital	D-Sub 25 pin (one per channel)
Reference	Composite Video: 1VP-P+-2db Sync (Tri Level)+-0.3V(BVC,loop through)
Output	
Analog	GBR: 1VP-P(0.7VP-P.Video into 75 ohms,+-0.3 Tri level Sync) (BNC, three outputs per channel)
Digital	D Sub 25 pin (one per channel)
Remote	1,2, 9 pin remote
Computer Parallel	DRV-11WA (for Q bus systems)
Interface	DR-11W (for unibus system)
Audio processing	None

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: HDL 2000 Videodisc Player

General:

Dimension:	Approx. 436(W)x286(H)x608(D)mm
Weight:	Approx. 35.2 Kg
Signal standard:	SMPTE 240M

Video:

S/N	42dB (Y)
Band Width	20 MHz (Y)
	6 MHz (C)

Audio:

Frequency bandwidth	20Hz to 20KHz (+/-1dB)
Harmonic distortion	Less than 0.05%
Dynamic range	90dB
Channel crosstal	-80dB
Wow and flutter	Below measurable levels

Input/Output:

Video Out	G/Y,B/Pb,R/Pr (BNC,2 outputs)
REF Video In	Loop-through BNC
Audio Out	CH-1/CH-2 (XLR 3-pin,2 channels)
Remote	RS-232C
Spare	D-sub 9-pin

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: DVR-10/D2

Dimensions:	approx.438(W) x 282(H) x 656(D)mm (17 1/4 x 11 1/8 x 25 7/8")
Weight:	approx.47 kg (103 lb 10 oz)
Power requirements:	AC 100 to AC 120V +- 10% 50/60Hz
Power Consumption:	Max. 450W
Operating Temperature:	5 C to 40 C (41 F to 104 F)
Humidity:	10% to 90%(non condensing)
Recording Format:	SMPTE D2 format
Tracks/Channels:	Digital Video and audio(4 channels) 5 tracks/1 field Analog Audio(cue) 1 track Time code1 track CTL1 track
Tape Speed:	
Writing Speed:	27.387 mm/sec
(Relative Speed)	
Record Time:	Max.94 min with M cassette Max.32 min with S cassette*Cassette Type:* D-1 cassette (M or S size)
Recommended Tape:	Sony metal (1500 Oe) tape or equivalent
Servo Lock Time:	Within 1.0 sec (with color frame servo lock mode from stand by mode)
Tape Timer Accuracy:	+-2 frames (with continuous CTL signal)
Edit Accuracy:	0 frames with time code
Error Correction:	Correction and concealment (Read Solomon code)
Fast forward/rewind time:	Within 70 sec.(with 32 minute tape) Within 165 sec.(with 94 minute tape)
Load/unload time:	Within 5 sec.

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: DVR-1000/DVPC-1000

Dimensions:	DVR-1000 approx.438(W)x325.6(H)x635(D)mm (17.2 x 12.8 x 25") DVPC-1000 approx.424(W)x650(H)x850(D)mm (16.7 x 25.8 x 25.6")
Weight:	DVR-1000 approx. 48 kg (105.8 lb) DVPC-1000 approx. 100 kg (220.4 lb)
Recording format:	SMPTE D1/EBU Tech 3252 format
TV Standard:	525/60, 626/50 switchable
Tracks:	Video 600 tracks/sec 20 sectors/field(525/60) 24 sectors/field(625/50) Digital audio 600 tracks/sec 40 sectors/field(525/60) 48 sectors/field(625/50) Analog Cue 1 track Time Code 1 track Control 1 track
Tape Speed:	286.688 mm/ec. (525/60) 286.675 mm/sec. (625/50)
Recording Time:	34 min with the Sony DCM-600 or equivalent.76 min with the Sony DCL-1300 or equivalent 94 min with the Sony DCL-1600 or equivalent
Video:	S/N Ratio: 66 dB(Y,R-Y,B-Y)
Audio:	S/N Ratio: 42 dB (at 3% distortion level)

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: Electron Beam Recorder

Specifications;

Input Signal	RGB Component
Gamma Data	10 bits
Gamma Data inputs	Sony SMC-70 Microcomputer and 3.5-inch microfloppy disk
Film Size	35mm
Film type	Black and white fine grain positive Fuji 71337 or equivalent
Film transport	Intermittent claw pulldown with registration pin
Film recording system	RGB color frame (sequential)
Writing lines	2090 lines in effective picture area
Operation	Microcomputer aided

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: HDC 300

Dimensions:	Appox. 166(W) x 291(H) x 290(D)mm (6 5/8 x 11 1/2 x 11 1/2)
Weight:	approx. 8.9 kg(19 lb 10 oz)
Pick up tube:	1 inch static focus/static deflection Saticon 3-tube system
Spectral system:	F1.2 high index quart filter
Special functions:	Graticule Centering Intercom (x 2) Focal Plane Indicator
Power req.:	DC 17V
Power consump.:	40W
Operating temperature:	0 C to 40 C (32 F to 104 F)

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: HDIR-550/550M Rear projector

Specifications:

Dimensions:	1340 x 1815 x 990 mm
Weight:	210 Kg
Horizontal Res.:	1000 TV lines (center) HDTV 700 TV lines (center) Composite
Vertical Res.:	750 TV lines (center HDTV input
Horizontal Freq.:	15 KHz to 35 KHz
Vertical Freq.	50 Hz to 120 Hz
Video Band width:	30 MHz
Brightness:	200 ft-L(peak white) 50 ft-L (all white)
Input:	G/Y, B/Pb, R/Pr, Sync/HD, VD(HDTV) x 2 lines: BNC, 75 ohms terminated. Composite Video: BNC, 75 ohms terminated.

OPTICAL:

Projection System:	3 picture tube,3 lenses, horizontal in line rear projection system.
Projection Size:	55" diagonally
Screen:	2 pieces type, black stripe coating
Optimum Viewing Angle:	Horizontal: +/- 50 degree Vertical: +/- 20 degree

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: HDM 2830

Specifications:

Dimensions:	approx. 754(W) x 615(H) x 677(D)mm
Weight:	approx. 92Kg
Picture tube:	Super Fine Pitch Trinitron 0.35mm phosphor trio pitch 28-inch visible picture measured diagonally
Picture height·	349mm
Picture width:	620mm
Aspect Ratio:	16:9
Resolution:	Center: H 1000 TV lines V 750 TV lines Corner: H 950 TV lines V 750 TV lines
Input/Output Video:	G,B,R/Y,Pb,Pr with loop-through (BNC x 6)
Sync:	Tri-level sync, bi-level syn, or HD/VD
Remote:	10-pin connector
Frequency response:	60 Hz to 30 MHz +-3dB
Linearity:	DG:Less than 5%
Convergence:	Center: Less than 0.7mm Corner: Less than 1.0mm
Color temperature:	Preset Mode: 6500K Manual Mode: Adjustable (6500K at ex-factory)

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: HDM 3830

Dimensions:	approx. 1030(W) x 76(H) x 865(D)mm (40 5/8 x 30 1/8 x 34 1/8 ")
Weight:	approx. 184Kg(405 lb 8 oz)
Picture tube:	Super Fine Pitch Trinitron 0.46mm phosphor trio pitch 38-inch visible picture measured diagonally
Picture height:	477mm
Picture width:	852mm
Aspect Ratio:	16:9
Resolution:	Center: H 1000 TV lines V 750 TV lines Corner: H 950 TV lines V 750 TV lines
Input/Output Video:	G,B,R/Y,Pb,Pr with loop-through (BNC x 6)
Sync:	Tri-level sync, bi-level syn, or HD/VD
Remote;	10-pin connector
Frequency response:	60 Hz to 30 MHz +-3dB
Linearity:	DG:Less than 5%
Convergence:	Center: Less than 0.7mm Corner: Less than 1.0mm
Color temperature:	Preset Mode: 6500K Manual Mode: Adjustable (6500K at ex-factory)

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: HDS-1000T

Dimensions:	approx.450(W) x 150(H) x 420(D)mm (17 3/4 x 6 x 16 5/8")
Weight:	approx. 13kg (28 lb 11 0z)
Signal Standard:	SMPTE 240M
Video Input:	VS x 7,RGB component
Title input:	VS x 2, B/W
Program output:	VS x 2, RGB component
Preview output:	VS x 1, RGB component
Return video output:	VS x 1, RGB component
Sync output:	Tri-sync x 2,+-0.3Vp-p
Differential gain:	Less than 2% at 50% APL
Frequency response:	-20MHz +-0.3dB, -30MHz +0.3-3.0dB
Cross talk:	-40dB at 30MHz
Path length deviation:	Less than +-0.2dB
Power require.	AC 100 to 120/220 to 240V, 160W

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: HDD-1000 Digital VTR System

General Specification:

Dimensions:	480(W) x 680(H) x 572(D)mm
Weight:	67 Kg
Tracks:	Video Tracks: 8 T/C tracks: 1 Audio Tracks: 8 Cue tracks: 1 CTL tracks: 1
Tape Speed:	80.5 cm/sec
Writing Speed:	51.5m/sec
Recording Time:	63 min with 11.75 inch reel
Fast Forward/ Rewind Speed:	approx. 5mins
Rec. tapes:	Sony's 1 inch HD tape
Reel Size:	NAB Standard,6.5-11.75 inch reel

Video (with HDDP-1000)

Signal standard:	SMPTE 240M
Signal System:	Y Pb Pr
S to N ratio:	Better than 56 dB (full band)
Quantization	8 bits
Sampling rate:	74.25 MHz
Bandwidth:	DC 30 MHz 0-1.5dB (luminance) DC 15 MHz 0-1.5dB (chrominance)
K factor:	Less than 1%, 2T pulse
Phase error of any component Channel:	Less than 3.5 nsec.

Audio

Frequency response:	20 Hz to 20 kHz
Crosstalk (at 1KHz):	Less than -80dB (between any two channels)

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: MVC-A7F7 Promavica Electronic Still Camera

Features:

- Dimensions: 173 x 201 x 103 mm
- Weighs 1.55 kg (w/o batteries)
- Full featured autofocus, autoexposure, still video SLR camera.
- Can record up to 25 frames or 50 fields of still video.
- Uses standard 2" Mavipak reusable video floppy.
- Has a horizontal resolution of 320 TV lines, and a 380,000 pixel surface.
- Can record digitally compressed FM audio with every picture. Can record 16 frame images with 9.6 seconds audio, or 25 image fields with 9.6 seconds of audio/field or 500 secs of audio w/o images at 9.6 sec/track.
- Fixed autofocus 6X zoom lens covers a range of 12mm/F1.4 - 72mm/F1.7.

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
TEL: (201) 930-1000

Product: HDD-1000 Digital VTR System

General Specification:

Dimensions:	480(W) x 680(H) x 572(D)mm
Weight:	67 Kg
Tracks:	Video Tracks: 8 T/C tracks: 1 Audio Tracks: 8 Cue tracks: 1 CTL tracks: 1
Tape Speed:	80.5 cm/sec
Writing Speed:	51.5m/sec
Recording Time:	63 min with 11.75 inch reel
Fast Forward/ Rewind Speed:	approx. 5mins
Rec. tapes:	Sony's 1 inch HD tape
Reel Size:	NAB Standard,6.5-11.75 inch reel

Video (with HDDP-1000)

Signal standard:	SMPTE 240M
Signal System:	Y Pb Pr
S to N ratio::	Better than 56 dB (full band)
Quantization	8 bits
Sampling rate:	74.25 MHz
Bandwidth:	DC 30 MHz 0-1.5dB (luminance) DC 15 MHz 0-1.5dB (chrominance)
K factor:	Less than 1%, 2T pulse
Phase error of any component Channel:	Less than 3.5 nsec.

Audio

Frequency res.:	20 Hz to 20 kHz
Crosstalk(at 1KHz):	Less than -80dB (between any two channel)

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
(201) 930-1000

Product: HDM 2830

Dimensions:	approx. 754(W) x 615(H) x 677(D)mm
Weight:	approx. 92Kg
Picture tube:	Super Fine Pitch Trinitron 0.35mm phosphor trio pitch 28-inch visible picture measured diagonally
Picture height:	349mm
Picture width:	620mm
Aspect Ratio:	16:9
Resolution:	Center: H 1000 TV lines V 750 TV lines Corner: H 950 TV lines V 750 TV lines
Input/Output Video:	G,B,R/Y,Pb,Pr with loop-through (BNC x 6)
Sync:	Tri-level sync, bi-level sync, HD/VD
Remote:	10-pin connector
Frequency response:	60 Hz to 30 MHz +-3dB
Linearity:	DG:Less than 5%
Convergence:	Center: Less than 0.7mm Corner: Less than 1.0mm
Color temperature:	Preset Mode: 6500K Manual Mode: Adjustable (6500K at ex-factory)

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
(201) 930-1000

Product: DDM-2802C Trinitron 20/20 Screen

Specifications:

Dimensions:	27.17"W x 28.7"H x 30.55"L
Weight:	238 lbs
Video Amplifier:	
Rise/Fall time:	1.5 ns/1.5 ns type.
Band Width:	60 Hz to 300 MHz +/- 3dB
Picture Tube:	20" x 20" useful screen area 0.31mm phosphor trio pitch
Resolution:	2048(H) x 2048(V) addressable pixels 19.6" x 19.6" +/-2% active raster size.
Brightness:	23 fl
Input Requirements:	
video:	0.714 V p-p Positive, RGB Video signal, HD, VD, TTL Negative, 75 ohms terminated
Connector:	BNC x 5
Alignment Interface:	RS-422A, 15 pin D type connector

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
(201) 930-1000

Product: DXC-3000A 3 Chip CCD Color Video Camera

Specifications:

Camera Head:	107.9 x 221 x 363.4mm 3.3 kg weight
Pickup Device:	Interline Transfer CCD 3 chip
Picture Element:	510 x 492 (H/V)
Sensing Area:	8.8mm x 6.6mm
Scanning System:	525 Lines, 2:1 interlace, 30 frames/sec
Horizontal frequency:	15.734 kHz
Vertical frequency:	59.94 kHz
Horizontal Resolution:	560 lines (Y channel at the center)
Sensitivity:	2000 Lux with F 5.6, at 3200 K
Gain Select:	0 dB, 9 dB or 18 dB
Minimum illumination:	25 lux (F 1.7 lens, +18dB gain)
Built in filter:	1. 3,200 degree K 2. 5,600 degree K+ 1/8 ND 3. 5,600 degree K
Signal to noise ratio:	58 dB

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
(201) 930-1000

Product: HDV 10 Video Cassette Recorder

General

Dimension:	424(W)x310(H)x630(D)mm
Weight:	Approx. 50 kg
Recording Format:	UNIHI format
Tracks/Channels:	Video 6 tracks/1 field
	Digital audio 6 tracks/1 field
	Analog audio 1 track
	Time Code 1 track
	CTL 1 track
Tape Speed	119.7mm/sec
Writing Speed	21.4mm/sec
Recording Time	Max. 63 minutes
Cassette type	UNIHI videocassette
Servo look time	Within 2 sec. (stand by on start)
Load/Unload time	Within 7 sec.
Fast forward/Rewind	within 120 sec.

Video

Video Bandwidth	Y:20MHz
	Pb, Pr:7MHz (line sequential)
S/N ratio	Y:41dB
	Pb, Pr:43dB

Sony Corp. of America
Sony Dr.
Park Ridge, NJ 07656
(201) 930-1000

Product: DXC-750 3 Chip CCD Color Video Camera

Specifications:

Camera Head:	70 x 75 x 113.5mm 600 gm weight, 920 gm weight(w/ 5m cable)
Camera Control *Unit:*	424 x 88 x 303mm 6.5 kg weight
Pickup Device:	Interline Transfer CCD
Picture Element:	768(H) x 493(V)
Sensing Area:	8.8mm x 6.6mm
Scanning System:	525 Lines, 60 Fields/sec, 2:1 interlace
Horizontal frequency:	15.734 kHz
Vertical frequency:	59.94 kHz
Horizontal Resolution:	700 TV lines
Sensitivity:	2000 Lux with F 5.6, 89.9% reflectance
Minimum illumination:	20 lux (F 1.4 lens, +18dB gain)
Electronic Shutter:	1/125, 1/250, 1/500, 1/1000, 1/2000, 1/4000, 1/10000
Color Temperature:	3200k/5600k selectable

Spyglass, Inc.
701 Devonshire Dr., C-17
Champaign, IL 61820
(217) 355-1665

Product: Spyglass Transform

Specifications:

Product Overview:
Transforms data into 2D images using color raster imaging - a paint by number method where colors are assigned to numbers to create images from 2D arrays of numbers.

System requirements:
Macintosh II series with 68881 or 68882 math coprocessor, 8 bit video display, 1 MB RAM, System 6.0 or later and a hard drive. Color monitor and 4 MB RAM recommended.

Printing Capability:
Prints to postscript printers and color printers.

Graphing capabilities:
Generates 2D interpolated, chunky and polar images. Synchronizes points among multiple datasets with same dimensions.

Dataset specification:
Data imported in ASCII text, HDF, or PICT. Linkable libraries for FORTRAN and C included in TRANSFORM package. Minimum size 2 x 2 ; maximum limited by memory.

Color Tools:
A number of tools for color imaging. selection of 20 Color tables available which can be edited, imported or created. Default is rainbow color table.

Dataset Value Manipulation:
Displays all or part of dataset; dataset editableVariable data display format.

Spyglass, Inc.
701 Devonshire Dr., C-17
Champaign, IL 61820
(217) 355-1665

Product: Spyglass View

Specifications:

Product Overview:
Displays sets of data points as color raster images, contour plots, surface plots, shaded data plots, ordered dither plots or XY graphs

System requirements:
Macintosh II series with 68881 or 68882 math coprocessor, 8 bit video display, 1 MB RAM, System 6.0 or later and a hard drive. Color monitor and 4 MB RAM recommended.

Printing Capability:
Prints to postscript printers and color printers.

Graphing capabilities: displays data as color or grayscale raster images, linegraphs, surface plots, contour plots and dither plots. Images can be enlarged, reduced and interpolated.

Animation capabilities: Creates animated movie of image files.

Color Tools:
A number of tools for color imaging. A selection of 20 Color tables available which can be edited, imported or created. Default is rainbow color table.

Data Manipulation:
Imports data as HDF rasterfile, HDF floating point file, PICT2 file, Binary file. Exports images as HDF raster file, PICT2 file, Binary file,or Clipboard PICT image.

Stardent Computer Inc.
95 Wells Ave.
Newton, MA 02159
(617) 964-1000

Product: Stardent 3000V

Features:

Graphics
- Real time 4K x 4K resolution texture mapping
- Dynamic anti-aliased vectors and polygons
- Shadows
- Real time compositing (2D and 3D)
- SeeTrue multipass transparency
- Sphere and circle primitives
- Spotlights, ambient, diffused, point and attenuated lights
- Arbitrary clipping planes
- X11 Release 4 Window system
- Dore' #D graphical system

System Technology
- Dual seat configurations
- Video out (NTSC/PAL with genlock)
- 180 bits per pixel
- 32 bit Z buffer
- Subpixel positioning with 32K x 32K addressable pixel resolution
- 31 overlay color
- 8-,12-,and 16- bit pseudo color mode with upto 16 lookup tables
- 320 MLINT/second

Graphics Performance
- 3D depth cued polyline,
- 10 pixel vectors: 336Kvectors/sec
- 3D depth cued, anti-aliased
- 10 pixel vectors,4 pixel filter160K vectors/sec
- Z-buffered,smoothly shaded 100 pixel
- triangles or quads: 225K polygons/sec

Computational Performance
- Integers upto 128 MIPS
- Scalar Floating Point up to 64 MFLOPS
- Vector upto 128 MFLOPS

Sun Microsystems, Inc.
2550 Garcia Ave.
Mountain View, CA 94043
(415) 960-1300

Product: SunVision

Specifications:

SunIP, SunIPLib (Image Processing)

Interfaces
- -Window based interactive tool
- -Fully configurable window controls
- -Programming interface to library routines

Data Types
- -Multibanded pixel images, including byte, short, and floating point

Features
- -Edge detection
- -Image enhancement and restoration
- -Utilities for image formatting
- -ROI

SunVoxel (Volume Rendering)

Interfaces
- -Window based interactive tool
- -Fully configurable windows control

Data Types
- -3-D rectangular grids
- -8 bits unsigned integers

Features
- -Electronic lightbox for viewing individual slices
- -Interactive substance classification
- -Interactive lighting and shading attributes
- -Interactive transparency tool
- -Interactive voxel editing for reading or writing of voxel data in user coordinates.
- -Access to image processing

SunGV (Geometric Viewer)
- Interface
  - -Window-based interactive tool
  - -Fully configurable windows controls
- Features
  - Scene composition and specification of
  - -Object transformation
  - -Viewing
  - -Multiple light sources
  - -Assignment of surface attributes
  - -Color
  - -Opacity
  - -Reflective properties
  - -Textures

SunART (High Quality Rendering)
- Interfaces
  - -Script driven
  - -Renderman compatible interface
- Data Formats Supported
  - -AutoCAD DXF
  - -movie.BYU
- Lighting
  - -Phong lighting model
  - -Multiple colored light sources
  - -Ambient, infinite, point and spot light sources
- Shading
  - -Gouraud (linear)
  - -True Phong
  - -Supports for user defined shaders
  - -Texture mapping
  - -Bump mapping
  - -Environment mapping
  - -Tranlucency

SunMovie (Movie Loop Display)
- Interfaces
  - -Window based interactive tool
- Operation Modes
  - -Continuous Playback
  - -Single frame playback
  - -Start/Stop
  - -Autoreverse

Sun Microsystems, Inc.
2550 Garcia Ave.
Mountain View, CA 94043
(415) 960-1300

Product: SPARC Station 1

Packaging Type:	Desktop
Integer Perform:	12.5 MIPS
SPEC marks:	8.3
Processor:	SPARC
Clock Speed:	20 MHz
Floating Point:	1.4 MFLOPS
Main Memory:	8-64 MB
Memory Type:	1 MB SIMMs
Floppy Disk:	3.5"
Disk Capacity:	1.3 GB (SCSI)
Graphics:	GX
Package Slots:	3 expansion connectors
Tape Backup:	150 MB 1/4 inch SCSI
Cache:	64 KB
Bundled Software:	SunOS ONC/NFS SunView
Base Price Configuration:	8 MB 17"mono diskless

Sun Microsystems, Inc.
2550 Garcia Ave.
Mountain View, CA 94043
(415) 960-1300

Product: TAAC-1 Software release 2.3

Features:

- Interactive 3-D Graphics
  - Transformed 3D 10 pixel vectors/sec 112,000
  - Anti-aliased,transformed 3D 10 pixel Vectors/sec: 55,000
  - Z- buffered Gouraud-shaded polygons/sec:15,000
- Image/Signal Processing
  - 3 x 3 convolution over an 8 bit 512 x 512 image: 0.485 sec
  - Floating point 2D Fast Fourier Transform:1 sec
  - Bilinear interpolation/sec 256,000
- Volume Imaging
  - Trilinear interpolations/sec:128,000
  - Extraction and display of 256 x 256 orthogonal slice: 0.033 sec

Application Software Library

- Viewing Operations
  - transformations,clippings, perspective division, double buffering, Z-buffer hidden surface removal, shading flat and Gouraud
- Drawing Primitives
  - 2D, 3D polygons, 2D, 3D vectors and polylines,text
- Point Function
  - image add, subtract, blend

Hardware Specifications

- Processor
  - 32 bit word length
  - 160 nsec. clock
  - Texas Instruments' 8800 Processor Family
  - 32 bit integer multiplier/accumulator
  - 32/64 bit floating point unit
  - 8K x 32 RAM look up table
- Memory
  - Data/image memory: 8- Mbyte
  - Program memory; 16K instruction words
  - Scratchpad/stack memory: 16K 32 bit words
- Display
  - sync range: 30 Hz interlaced to 66 Hz non interlaced
  - Display: programmable upto 1024 x 1024
  - Pixel depth: 32 bits/pixel

- Configuration Information
  - Compatible with Sun-3 and Sun-4 family

Symbolics, Inc.
8 New England Executive Pk.
Burlington, MA 01803
(617) 221-1000

Product: FT 100 Frame Thrower

Requirements:

Symbolics XL400 Workstation
IU VME Form Factor Slot
NTSC/PAL, MULTISCAN, High Resolution or HDTV Color Monitor/
Color Projector
General Release 8.x
Symbolics Compatible Color System with sources included

Display Memory:

8 MBytes, Software Configurable
Addressable in Pixel, Plane
Packed and Component modes

Color:

256 color out of palette of 16 million in 8 bit mode
16.7 million colors in 32 bit mode with 2 overlay planes available

Standard Video Output:

Composite RGB video and/or separate composite sync
Nominal RS-343 video levels, programmable
Black pedestal programmable
Nominal 15 KHz to 64 KHz. Horizontal frequency (programmable)
Nominal 30 Hz to 120 Hz. Vertical frequency (programmable)
Pixel clock programmable upto 150 MHz
Supported display formats (8 or 32 bit models)
NTSC 1-640 by 484 at 29.94 Hz or 60 Hz non interlaced
NTSC 2-720 by 484 at 29.94 Hz or 60 Hz non interlaced
PAL 1-640 by 576 at 25 Hz or 50 Hz non interlaced
PAL 2-720 by 576 at 25 Hz or 50 Hz non interlaced
High Resolution - 1280 by 1024 at 30 Hz or 60 Hz non interlaced
Zenith Spectrum Compatible HDTV 1280 by 720 at 59.94 Hz non interlaced
SMPTE 240M HDTV-1920 by 1035 at 30 MHz
Additional Sync programs can be generated by Symbolics
for nominal NRE fee.

Tektronix, Inc.
Wilsonville Industrial Pk.
P.O. Box 1000
Wilsonville, OR 97070
TEL: (503) 682-3411

Model: 1730 HD High Definition Waveform Monitor

Specification:

Signal Format: 525/60, 625/50, and 1125/60 line/field rate

Signal Inputs: 6 video channels. One external reference channel. Return loss > 35 dB, 50 kHz to 30 MHz, power on or off.

Vertical deflection:

Deflection factor: Within 1% of 1V
Variable Gain range: +0, -14 dB

Frequency response:

Flat:50kHz to 10 MHz within 2%, 3% to 20 MHz(x1), within 5% to 6 MHz (x5).
Low pass: 10 dB attenuation at 20 MHz. Low pass response within 1% of flat response at 15 kHz

Picture monitor output:

Corresponds to waveform display. Frequency response 50 kHz to 30 MHzwithin 5% .
Differential gain < 1% at 4.43 MHz
Differential phase < 1% at 4.43 MHz

Physical:

5 1/4" (H) x 8 1/2" (W) x 18 1/8" (D)
Weight 10.3 lbs

Tektronix, Inc.
Wilsonville Industrial Pk.,
P.O. Box 1000
Wilsonville, OR 97070
(503) 682-3411

Product: XD88/35 3D Graphics Superstation

Specifications:

System Architecture:

Central Processor:	Motorola 88100 25MHz Integral floating point unit, 4 88200 CMMUs
System Buses:	Futurebus, VMEbus with 6U and 9U compatibility
Virtual Address Space:	4 GB
Graphics Processor:	4G graphics accelerator, 24 bit Z buffer, 4,8 or 16 additional bit planes
Memory:	8 MB standard, 168 additional optional
Graphics:	4 MB standard, 48 MB additional optional
Display:	
Viewing Area:	11.6 x 9.3 in (Standard) 13.5 x 10.8 in (optional)
Screen addressability:	1280 x 1024
Virtual coordinate space:	4 billion x 4 billion
Colors	
Standard:	256 graphics and 8 dialog simultaneously from 16.7 million palette
Optional:	4096 or over 1 million graphics and 16 dialogs simultaneously

Input and Output:

Memory:	156 MB hard disk, 150 MB streamer tape

Interfaces:

Standard:	4 RS-232-D, centronics, IEEE 802.3 Ethernet LAN, SCSI

Output Devices:

Color Printer Support:	Tek 4693D, 4693DX, 4693 RGB, 4692, 4696, ColorQuick
Monochrome Printer support:	Tek 4644, HP LaserJet, LaserJet+, Epson FX-80, DEC LA210

Tektronix, Inc.
Wilsonville Industrial Pk., P.O. Box 1000
Wilsonville, OR 97070
(503) 682-3411

Product: XN11 Graphics X Station

Specifications:

Display:

Viewing Area:	10.5 x 8.0 in (Standard) 13.6 x 10.2 in (optional)
Screen addressability:	1024 x 768
Virtual coordinate space:	4 billion x 4 billion

Graphics Memory:

Standard:	2 MB
Optional:	6 additional MB

Colors:

Standard:	16 graphics and 8 dialog simultaneously
Optional:	256 graphics and 8 dialog simultaneously 16.7 million color palette.

Input and Output:

Interfaces Standard:	One Rs-232-C host, two RS-232-C peripheral, one parallel,one RGB, one Ethernet TCP/IP LAN

Output Device:

Color Printer support:	Tek 4693D, 4693DX, 4693 RGB, 4692, 4696, ColorQuick
Monochrome Printer support:	Tek 4644, HP LaserJet, LaserJet+, Epson FX-80, DEC LA210

Telettra USA, Inc.
375 Park Avenue
New York, N.Y. 10152
TEL: (212) 355-2600

Product: DTV 45 Video Codec.

Specifications:

Physical:	10.5 x 19 x 12 inches
Video:	
Composite Video Signal:	NTSC 525 lines, 60 fields/s
Video Band Width:	4.2 MHz
Video I/O Level:	1.4 Vpp
I/O impedance:	75 Ohms unbalanced
TV Cable equalizers:	25-175 m
Analog parameters:	
Signal to noise ratio:	>= 60 dB (weighted)
Frequency response:	flat 0.5 - 4.1 MHz
Insertion gain:	0 +/- 0.5 dB
Gain Adjustment:	+/- 3dB
Chrominance to Luminance inequality:	+/-3.8 IRE
Chrominance to Luminance delay:	+/- 28 ns
Differential gain:	<= 4.1% (average)
Differential phase:	<= 1.3 degree (averaged)
Digital studio standard:	4:2:2/525 CCIR Rec. 601

Telettra
20092 Cinisello Balsamo
Viale F. Testi, Milan 136, Italy
(02) 24203.1

Product: DTV 34 DCT Encoder/Decoder

Specifications:

Physical:

Rack:	2600x120x225 mm DTV-34 Tx Coder subrack: 600x120x180 mm DTV-34 Rx Decoder subrack: 600x120x180 mm

Video:

Composite Video Signal:	NTSC 525 lines/ PAL 625 lines
Video Band Width:	NTSC 4.5 MHz/ PAL 6 MHz
Input level:	0.7-1.41 Vpp
Output level:	2 x (0.7-1.41 Vpp)
I/O impedance:	75 Ohms unbalanced
TV Cable equalizers:	25-175 m
I/O return loss:	better than 26 dB over the 25 Hz to 6 MHz band and better than 30 dB in the region of color subcarrier
Video Coding:	9 bits/sample linear PCM
Signal to noise ratio:	better than 58 dB (weighted)
Differential gain:	better than 3%
Differential phase:	better than 2 degree
Digital studio standard:	4:2:2 (CCIR Rec. 601)

Toshiba America Consumer Products, Inc.
82 Totowa Rd.
Wayne, NJ 07470
TEL: (201) 628-8000

Product:: P32H100 32"HDTV Color Monitor

Specification:

Dimensions:	822 x 619 x 658 mm
Weight:	70 Kg
Screen Size:	32"
Field frequency:	60 Hz
Line frequency:	33.75KHz
Resolution:	H 800, V 750 (TV lines)
Video Input:	R,G,B/Y,PB,PR HD VD

Toshiba America Consumer Products, Inc.
82 Totowa Rd.
Wayne, NJ 07470
(201) 628-8000

Product:: P500SRI 50"HDTV Projection Display

Specification:

Dimensions:	1345 x 1705 x 1020 mm
Weight:	135 Kg
Projection System:	Rear Projection
Screen Size:	50" (W 106 x H 622 mm)
CRT:	7" High Contrast CRT x 3
Lenses:	7 Element hybrid lens
Screen:	High Contrast, Fine Pitch Screen
Scan Lines:	1125 lines(HDTV),525 lines(NTSC)
Picture Aspect Ratio:	16:9(HDTV), 4:3(NTSC)
Line frequency:	33.75KHz (HDTV), 31.5KHz(NTSC)
Interlace Ratio:	2:1 (HDTV), 1:1 (NTSC)
Resolution:	H 1000, V 750 (TV lines)
Video Input:	R,G,B/Y,PB,PR HD VD

Toshiba America Consumer Products, Inc.
82 Totowa Rd.
Wayne, NJ 07470
(201) 628-8000

Product: TT-MD5 Muse Decoder

Specification:

Dimension:	430 x 100 x 525 mm 11.4 kg
Input Signals:	MUSE signal Disk Muse signal
Output signal:	
Video Signal:	Y PR PB RGB HD VD
Sound signal:	analog 4 channel 1 analog 4 channel 2 digital 4 channel

Truevision: Inc.
7340 Shadeland Sta.
Indianapolis, IN 46256
(317) 841-0332

Product: ATVISTA 1M/ NuVista 4M

Features:	ATVista 4M	NuVista 4M
PCHOST:	IBM PC AT	Macintosh II
Data Bus Width:	8 or 16	8,16,32
Video Memory:	4 Mbyte	4 Mbytes
Maximum Addressable Resolution:		
32 bit:	1024 x 1024	1024 x 1024
16 bit:	2048 x 1024	2048 x 1024
8 bit:	2048 x 2048	2048 x 2048
Look Up Table:	4 x 2 Kbytes	4 x 2 Kbytes
Alpha Channel:	yes	yes
On board TI34010:	yes	yes
Row Table:	yes	yes
NTSC Compatible:	yes	yes
Pal Compatible:	yes	yes
Genlock:	yes	yes
Zoom(programmable):	yes	yes
Pan:	yes	yes
VMX expansion:	2-10 Mbytes	2-10 Mbytes
Video Memory:	no	no

Truevision Inc.
7340 Shadeland Sta.
Indianapolis, IN 46256
(317) 841-0332

Product: Horizon860 System

Features:

- High performance Intel i860 microprocessor
- 33 MIPS of performance
- 66 MFLOPS
  40,000 polygons/seconds in graphics intensive applications
- Data transfer rate up to 264 MB/second, allowing support of multiple channels of video,audio and data simultaneously
- 64 bit data path, 32 bit address path
- Multiple HorizonBus masters
- Utilizes 1 and 4 Mb DRAM technology
- Can carry 2 memory expansion modules with up to 64 MB of memory
- Linear memory mapping allows host to access and utilize Horizon860 memory

Truevision Inc.
7340 Shadeland Sta.
Indianapolis, IN 46256
(317) 841-0332

Product: Targa M8 Board for PC/AT

Specifications:	
Color Resolution:	256 grey levels or256 colors from a palette of 16,777,216
Input Signals:	4 RS 170 compatible (black & white) Video or analog RGB, Digital RGBI input
Output signal:	Analog RGB Monochrome, RS-170 composite Video
Overlay Capability:	Overlay live input with memory
Memory:	8 bits/pixel 256 kbytes
Overscan:	optional

Ultimatte Corp.
18607 Topham St.
Reseda, CA 91335
TEL: (818) 345-5525

Model:: Ultimatte 6 system

General Specification:

Dimension:	12.22" x 17.67" x 18.75" (Main Unit) 17" x 3.5" x 3.75" (Remote)
Weight:	Main Unit 58 lbs, Remote 8 lbs
Frequency Response:	13 MHz
Delay Time:	560 ns
Interface:	Two RS 422 ports on main unit for connection with system 6 remotes or computer remote. One RS 232 Serial port on remote for connection to external disk drive.
Accessories:	External 3.5" disk drive, transcoder, Link software, Board & software for PC remote.

Inputs:

Fore Ground	RGB: 0.7 V p-p. 525/60 or 625/50 selectable. BNC 75 ohm loop through Screen Correction
RGB;	0.7 V p-p. 525/60 or 625/50 selectable. BNC 75 ohm loop through.This is an optional input.
Background RGB	0.7 V p-p. 525/60 or 625/50 selectable. BNC 75 ohm loop

	through.
BG NTSC/PAL:	1.0 V p-p 525/60 or 625/50 selectable. BNC 75 ohm loop through.
Matte In:	1.0 V composite or 0.7 V p-p Non composite 55/60 or 625/50 selectable. BNC 75 ohm loop through.
REF Video:	BNC 75 ohm Black Burst or Composite Video.
EXT Window:	1.0 V composite or 0.7 V p-p. Non composite 525/60 or 625/50 selectable. BNC 75 ohm loop through.
Time Code:	XLR Female 600 ohm SMPTE/EBU Time Code Terminated

Output:

RGB(2):	0.7 V p-p. 525/60 or 652/50 selectable. BNC 75 ohm
Matte Out:	1.0 V composite or 0.7 V p-p non composite 525/60 or 625/50 selectable.
Window Out:	1.0 V Composite or 0.7 V p-p non composite 525/60 or 625/50 selectable. BNC 75 ohm
Black Burst Out:	Stripped from reference video input and delayed 560 ns.

VPL Research, Inc.
656 Bair Island Rd., Ste. 304
Redwood City, CA 94063
(415) 361-1710

Product: DataGlove Model 2

Performance Specifications:

Joint Coverage:

The standard system instruments the fleexion and hyperextension of th metacarpophalangeal joints of the five fingers, the interphalangeal joint of the thu and the proximal interphalangeal joints of the other four fingers. An additional opti is available to measure abduction between the thumb and the index, the index and tl middle, and the middle to the ring finger accuracy.

Hand Orientation Coverage:

The orientation of Dataglove is all-attitude.

Static Accuracy:

Position: 0.13 inches RMS (Root-Mean Square) between 4" and 15"
0.25 inches RMS @ 30"Linear edgradation between 15" and 30"

Angular: 0.35 degree RMS @ 30"

Data Acquisition and Transfer:

Data Acquisition Rate: 60 times per second, crystal controlled, for each full record

Data Transfer:
RS-232C (dip-switch selectable from 300 to 19200 bps)
RS-422C (dip switch selectable from 900 to 192000bps)

Commands:
One full record at a time
30 full records per second
60 full records per second

DataGlove	Hand size	5
Source	2.4 x 1.4 x 1.4	3.5
Electronics system unit	16.75 x 9.8 x 5.5	300.0

Power Requirements: 110 VAC, less than 100W

Wolfram Research, Inc.
P.O. Box 6059
Champaign, IL 61826
(217) 398-0700

Product: Mathematica 1.2

Purpose:
Numerical, symbolic,and geographical computation, symbolic programming language.

Mode of Operation:
Interpreter (transformation rules are compiled into internal form). Open architecture for connection to external programs.

Machine dependency:

Operation of Kernel is independent of machine (except for commands requiring multitasking); front ends are built for specific machines.

Size of Programme:

2-3 megabytes of compiled code, depending upon computer system.

Versions:
Apple Macintosh; 386 based MS-DOS; Apollo DN 3000 and DN 4000; Ardent Titan; DEC VAX VMS and Ultrix, and DECstation 3100; Hewlett-Packard 9000/300 and 800; IBM AIX/RT; MIPS; NeXT;Silicon Graphics Iris-4D; Sony NEWS; Stellar GS-1000; Sun3, 4 and 386i.

Zenith Electronics Corp.
1000 Milwaukee Ave.
Glenview, IL 60025-2493
(708) 391-8181

Product: ZEC 20" FTM CRT

Specifications:

Size:	20" Diagonal
Active Video Display	15.2" x 11.4" x 19"
Resolution:	1280H x 1024V
	Dot Pitch 0.21mm
Scan Frequency	Horizontal 64 Khz
	Vertical 60 Hz
Features:	Flat Tension Mask Technology with `DQ` gun

Dark tinted glass (44% glass transmission)for cont enhancement There will be no noticeable color impurities anywhere in th display area. Convergence is 0.2mm (`A`Zone) /0.4mm (`B`Zone Brightness is 3 Line Straightness less than 2.5mm (full screen vertical lines), less than 2.0mr screen horizontal lines), less than 1.0mm (any half line segment).

Zenith Electronics Corp.
1000 Milwaukee Ave.
Glenview, IL 60025-2493
(708) 391-8181

Product: ZEC 1592-IAF 15" FTM Color Monitor

Specifications:	
Size:	15" Diagonal
Screen Size	11.0"H x 8.25"V
Resolution:	640 x 480
	Dot Pitch 0.28mm
	Sync (Horizontal and Vertical) 5V TTL
	separate Sync negative/positive polarity
Features:	Flat Tension Mask Technology with \`IAF\`gun
	Improved Astigmatic Focus
	Dark Tinted Glass (30% glass transmission)
	for contrast enhancement
Video Bandwidth	better than 28 Mhz (+/.3db)
Brightness	60 Ft-L
Convergence	0.3mm (\`A\`Zone)/0.5mm (\`B\`Zone)
Price:	
Availability:	

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