



<https://www.youtube.com/watch?v=pCVUOxvQWaU>

Bill Buxton, Alias' Chief Scientist in 1994, has a collection of Alias videos on his website at

<http://billbuxton.com/buxtonAliasVideos.html>

8.4 Alias/Wavefront



Alias/Wavefront Logo

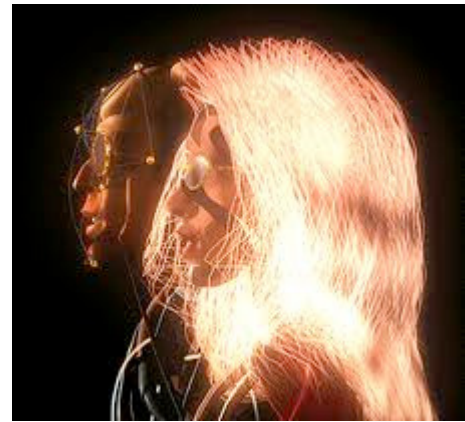
The corporate history of Wavefront Technologies changed dramatically in 1995, with the merger of Alias and Wavefront. On February 7, 1995, Wavefront Technologies, Inc., Silicon Graphics, Inc. and Alias Research, Inc. announced that they entered into definitive merger agreements. The new company's mission was to focus on developing the world's most advanced tools for the creation of digital content. "We created digital skin, then [Alias] did; now they've created digital hair and we're working on digital clothing. With both of us working together, we can attack the bigger technical problems instead of duplicating work," said Mark Sylvester, cofounder of Wavefront.

In April, 2003 the company was renamed Alias.

Following are some important events in the continuing history of the new company:

- 1995 – Alias used in films including *Toy Story*, *Pocahontas*, *Casper* and *Golden Eye*, and *Batman Forever*.
- 1995 – Sega Interactive uses PowerAnimator to create Stars Wars Arcade.
- 1996 – Alias|Wavefront sets up new offices in Hong Kong, Singapore, Malaysia and Australia.
- 1996 – Alias|Wavefront's Chris Landreth is nominated for an Academy Award for the short film, *The End*, to test new features added to the development of Maya including motion capture, **facial animation** and hair. (See Section 19.8 for more on Landreth.)

- 1997- Alias|Wavefront reports a 44% increase in its sales over the previous year in industrial design sales and attributes it to the delivery of new advances in CAID technology as well as the release of new product versions: AliasStudio 8.5, Alias AutoStudio 8.5 and Alias Designer 8.5 Its existing customers include Philips design, Daewoo(UK), Rubbermaid, BMW, Renault, Honda and Audi.
- 1997 – Ford Motor Company chooses AliasStudio to standardize its existing computer-aided industrial design processes. Valued at over \$4 million in sales and services, this is one of the largest sales in the company history. As a significant step in the implementation of Ford’s C3P program, the purchase of AutoStudio represents the automaker’s decision to replace its existing computer-aided industrial design processes and standardize on Alias|Wavefront software.



Scene from Landreth Film

- 1997 – Launch of Composer 4.5 featuring motion blur, lens distortion and time warp technology. Effects created with Composer are featured in many Hollywood films including *Mars Attacks*, *Dante’s Peak*, *Casino*, *Broken Arrow* and *Waterworld*.
- 1998 – Alias|Wavefront introduces its new 3D flagship product Maya. Maya is a leader in the industry in the following key areas: bringing characters to life, explosive visual effect and system architecture. Representatives from Blue Sky/VIFX, Cinesite, Dream Pictures Studio, Dream Quest Images, GLC Productions, Kleiser-Walczak, Rhonda Graphics, Square, Santa Barbara Studios and Imagination Plantation were among many of the BETA customers to support Maya. Industrial Light & Magic makes a strategic investment in purchasing enough seats of Maya to give technical directors and artists throughout its digital production departments extensive use of Alias/Wavefront’s most advanced 3D software.
- 1998 – Academy Award Plaques are awarded to Bill Kovacs and Roy Hall of Wavefront for the development of Advanced Visualizer. Certificates are awarded to Jim Keating, Michael Warhman and Richard Hollander for their contribution to the development of the Advanced Visualizer. Plaques are also awarded to John Gibson, Rob Krieger, Milan Novacek, Glen Ozymok and Dave Springer for PowerAnimator. Advanced Visualizer is acknowledged by the Academy as the first commercial software package for modeling, animating and rendering adopted into widespread use to create digital images with sufficient quality for motion pictures.



Maya Logo

- 1998 – Chris Landreth produces *Bingo*, an animated short, to run Maya through its paces, pushing the product to its limits and making sure it lives up to the industry’s expectations. In *Bingo*, Chris Landreth introduces a cast of animated characters who are human-like and disturbingly freakish. *Bingo* garners international attention and is recognized at film festivals around the world.
- 1999 – Alias|Wavefront announces industrial design software Studio and DesignStudio for the Windows NT platform. Studio and DesignStudio are the choice of major automotive companies such as BMW, Fiat, Ford, Honda, Italdesign, and Renault.
- 1999 – Maya Complete incorporates all of the tools and features for world class animation on both IRIX and NT platforms. Maya Complete has been developed to provide state-of-the-art 3D solutions for a more broader, professional market. It includes Alias|Wavefront’s award winning 3D modeling, rendering, and animation technology.
- 1999 – Maya Unlimited, the new graphics production suite for high-end film and video industry is introduced. Maya Unlimited incorporates all of Maya Complete elements plus Maya Cloth, Maya Fur, Maya Live, and Maya Power Modeling. It addresses the unique needs of high-end production houses, by providing them with tools that will help solve complex problems.
- 1999 – A subset of Maya Complete, Maya Builder was optimized to address the specific needs of level designers and programmers in the game and interactive title development community.
- 1999 – Alias|Wavefront announces at SIGGRAPH 99 that Maya has been used by Industrial Light & Magic (ILM) in the summer blockbusters *Star Wars: Episode I “The Phantom Menace,”* *The Mummy,* and *Wild, Wild West*.
- 2000 – Alias |Wavefront includes a universal rendering policy for the release of Maya 3 that enables Maya Complete and Maya Unlimited customers to “float” the Maya Batch Renderer across any number of machines on Windows NT, IRIX and Linux platforms.
- 2000 – Alias|Wavefront announces its intentions in bringing Maya to the Apple® Mac® OS X platform.
- 2000 – Alias|Wavefront was rewarded with its largest, single software agreement ever from General Motors. The primary software provided is AutoStudio, SurfaceStudio, and StudioPaint
- 2000 – Maya was used to create the top four selling December 2000 titles for the PlayStation® 2 console. Electronic Arts (EA) Madden NFL 2001 led the list of top-sellers for December with SSX: Snowboard Supercross (EA) second, Tekken Tag Tournament (Namco) third, and NHL 2001 (EA) fourth. All three nominees for Best Visual Effects in a motion picture used Alias |Wavefront software. *The Matrix*, (Manex) *Stuart Little*, (Sony) and *Star Wars Episode I: The Phantom Menace*, (ILM) were rewarded with nominations for the ground breaking work in film. *The Matrix* went home with the Oscar.
- 2001 – In March, Alias|Wavefront ships entire suite of Maya 3D software products to the Red Hat™ Linux® operating system.
- 2001 – Alias|Wavefront expansion program continues with the release of version of its 3D computer-aided industrial design (CAID) software family, StudioTools, made specifically for the Hewlett-Packard® HP-UX® operating system.



Scene from *Bingo*

- 2001 – Maya software played a pivotal role in allowing Square® USA to create a 23-digital-person cast for the much anticipated summer film *Final Fantasy*.
- 2001 – The recently unveiled mental ray® for Maya technology ships.

NOTE: In October of 2005 Autodesk announced that it had signed an agreement to acquire Alias. In January of 2006, the [acquisition](#) was finalized for US\$197M in cash.

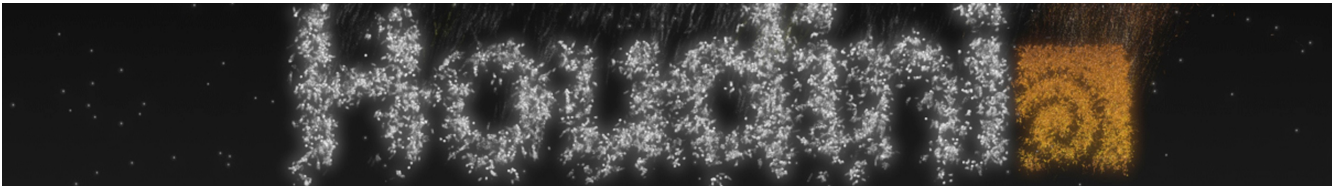
Movie 8.6 Alias/Wavefront Maya



1998 Alias/Wavefront Maya demo reel

<https://www.youtube.com/watch?v=pHFLapfliN8>

8.5 Side Effects



The following history of Side Effects was extracted from? <http://www.sidefx.com>



Side Effects Logo

Based in Toronto, Canada, Side Effects Software was established in 1987 by Kim Davidson and Greg Hermanovic, an animation director and programmer respectively. This duo founded their new production/software company on a 3D animation package, PRISMS, which they had acquired from their former employer Omnibus. Side Effects Software developed this procedural modeling and motion product into a high-end, tightly-integrated 2D/3D animation software which would incorporate a number of technological breakthroughs.

Prior to co-founding Side Effects, Hermanovic worked as the Director of Research at Omnibus. When the company went bankrupt in 1987 he teamed up with Director of Animation, Kim Davidson, to buy the rights to the company's PRISMS 3D animation software code. The two partners incorporated Side Effects and set out both to provide content for the Toronto broadcast market and to continue developing PRISMS. In the time that has elapsed since then, the company has turned its attention fully toward development and grown to become one of the world's leading 3D animation software providers. Throughout his career with Side Effects Software, Hermanovic was the driving force behind the implementation of such cutting edge innovations as: procedural modeling, morphing and CHOPs (nonlinear, nondestructive motion editing). Hermanovic was experimenting with C-music and algorithmic composition as far back as 1982. In February 2000, he founded Derivative, Inc. to bring professional special-effects technology to the VJ (visual jockey) scene. Derivative produces innovative tools for designing and performing interactive 3D artworks and live visuals.

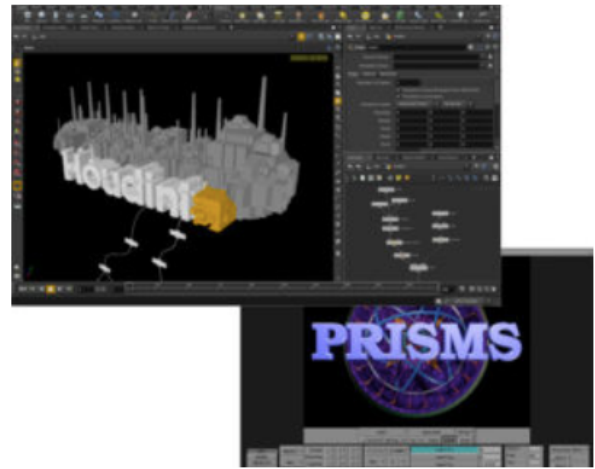


Kim Davidson

Davidson also owned Catapult Productions, which was founded in 1992 for the purpose of creating entertainment using computer character animation. Their specialty was children's content. He graduated from the University of Waterloo with degrees in Architecture and Mathematics and did extensive graphics programming since 1980. He was the animation director at two large commercial animation houses in Toronto from 1986-1990 and worked on or directed over 300 hundred computer animated pieces in that time.

PRISMS was used extensively to create visual effects for broadcast and feature films in the late '80s and '90s. Early film projects included: *Apollo 13*; *Twister*; *The Fifth Element*, *Independence Day* and *Titanic* – the last two having won an Academy Award for Best Visual Effects. The company would continue to develop and support PRISMS until version 7.1 in 1998.

At SIGGRAPH 1996 Side Effects Software introduced Houdini: a next-generation 3D package that would prove to be more sophisticated and artist-friendly than its predecessor. From the following year to the present Houdini has been honored with numerous awards including an annual CGW Innovation Award. Houdini is used around the world to develop cutting edge 3D animation in the film, broadcast and gaming industries. To better serve the needs of its West Coast clients, Side Effects opened a Santa Monica, California-based office in 1995. The positive results can be seen in such recent hit movies such as *Fight Club*, *Hollow Man* and *X-Men* as well as Academy Award winners: *What Dreams May Come* and *The Matrix*.



Houdini/Prisms



Davidson, Hermanovic, Breslin and Elendt

In 1998 the Academy of Motion Pictures Arts and Sciences presented a Technical Achievement Award to Side Effects Software principals Kim Davidson and Greg Hermanovic and programmers Paul Breslin and Mark Elendt, for the development of the procedural modeling and animation components of PRISMS. Whether it's procedural motion/animation, or motion and audio editing, Side Effects Software has proven itself time and again to be an industry innovator. Some of the first breakthroughs that Side Effects included a high-end commercial 3D animation package:

- 1987 First to put a GUI on a **procedural modeling** system
- 1988 First to incorporate an expression language in the user interface
- 1989 First to add **metaballs**; First to have a polygon reduction tool (greduce)
- 1992 First to include a particle system; First to have a morphing package (mojo)

- 1993 First to have integrated motion capture (moca); First to include time frame sampling (tima)
- 1995 First to integrate all components (modeling, animation, rendering, compositing) into one executable; First to support NURBS, polygons, and Beziers as “equal citizens”
- 1998 First to have audio editing (Chops); First to put a GUI on a procedural particle system; First to introduce hierarchical splines
- 1999 First to port to the Linux O/S

Movie 8.7 Side Effects



Side Effects 20 Year Anniversary Reel (2007)

<https://www.youtube.com/watch?v=ScrDrCN5b5s>

8.6 Softimage



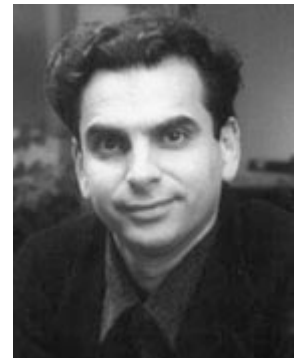
The following history of Softimage was extracted from corporate historical accounts.



SoftImage Logo

Softimage was founded in 1986 by National Film Board of Canada filmmaker **Daniel Langlois**. Langlois wanted to create animated films but was dissatisfied with the existing technology, which he felt was insufficient for his needs and designed to be used by computer scientists and technologists. His vision was a software company that addressed the creation of 3-D animation software not only for, but by artists. He felt that the concept marked a fundamental shift in how the industry viewed visual effects creation and generated a new breed of visual effects artists and animators. Other important members of the company included artist Char Davies (Davies left the company at the end of 1997 to pursue her artistic research separately.) Several important milestones that have influenced the industry have come from the “artist/technology” vision:

- the first integrated animation and effects system
- the first company to port animation tools to PC (NT)
- a broadening of integration to include post-production – with the release of Softimage|DS (now Avid|DS) and Softimage|XSI
- the expansion of animation and effects tool accessibility to the mass-markets in games and web content industries.



Daniel Langlois

The first development effort for the startup company was the Softimage Creative Environment system, with “creative workflow and process integration”. In 1987 Langlois and engineers Richard Mercille and Laurent Lauzon began development of the company’s 3-D application software. Creative Environment 1.0 was launched

at SIGGRAPH 88. For the first time, all 3-D processes (modeling, animation, and rendering) were integrated. The system featured advanced tools and the first production-speed ray tracer. Creative Environment (eventually to be known as Softimage®|3D), became the standard animation solution in the industry.

Over the next several years the development team at Softimage released new versions of the 3-D software that included new innovations in image creation. For example, Creative Environment 1.65 added texture mapping (1989), Creative Environment 2.5 (1991) featured the Actor Module with IK (inverse kinematic), enveloping, and constraints, which enabled animators to combine conventional techniques (such as editing and keyframing) with these new capabilities. The system later won an award from the Academy of Motion Pictures Arts and Sciences. In 1990, the software was sold with an SGI workstation for \$65,000.

Softimage went public on NASDAQ in 1992. That same year they started an aggressive acquisition effort, with the inclusion of the EDDIE® software and Painterly Effects. This provided a complete effects generation toolkit with advanced image processing tools for color correction, filtering, rotoscoping, morphing and painting. 1992 also saw an important corporate philosophy realized as Softimage opened their software to third-party developers. The channels performance capture technology offered a new dimension to CG character animation. The technology was used that year to create a memorable spot featuring 3-D dancing cars and gas pumps for Shell Oil.

1993 saw the second public offering of Softimage stock. The expansion of the creative product environment continued, with an agreement between Softimage and mental images that addressed rendering technology. Creative Environment 2.6 was released, featuring file management, metaclay, clusters, flock animation, weighted envelopes, channels, and an expansion of the open system policy. The Creative Toonz 2-D animation package automated the more tedious tasks involved in 2-D cel animation, such as inking-&-painting, while still maintaining the look of hand-drawn images and characters. With computer workstations advancing to be able to handle video, Softimage began the development of Digital Studio, as a step towards integrating the 2D/3D production pipeline. The power of a post-production environment in a software-based solution is consistent with Langlois' original vision for the company. mental ray®, an advanced stand-alone rendering system and Particles, an interactive particle animation system used to create natural phenomena such as clouds, snow, fire, etc. became part of the Softimage stable.

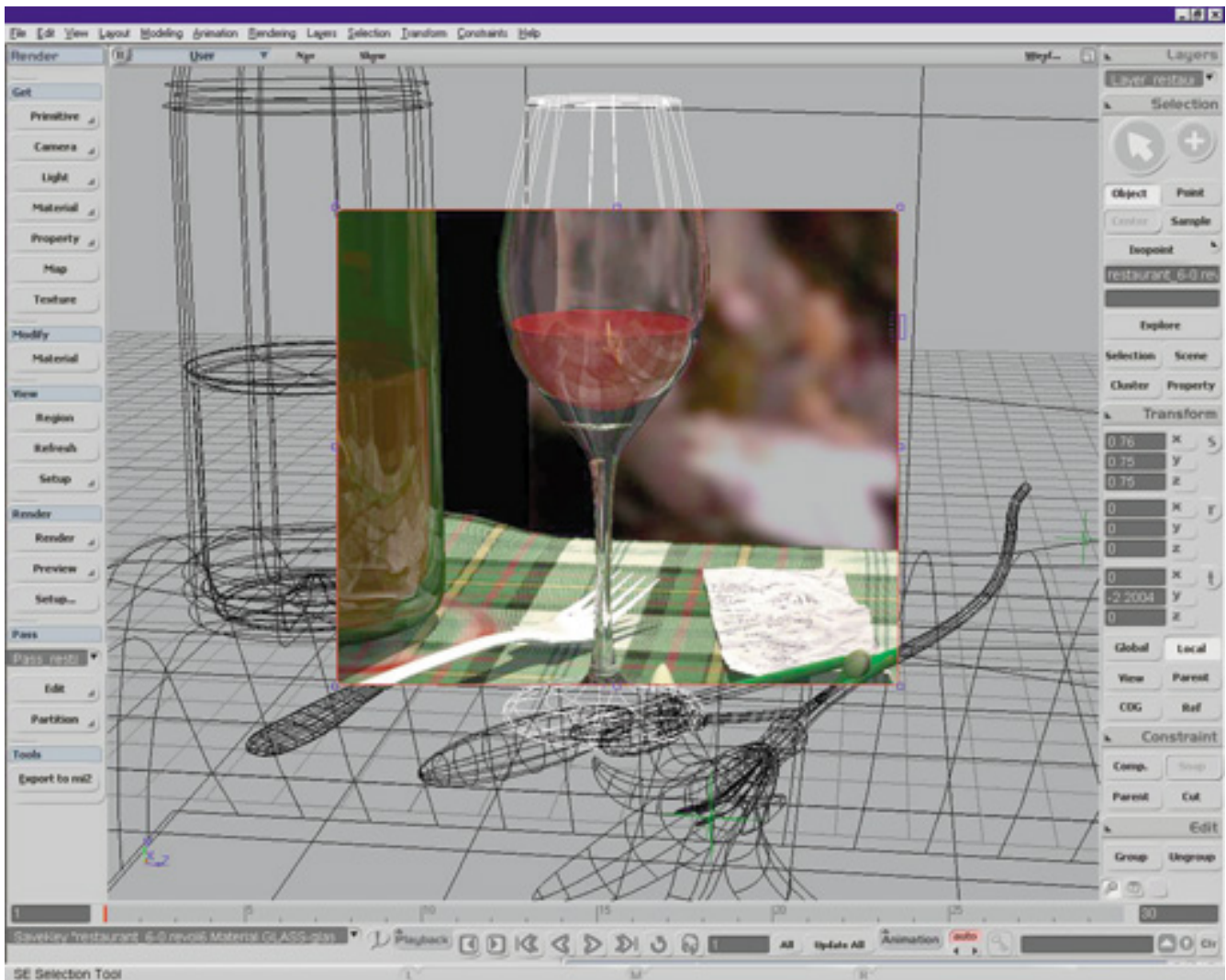
In 1994 Softimage merged with Microsoft Corporation, who acquired the company for \$160M. Creative Environment 2.65 was released which featured expressions, dopesheet, ghost mode, and shape interpolation. The IDEAS (Interactive Developer's Entertainment Authoring Software) with ProPlay and ProPlay Plus was released. This software included Softimage Creative Environment, NURBS support, polygon and color reduction tools, dynamic simulations and inverse kinematics. It also featured Eddie compositing, video-effects software, distributed ray tracer and the 3-D particles kit. Much of this system was aimed at the evolving game developer market.

Exploiting the power of the Pentium processor, Softimage developed the first high-end product on Irix and Windows NT in 1995. Creative Environment became Softimage|3D with a release that featured NURBS modeling, relational maudlin, trimming, instantiation, polygon reduction, tangent-to-path, constraint, Q-stretch, expressions, motion control, Actor, Particle, mental ray rendering, and Metaclay. (Langlois received a Scientific and Engineering Award from the Academy of Motion Pictures Arts and Sciences in 1998 for Actor). User-interface enhancements included hot-key remapping. The Softimage|3D "extreme" version included *Osmose*

(virtual reality), the new Virtual Theatre (featuring performance capture and real-time compositing), and mental ray. The Softimage|Toonz version 3.5 and Softimage|Eddie version 3.2 were also released.

The next two years saw the release of Softimage|3Dv 3.5 and Softimage|SDK Trance, “Sumatra”(code name) and RenderFarm, and Softimage|DS, one of the world’s most comprehensive nonlinear production systems (NLP™) for creating, editing and finishing videos. Softimage|DS enabled users to seamlessly integrate picture and audio editing, compositing, paint, image treatment, special effects, character generation and project management into one environment.

In 1998 Avid Technology, Inc. acquired Softimage for \$247.9M (some reports indicate that the purchase price was closer to \$300M). The two companies joined forces to develop the next generation tools for digital artists. The Animation Sequencer was introduced, and in 1999 “Sumatra” became the world’s first nonlinear animation editing system and merged all 3-D animation, editing, and compositing tasks. In 2000 The Motion Factory, Inc., was acquired. The Fremont, CA-based company specialized in applications for the creation, delivery and playback of interactive rich 3-D media for character-driven games and the Web. In 2001 Softimage entered into an Xbox tools and middleware agreement with Microsoft, and they announced support for Linux. Softimage and Electric Rain collaborated to bring Flash, EPS, AI and SVG exports to Softimage|XSI customers. Michael Stojda became the Managing Director of the company in April of 2001 after working at Softimage and Avid and managing a wide range of effects, editing, and finishing products at both companies.



Screenshot composition from Softimage

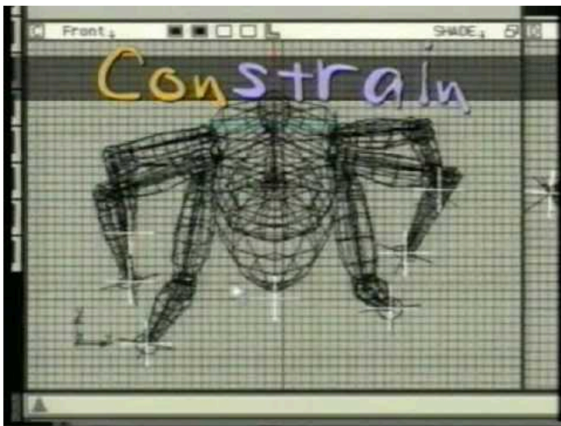
Softimage customers include some of the most prominent production studios, such as Industrial Light and Magic, Digital Domain, Sega, Nintendo, and Sony . They have used Softimage to create animation for hundreds of major feature films (*Jurassic Park*, *Titanic*, *The Matrix*, *Men in Black*, *Star Wars – the Phantom Menace*, *Gladiator*, *Harry Potter*, *AI: Artificial Intelligence*, *Pearl Harbor*, *Queen of the Damned*), games (Super Mario 64, Tekken, Virtual Fighter, Wave Race, NBA Live) and thousands of commercial, corporate and student projects.

On October 23, 2008, Autodesk signed an [agreement](#) with Avid Technology to acquire the brand and the 3D animation assets of Softimage for approximately \$35 million, thereby ending Softimage Co. as a distinct entity. The video-related assets of Softimage, including Softimage|DS (Avid|DS) continued to be owned by Avid. In 2014, Autodesk [announced](#) that it would “retire” Softimage and provide a migration platform for their customers to either the 3ds Max or Maya products.

Michael Burns. [The Long and Lonely Death of Softimage](#), Digital Arts, March 17, 2014.

In the Spring of 1997 through an endowment provided by Daniel Langlois, the *Daniel Langlois Foundation* was established. It is a private philanthropic organization whose scope of activity is international. The purpose of the Foundation is to further artistic and scientific knowledge by fostering the meeting of art and science in the field of technologies. “The Foundation’s mission is to promote contemporary artistic practices that use digital technologies to express aesthetic and critical forms of discourse, to encourage interdisciplinary or multidisciplinary research projects and, in general, to support the development of projects calling for cooperation between people from a variety of fields, such as artists, scientists, and engineers or technologists.” explained the Foundation’s Director of Programs, Jean Gagnon.

Movie 8.8 Softimage



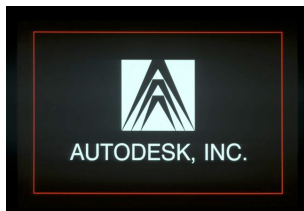
Softimage Animation Reel (1995)

<https://www.youtube.com/watch?v=LrNQqvAKO2o>

This is Part 1 of 2. The second part can be viewed at

<http://www.youtube.com/watch?v=xHeKXv4BY0M>

8.7 Autodesk/Kinetix/Discreet



Autodesk Logo

Autodesk Inc. was founded in 1982 with a focus on design software for the PC. They went public in 1985. For a first-person account of the history, read **John Walker**'s online history of Autodesk at <http://www.fourmilab.ch/autofile/> told through the letters and memos from and to the inner circle of the company.

Autodesk in 1986 began efforts to develop an animation package. Key developers were Jamie Clay and Autodesk founder John Walker. Autodesk's first animation package was AutoFlix (for use with AutoCAD and AutoShade), and AutoFlix 2.0 which included the Animation Tool Kit for AutoCAD.



John Walker

In early 1988, Gary Yost left Antic, developers of software for the Atari, to pursue a contract development deal with Eric Lyons and David Kalish at Autodesk and to begin work on Autodesk 3D Studio (code-named THUD after its principal developer Tom Hudson), and Autodesk Animator. Gary brought Jack Powell along, too, and the Yost Group, Inc. was born. (The Yost Group was eventually bought by Autodesk.)

At the 1989 SIGGRAPH in Boston, Autodesk unveiled a new PC based animation package called Autodesk Animator. As a full featured 2D animation and painting package, Animator was Autodesk's first step into the multimedia tools realm. The software-only animation playback capabilities achieved very impressive speeds and became a standard for playing animation on PCs.

This early PC based animation software was used to visualize how nano machines might look. This animation was used in the BBC documentary "Little by Little" and was the first time an Autodesk animation product had been used for broadcast television.

Shortly before the release of the next generation of 3d Studio in 1996, the product MAX, the Multimedia Division of Autodesk was renamed to Kinetix, A Division of Autodesk. MAX shipped as Kinetix 3D Studio MAX. Since

its release in 1997, 3D Studio VIZ continues to gain more acceptance within the architectural community for design and visualization. As a result it has shifted more specialized architectural users from MAX to VIZ. 3D Studio VIZ enables professionals in the architectural, land design and mechanical design sectors to design in 3D Studio VIZ and then transfer the images directly into a CAD environment.



Discrete Logo

Discreet, a division of Autodesk, was established in 1999 after Autodesk acquired Discreet Logic Inc. for US\$520M and merged its operations with Kinetix®. Autodesk is the world's leading design and digital content creation resource. The company provides software and Internet portal services to help customers drive business through the power of design. One of the largest software companies in the world, Autodesk helps more than 4 million customers in over 150 countries turn designs into reality.

From an investment banker's research analysis:

“Since its launch, 3D Studio Max has had a phenomenal impact on the 3D animation market. Originally priced much lower than some of its counterparts who's products ranged anywhere from \$10,000 to \$45,000, 3D Studio Max was quickly viewed as the attainable solution for professionals that had some price/performance issues. It continues to maintain strong price/performance value for users and the product's expectancy remains high. One of the key success factors of 3D Studio Max has been the product's ability to address the needs of a wide range of 3D animation professionals. Of all the animation packages 3D Studio Max runs across more vertical markets than any other package. Its largest user base continues to be within the game development sector. Aside from game development, it is used in film and broadcast, corporate design, industrial design and visualization, educational, forensic, and now Internet design.”

One of the keys to this broad base of users is it's open architecture and support of third party vendors. This has enabled the product to build up over 100 plug-in products for more specialized functionality. Third party developers can develop standalone software modules (plugins) which can interface with the 3D Studio product. One of the more prominent plugins is Character Studio, developed by *Susan Amkraut and Michael Girard* of Unreal Pictures. Girard and Amkraut were the creators of the famous animation *Eurhythmy* while they were students at Ohio State, and developed the cult legend “*Dancing Baby*” as a test of their software. In 2004, Autodesk division *Discreet acquired Unreal Pictures*.

In January of 2006 Autodesk acquired Alias for \$197M in cash, bringing the StudioTools and Maya software products under the Autodesk banner.

Movie 8.9 Eurythmy

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/eurythmy-1.m4v>

This video is an excerpt from the movie Eurythmy by Michael Girard and Susan Amkraut.

Movie 8.10 Baby Cha

<https://osu.pb.unizin.org/graphicshistory/>

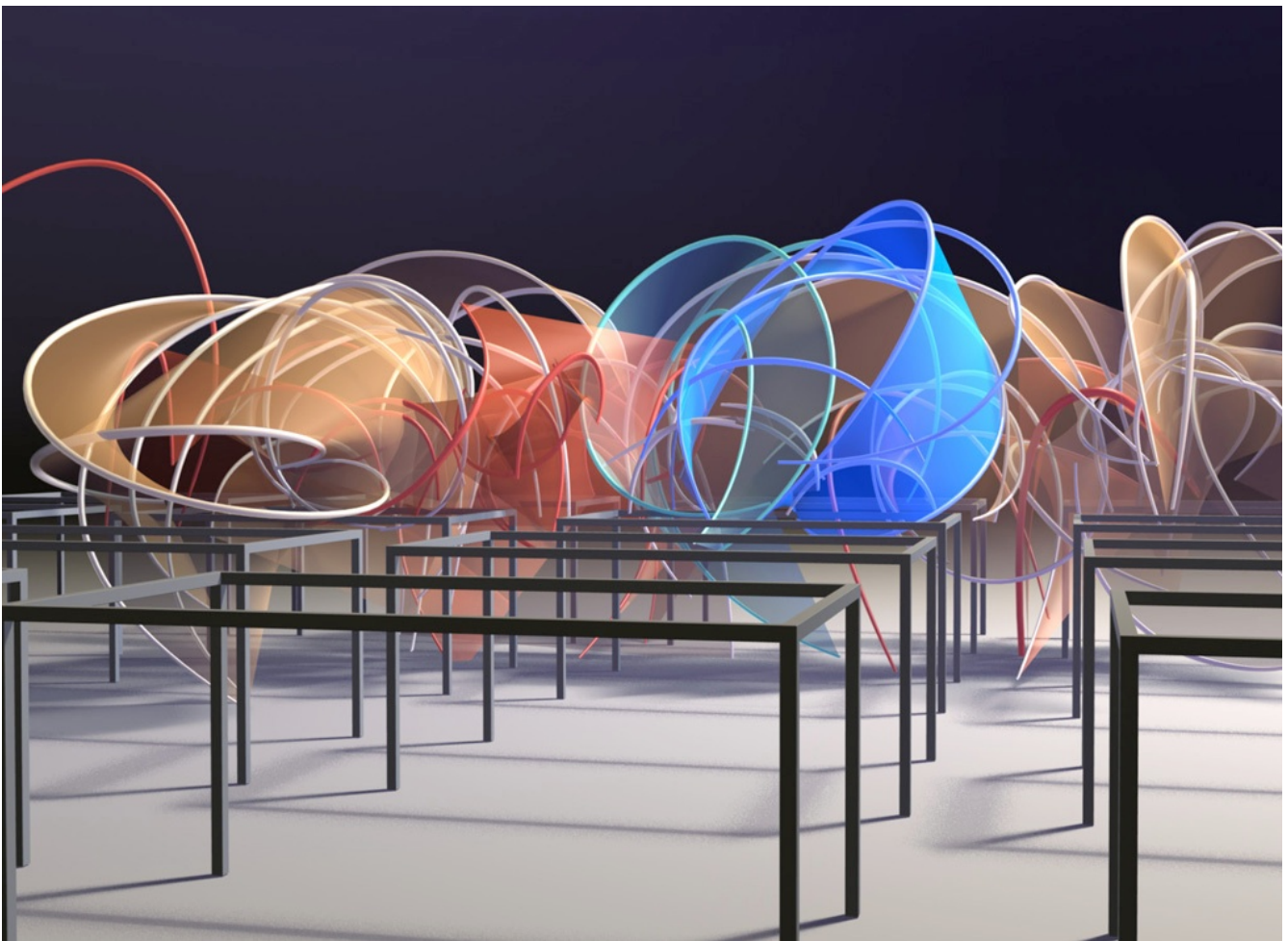
[wp-content/uploads/sites/45/2017/04/
baby1-1.m4v](#)

Michael Girard of Unreal Pictures originally used the surreal Dancing Baby figure as a sample to show off his animation software. It evolved as a popular Internet “meme”

Chapter 9: Computer Artists

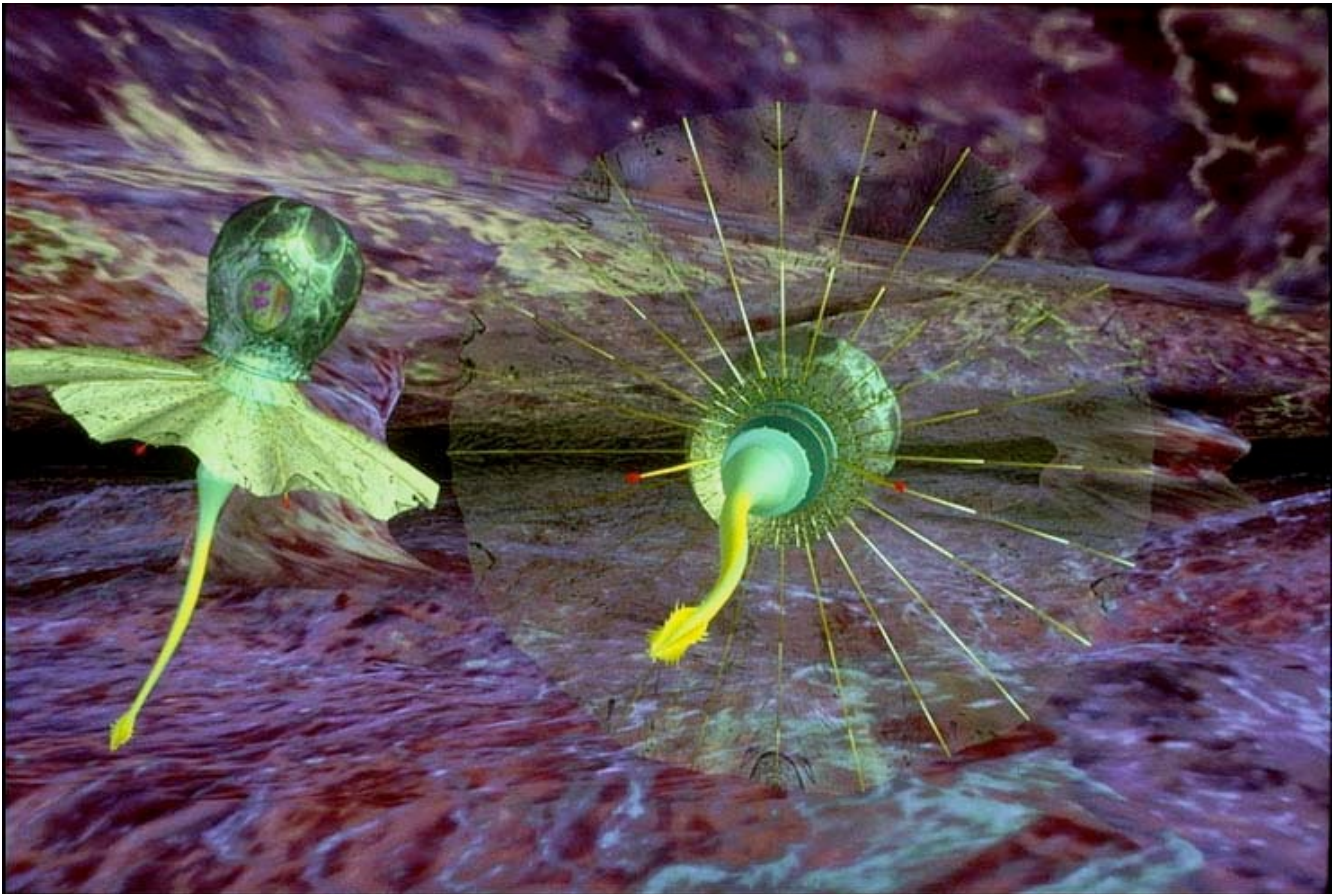
Computer Artists

As computer graphics software developed, many of the earliest users of this new technology were artists, or in some cases, scientists using the image making capabilities to create artwork.



Animation of dancer's traceforms in *One Flat Thing*, reproduced to map to 3D space.
Credit: Synchronous Objects Project, The Ohio State University and The Forsythe Company (2009)

9.1 Introduction



The mid-1960s saw many artists becoming interested in the creative activities at the confluence of art and technology. Previously, most individuals involved in the creation of computer art were in fact engineers and scientists. This was due to several factors: 1) access to mainframe computers, the only kind of computing resource available at the time, was available only to scientists at industrial and university scientific research labs; 2) there was no real interactive software, requiring the scientific programming expertise of the engineers or scientists; 3) the process of art-making on the computer was very algorithmic in nature, which was not necessarily the way traditional artists were used to thinking; and 4) the art community was hesitant to regard the new art form as a reputable or even acceptable art form.

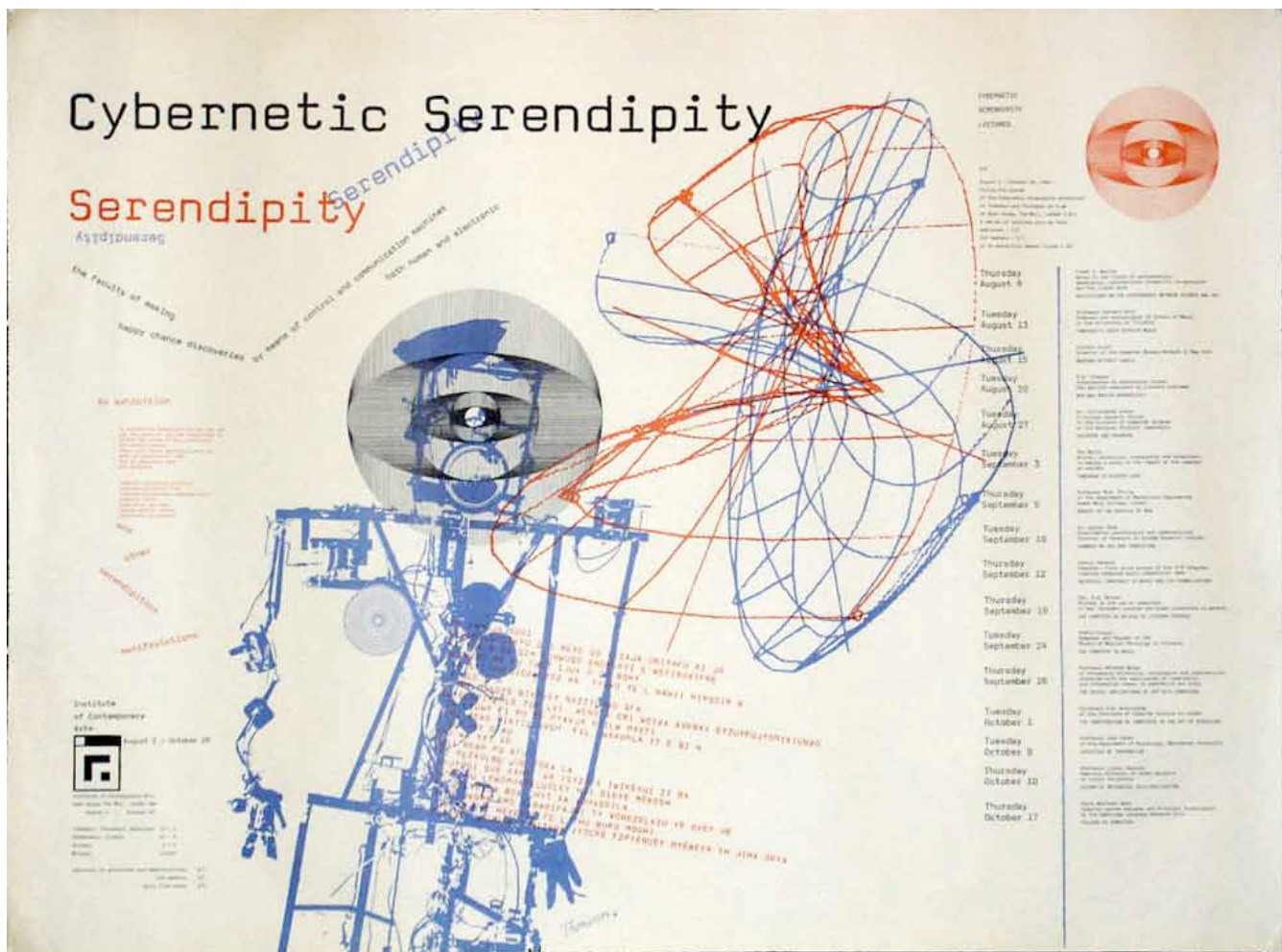
In spite of this, and maybe in part because of this, collaborations between artists and scientists began, and in many cases flourished. It was not without difficulty, however. As Ken Knowlton portrayed the two mindsets:

Artists are illogical, intuitive, and impulsive

Scientists are constrained, logical, and precise

In many cases, the scientists themselves were portrayed as, or at least called themselves artists. In some cases, artists learned the complexities of interacting with the computer and became hybrid in their approach. The first two exhibitions of computer art (at the Wise Gallery in New York and in Stuttgart Germany, both in 1965), were organized by scientists. Most of the submissions, and nearly all of the selections were from scientists. Nevertheless, they were important events in the establishment of computer art as a recognized and eventually an accepted art form.

In 1966, Bell Labs engineer Billy Klüver and artist Robert Rauschenberg founded a formal entity to “develop an effective collaboration between the artist and the engineer.” This organization was very important in recognizing the important intersections between the artist and the computer. Called the *E.A.T.* (Experiments in Art and Technology) it provided an environment that encouraged important artistic creations, including collaborations between contributors such as Kluver, Andy Warhol, Rauschenberg, John Cage and Jasper Johns. Support was in part provided by Bell Labs.



Cybernetic Serendipity Poster (1968)

One of the most important early artistic exhibitions of computer art and digital installations was called *Cybernetic Serendipity*, which was held in 1968 at the Institute of Contemporary Arts in London. Organized by Jasia Reichart, it included most of the important contributors to the technology art world at the time, including Charles Csuri, Michael Noll, Nam June Paik, Frieder Nake, John Whitney, John Cage and others. Although it was not the first computer art exhibition, it is acknowledged as an important milestone in the recognition of this new medium in the art world.

Cybernetic Serendipity ran for two months and featured exhibits from 325 participants from around the world. They showed off the latest in computer graphics and some early computer-composed music. There were robots and drawing machines and the first computer sculpture.

The exhibition was the first of its kind in Britain and the curator Jasia Reichardt wrote that it showed how “man can use the computer and new technology to extend his creativity and inventiveness.” It later traveled to Washington, DC and San Francisco between 1969-70.

In several previous chapters, most notably Chapter 4, several pioneering computer artists (Whitney, Laposky, Noll, Csuri, Knowlton, vanderBeek, Foldes, Em, and others) were featured. This section highlights several more artists, representing artistic activities that have contributed to the broader discipline of computer graphics and

animation; it is not intended to be an exhaustive treatment of the computer art discipline; that is beyond the scope of this document. I refer you to several sources, including the online Digital Art Museum, Cynthia Goodman's book *Digital Visions* , and *The Computer in the Visual Arts* by *Anne Morgan Spalter* for more information in this regard.

Dietrich, Frank, "*Visual Intelligence: The First Decade of Computer Art (1965-1975)*", Leonardo, V19 #2, pp. 159-169, 1986

Franke, Herbert, *The New Visual Age: The Influence of Computer Graphics on Art and Society*, Leonardo, Vol. 18, No. 2, pp. 105-107, 1985.

Jones, Beverly, *Computer Imagery: Representation and Realities*, Leonardo, International Journal of Science and Art , Computer Art in Context: 1989 A Special Edition Juried by the Special Interest Group in Graphics (SIGGRAPH) Association of Computing Machinery (ACM)31- 38.

Macgregor, Brent, *Cybernetic serendipity revisited*, Proceedings of the fourth conference on Creativity & cognition, Loughborough, UK
pp, 11 – 13, 2002

Digital Art Museum timeline

<http://www.dam.org/timelines/artists>

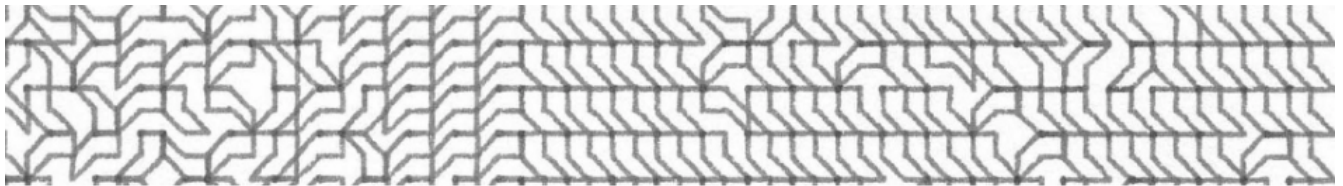
An essay specially written by Mike King for the Digital Art Museum, traces the relationship between the Pioneers of computer fine art and Modern art movements.

<http://www.dam.org/essays/king-digital-art-museum-2002>

Goodman, Cynthia, *Digital Visions: Computers and Art*, Abrams, 1987 (published in connection with the exhibition Computers and Art at the Everson Museum of Art in Syracuse, NY, 1987)

Spalter, Anne Morgan, *The Computer in the Visual Arts* (Addison Wesley) 1999

9.2 Vera Molnar



Vera Molnar was born in 1924 in Budapest, Hungary. After studying at the Budapest Academy, she received her diploma in 1947 in Art History and Aesthetics. Her artwork has always been focused on abstract and geometrical paintings. That same year, she received the Rome Scholarship and moved to Paris.

In 1960, Molnar co-founded the “Groupe de recherche d’art visuel” , or GRAV (GRAV was founded in July 1960 by Vera Molnar, François Morellet, Horacio Garcia Rossi, Julio Le Parc, Francisco Sobrino, Joël Stein, and Jean-Pierre Yvaral). This group was a proponent of stripping the content away from the visual image in their medium in order to focus on seeing and perceiving. They were instrumental in the **Op-art** and **Kinetic Art** movements of that decade. Molnar was also co-founder of the group “Art et Informatique” at the “Institut d’Esthetique et des Sciences de l’Art” in Paris in 1967.

According to Molnar, in her eyes her work has a hypothetical character. In order to systematically process her research series, she invented a “technology”, which she called “Machine Imaginaire”. She sketched a program, and then, step by step, realized a simple, limited series, which was self-contained.

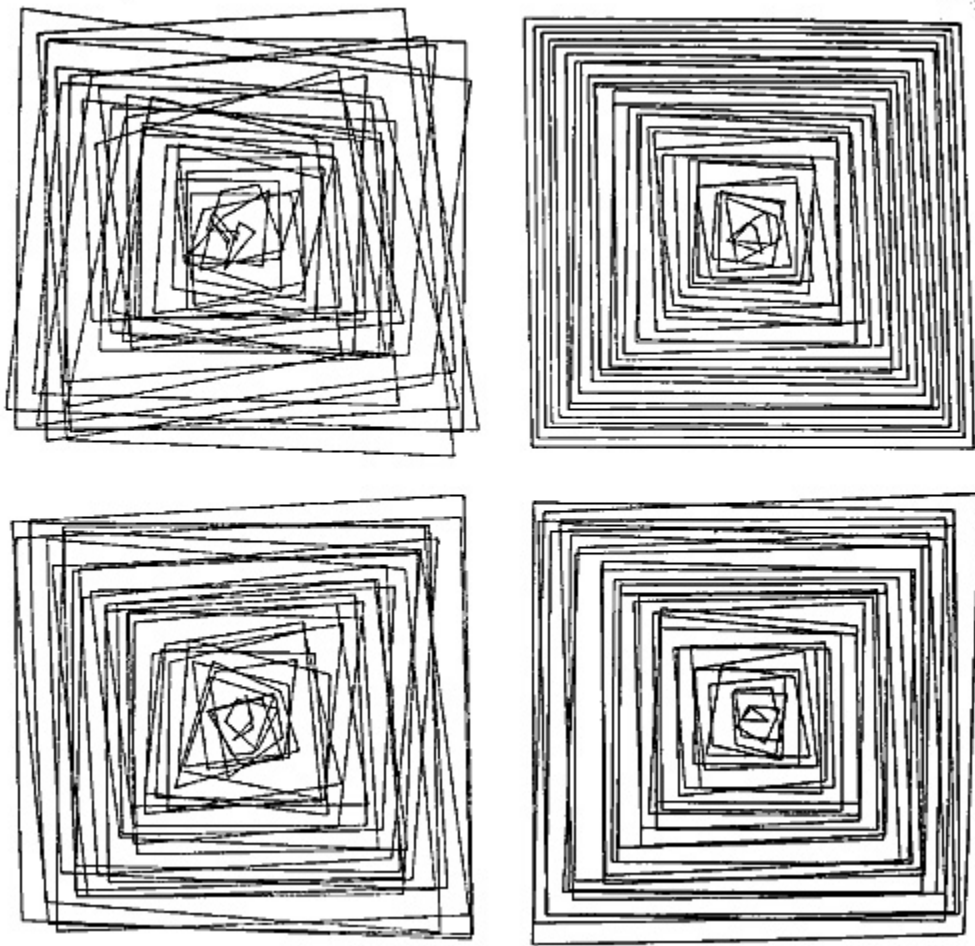
In 1968 she discovered the power of the computer to allow an artist to step away from “the social thing” in order to get at the real creative vision. She replaced the illusory computer, the invented machine, by a genuine computer. Her initial work involved transformations of geometric objects, such as a square, by rotating, deforming, erasing all or parts of them, or replacing portions with basic elements of other geometric shapes. She would often repeat the geometric primitives while fracturing or breaking them as she transformed them, ultimately outputting them to a plotter.

Molnar did work at the Centre Pompidou, ARTA (Atelier du Recherche des Techniques Avancees) and was a member of the CREIAV (Centre de Recherche Experimentale et Informatique des Arts Visuels). In 1985 she became a Professor at the University of Paris, Sorbonne.

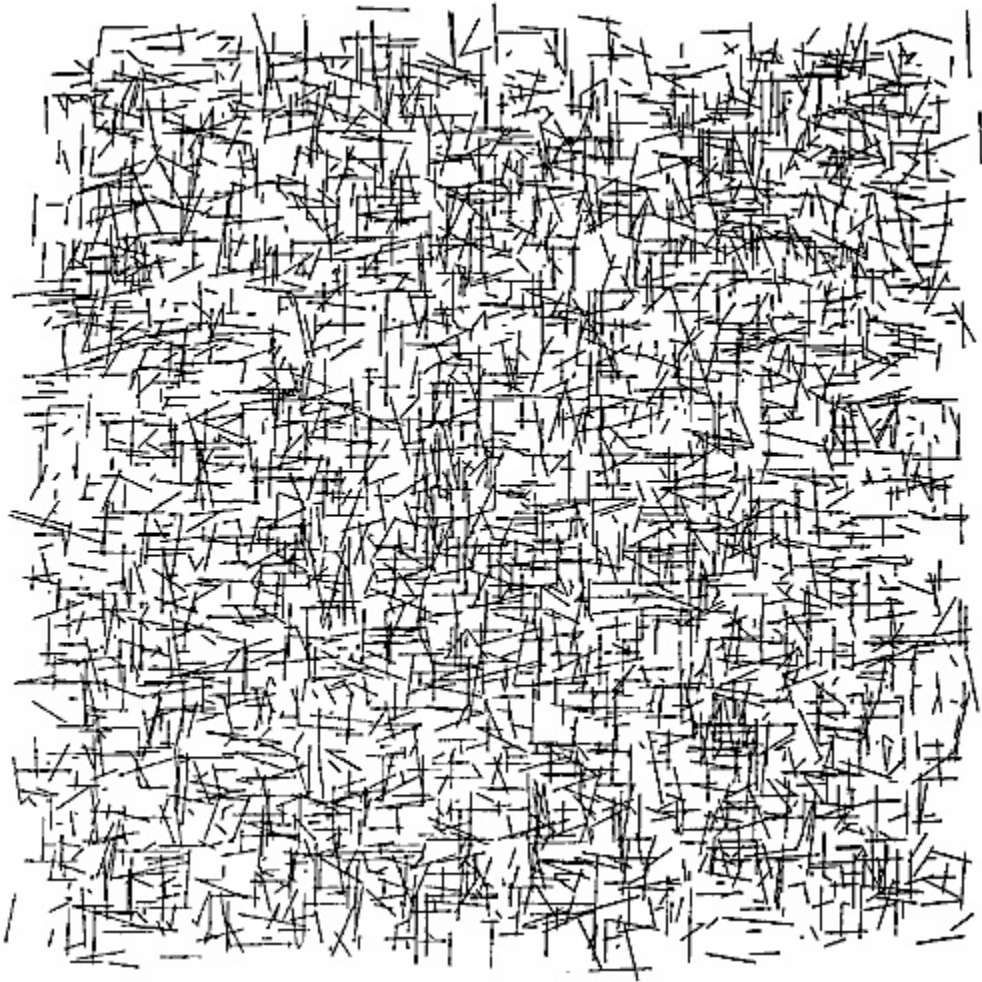
“Proceeding by small steps, the painter is in a position to delicately pinpoint the image of dreams. Without the aid of a computer, it would not possible to materialize quite so faithfully an image that previously existed only in the artist’s mind. This may sound paradoxical, but the machine, which is thought to be cold and inhuman, can help to realize what is most

subjective, unattainable, and profound in a human being.”

From Frank Popper's *Visualization, Cultural Mediation and Dual Creativity in Leonardo*.



Du Cycle – Carres Non Concintriques, 1974

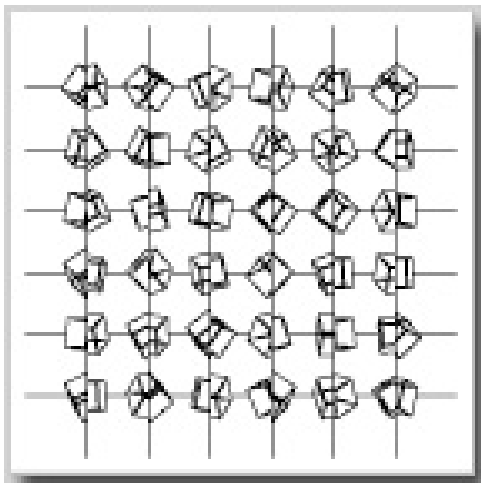


Mondrian Derange, 1974

9.3 Manfred Mohr



Manfred Mohr was born in 1938 in Pforzheim (Germany). He studied lithography at the Ecole des Beaux Arts, in Paris. He turned from traditional painting to the computer in 1969 to realize his artistic interest in **Constructivist** artforms. He focused his artistic vocabulary and aesthetic expression by working only in black and white, not reverting to a color palette until 1998, using a plotter as output from the computer.



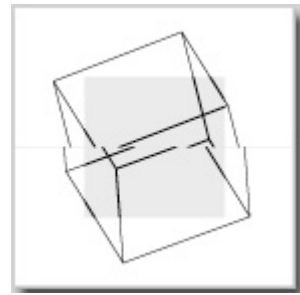
Cubic Limit II

As quoted by Goodman in her book *Digital Visions*, Mohr says “The paradox of my generative work is that form-wise it is minimalist and content-wise it is maximalist.” He has chosen the cube, and the seemingly uncountable variations of it as his primitive element. Mohr has the computer start with a cube and transform it through distortions and various rotations. According to Mohr, “Since 1973, in my research, I have been concentrating on fracturing the symmetry of a cube (including since 1978 n-dimensional hypercubes), using the structure of the cube as a “system” and “alphabet”. The disturbance or disintegration of symmetry is the basic generator of new constructions and relationships.”

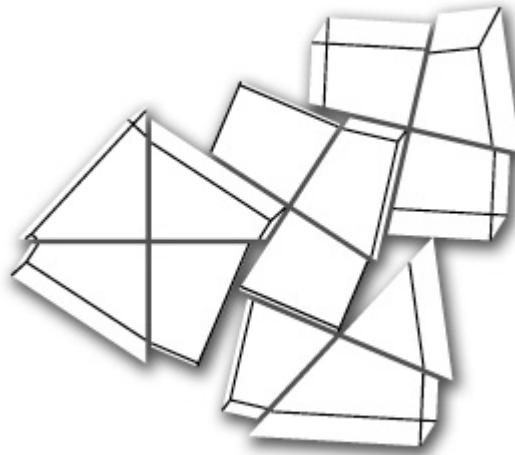
Former Ohio State University Eminent Scholar in Design, Mihai Nadin said of Mohr, “In order to free his explorations from the burdens of psychological patterns, Manfred Mohr literally harnesses randomness and makes it operate on the entities selected for exploration. “

In 1971, Mohr was featured in a one-man show at the Musee d’Art Moderne de la Ville de Paris, which has been marked as the first museum sponsorship of a one-man exhibition of computer art. Mohr has also been honored by winning Ars Electronica in Linz.

“The computer became a physical and intellectual extension in the process of creating my art. I write computer algorithms i.e. rules that calculate and then generate the work which could not be realized in any other way. It is not necessarily the system or the logic I want to present in my work, but the visual invention which results from it. My artistic goal is reached, when a finished work can visually dissociate itself from its logical content and convincingly stand as an independent abstract entity.”

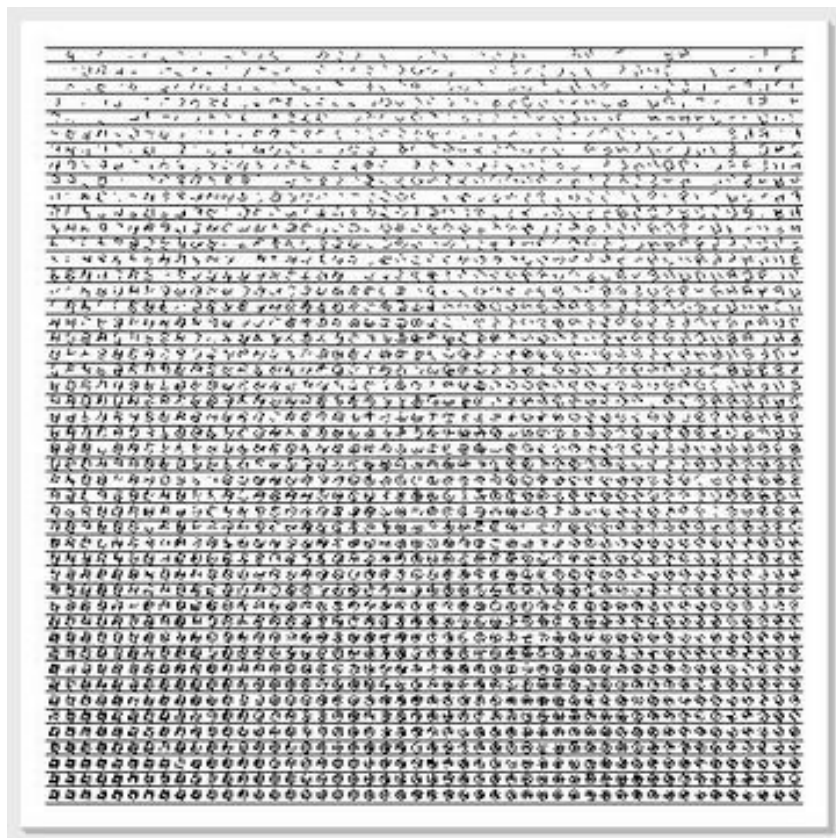


Cubic Limit II



Divisibility II

[Manfred Mohr Retrospective on the Rave WebMuseum of Cyberart](#)



Cubic Limit I

9.4 Larry Cuba



Larry Cuba is widely recognized as a pioneer in the use of computers in animation art, and was one of the “hybrid” artist/technologists” that were referred to in Chapter 3. According to Gene Youngblood, “Larry Cuba works in the tradition known variously as abstract, absolute or concrete animation. His works are characterized by cascading designs, startling shifts of perspective and precise, mathematical structure.”

In his own words, Cuba describes his work as: “...consist[ing] of experimenting with algebraic structures to generate visual material that is unpredictable in its form. By that I mean that it was not designed, imagined or otherwise pre-visualized. The results are only known after the program is run, the computer executes the computations and produces the animation.”



Briefing from the movie Star Wars; graphics done by Cuba on DeFanti's GRASS system at UICC

To accomplish his work, much like was done by other early computer artists (such as John Whitney, Sr., Stan Vanderbeek, Chuck Csuri, Lillian Schwartz), Cuba started in the CG filmmaking efforts by gaining access to large mainframes, most notably those at NASA's Jet Propulsion Lab. This is the same facility where Jim Blinn did his seminal work. It was there that he completed his first piece in 1974, *First Fig*. According to Cuba, he showed this film to George Lucas as a means of convincing Lucas to let him work on the creation of graphics for the *Star Wars* movie.

In 1975, John Whitney, Sr. was in the process of making his film *Arabesque*, and invited Cuba to provide programming assistance. He did, and he learned much from the foot of the master during this collaboration about the relationship between the visual image and music, so much so that Youngblood called him “the Bach of abstract animation.”

Later that year he was resident at the University of Illinois Chicago *Circle Graphics Habitat*, working with Tom DeFanti on the GRASS system that he developed as a graduate student at Ohio State and was pushing further

into the computer art application world. It was on this system that Cuba produced the graphics for the training sequence for the attack on the Death Star in *Star Wars*. He commented in an interview that he pushed the system to the limit, so much so that the computer kept crashing. It was only by working in the frigid temperatures of the room with the AC turned way up that he was able to keep the computer running in order to complete the filming.



Frame from *Two Space*

Cuba completed two more computer-animated films: *3/78 (Objects and Transformations)*, and *Two Space* using similar approaches to designing and producing and filming the graphics.

DeFanti extended the GRASS system to be used on a personal computer which resulted in the development of the ZGRASS environment (Chapter 5, Section 4). Cuba purchased a ZGRASS system, for his personal use, and completed his film *Calculated Movements* using this new approach, and used a LyonLamb system to record it. According to Cuba, the filmmaking effort for this production was different. “The most obvious difference comes directly from the hardware. The other films were

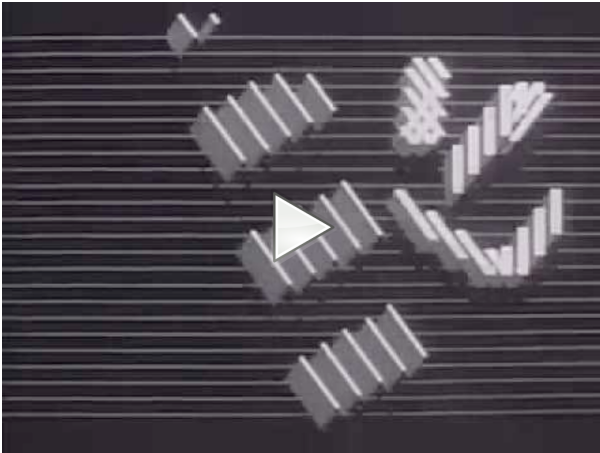
done on vector systems, so I was using dots. Going to the Zgrass machine meant not only going down from a mainframe to a mini to a micro but also going from vector to raster graphics. So this is my new palette, so to speak. New in two ways: I could draw solid areas so that my form became delineated areas instead of just dots, and I had four colors: white, black, light grey and dark gray.”

Cuba studied at Washington University and at [The California Institute of the Arts](#), where he received his MFA. He has won both NEA and AFI Independent Filmmakers grants and his works have screened in many exhibitions, including *Trickfilm/Chicago* (1980) and the *Best of Hiroshima '85*. Cuba was also an artist-in-residence at the Institute for Visual Media of the ZKM in Karlsruhe, Germany.

His works have been shown at film festivals throughout the world and have won numerous awards. Cuba has presented his work at SIGGRAPH, ISEA, Ars Electronica, and other, and his films have been included in screenings at top-end museums throughout the world.

Cuba received grants for his work from the American Film Institute and The National Endowment for the Arts and was awarded a residency at the Center for Art and Media Technology Karlsruhe (ZKM). He has served on the juries for the SIGGRAPH Electronic Theater, the Montpellier Festival of Abstract Film, The Ann Arbor Film Festival and Ars Electronica.

Movie 9.1 Larry Cuba



Short sequence from *Calculated Movements*

<https://www.youtube.com/watch?v=HcvN1dt0yJo>

Calculated Movements, An Interview with Larry Cuba, Video and the Arts Magazine, Winter 1986, Gene Youngblood.

Star Wars: Episode IV – A New Hope: Making of the Computer Graphics for Star Wars, <http://www.movieweb.com/movie/star-wars-episode-iv-a-new-hope/making-of-the-computer-graphics-for-star-wars>

9.5 Lillian Schwartz



Lillian Schwartz

The following text is taken from the artist's website at <http://www.lillian.com>

Lillian Schwartz is best known for her pioneering work in the use of computers for what has since become known as **computer-generated art** and computer-aided art analysis, including graphics, film, video, animation, special effects, Virtual Reality and Multimedia. Her work was recognized for its aesthetic success and was the first in this medium to be acquired by The Museum of Modern Art. Her

contributions in starting a new field of endeavor in the arts, art analysis, and the field of virtual reality have been recently awarded Computer-World Smithsonian Awards.

Schwartz began her computer art career as an offshoot of her merger of art and technology, which culminated in the selection of her kinetic sculpture, Proxima Centauri, by The Museum of Modern Art for its epoch-making 1968 Machine Exhibition. She then expanded her work into the computer area, becoming a consultant at the AT&T Bell Laboratories, IBM's Thomas J. Watson Research Laboratory and at Lucent Technologies Bell Labs Innovations. On her own, and with leading scientists, engineers, physicists, and psychologists, she developed effective techniques for the use of the computer in film and animation.

Besides helping to establish computer art as a viable field of endeavor, Schwartz additionally contributed to scientific research areas such as visual and color perception, and sound. Her own personal efforts have led to the use of the computer in the philosophy of art, whereby data bases containing information as to palettes and structures of paintings, sculptures and graphics by artists such as Picasso and Matisse are used by Schwartz to analyze the choices of those artists and to investigate the creative process itself.

Her contributions to electronic art analysis, and restoration, have been recognized, specifically in Italian Renaissance painting and frescoes. Her work with colleagues to construct 3-dimensional models of the Refectory

at Santa Maria Grazie to study the perspective construction of Leonardo's Last Supper and, more recently, a finite element model of the Leaning Tower of Pisa to aid in the preservation of the tower in understanding its structure, have proved invaluable to Art Historians and Restorers.

Schwartz's education began immediately after World War II when she studied Chinese brushwork with Tshiro in Japan. Over the following years she studied the fine arts with professionals such as Giannini, Kearns, and Joe Jones. She is self-taught with regard to film and computer interfacing, and programming.

Schwartz has always had close ties to the academic community, having been a visiting member of the Computer Science Department at the University of Maryland; an adjunct professor at the Kean College, Fine Arts Department; an adjunct professor at The Rutgers University Visual Arts Department; an adjunct professor at the Psychology Department, School of Arts and Sciences, New York University; and is currently a member of the International Guidance Panel, under the co-sponsorship for The Society for Excellence Through Education, Israel, Teachers College, Columbia University and S.A.G.E., and a Member of the Graduate Faculty of The School of Visual Arts, NYC. She has also been an Artist in Residence at Channel 13, WNET.



Lillian Schwartz

Schwartz's work has been much in demand internationally both by museums and festivals. For example, her films have been shown and won awards at the Venice Biennale, Zagreb, Cannes, The National Academy of Television Arts and Sciences, and nominated and received Emmy nominations and award. Her work has been exhibited at and is owned by museums such as The Museum of Modern Art, The Metropolitan Museum of Art, The Whitney Museum of American Art, The Moderna Museet (Stockholm), Centre Beauborg (Paris), Stedelijk Museum of Art (Amsterdam), and the Grand Palais Museum (Paris).

Representing the United States, Schwartz has been a guest lecturer in over two dozen countries, ranging from the Royal College of Art in London to the US/China Cultural Relations speaker in the People's Republic of China. Schwartz has also had numerous other fellowships, and honors conferred upon her, including a Doctor of Humane Letters Honoris Causa from Kean College, New Jersey, and grants from the National Endowment For The Arts and The Corporation For Public Broadcasting. Most recently she has received Computerworld Smithsonian Awards in three categories: For the Application of the Computer as a Medium in the Arts, including Graphics, Film/Video, and Special Effects; pioneering work in the field of Virtual Reality; and for her contributions in special editing techniques in Media and Arts & Entertainment.



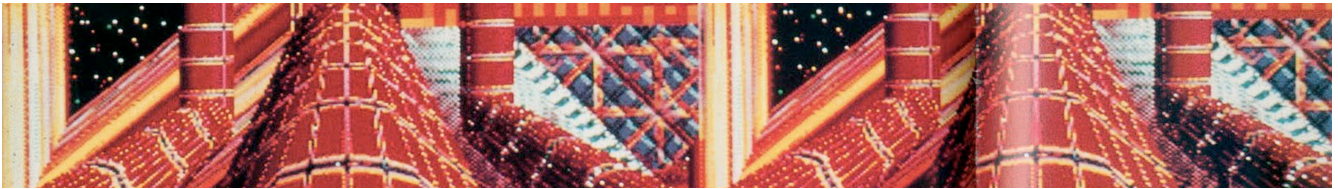
The Hidden Mona Lisa © Lillian Schwartz

at <https://vimeo.com/31521570>.

She has been the subject of numerous articles, books, and television news and documentary programs. She is a Fellow in The World Academy of Art & Science. She has been appointed as a committee member of the National Research Council Committee on Information Technology and Creativity under the Computer Science and Telecommunications Board of The National Academies from May, 2000 to December, 2001. Schwartz is the author (together with Laurens R. Schwartz) of *The Computer Artist's Handbook*, W.W. Norton & Company.

Additional information can be viewed in Chapter 4, Section 2 – Bell Laboratories. Three early films by Lillian Schwartz (*Pixellation*, *The Artist and the Computer*, and *UFOs*), followed by a 2011 discussion between the artist and Dan Streible, the programmer of “Sonic Truth”, the 2011 Flaherty Seminar, can be seen

9.6 David Em



Artist **David Em** was hired at JPL as an artist-in-residence, and adapted scientist Jim Blinn's visualization software to realize his own artistic ideas. Em admitted, though, that the JPL deep space environment influenced the quality and look of his artwork. From the Digital Art Museum entry on David Em:



Artist David Em at the display at JPL

David Em started as a painter but in 1974 began to experiment with electronic manipulations of TV images. This led to his involvement with the Xerox Research PARC in Palo Alto and to collaboration with computer graphics pioneers Alvy Ray Smith and Dick Shoup, inventor of the frame buffer. In 1976 Em had access to equipment at Triple-I, set up by Gary Demos and John Whitney Sr., but it was the introduction to the Jet Propulsion Laboratory (JPL) and the research work of pioneer James Blinn that led to Em's mature computer art style. The works produced at JPL led to the first ever artist's monograph published on digital art.¹

Author Ray Bradbury made the following statement about David Em and his work, titled EM SQUARED, taken from the introduction page on Em's website.

We live in confusing times.

1. (The Art of David Em , published by Harry N. Abrams) More work from David Em can be seen at a siggraph profile website, http://www.siggraph.org/artdesign/profile/David_Em/

Books do not look like books. They sometimes resemble computer chips. This makes for a slight misalignment among some readers who refuse to pick up a computer chip to try to turn the pages

In the field of art a semipanic spreads. Artists, like many another in other fields, fear that the machine is here to mash their toes, chop their fingers, or put out their eyes.

The computer lurks with intention to loom. Men run down the middle of the streets crying, "The dam has broke!" forgetting they live in a town with no water and no dam.

Have you or have you not heard it said that the day is fast coming when the artists will be replaced by a robot. We will all retire from the field and leave the computer as mindless Michelangelo inside the church painting the far wall and the upper ceiling. When God reaches down his Great Hand it will not touch Adam, it will touch Apple or Commodore or the Xerox Mark 10.

It's enough to make a chap turn in his oils and burn his canvases.

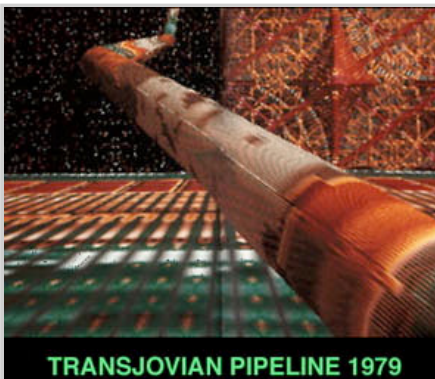
And yet. And yet...

Behold the work of David Em No computer, no robot, he. A man of flesh and wildly imaginative blood. But what's that he holds in his hand? Is it a brush, a tube of color, a jar of ink? It is not. It is, God help us all, the dread machine, the awful electric device that will fry and bury all art and artists. Yet, further behold. David Em is neither fried nor buried. HE is much alive, alive, O. And the landscapes of his imagination juice out his fingertips, through his pet Ben Franklin lightning bolt device, and flash as images not unlike those of childhood when someone struck your brow with a horseshoe or baseball bat. From these painful kaleidoscopic explosions Mr. Em has culled forth some bright new shapes and forms, told them to pull up their socks and behave, and delivered forth into our hands and eyes, a New Art Form. He has not, of course, done this alone. But he is preeminent in a field that is as swiftly flowing and changing as a storm stabbing its way across country walking on stilts of electric fire.

Ready or not, here he comes.

Watch his computerized, electric dust.

Gallery 9.1 David Em Artwork



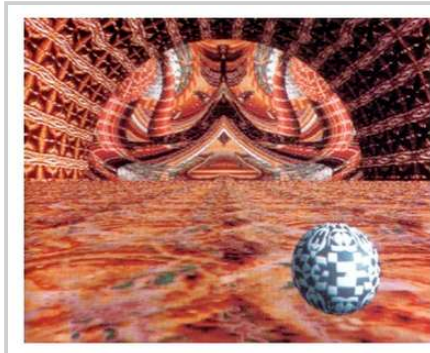
Transjovian Pipeline



Nora



Dr. Jim, Number 1



Persepol



Utah Spirits



Far Away

9.7 Yoichiro Kawaguchi



Yoichiro Kawaguchi

One of the foremost international computer artists is **Yoichiro Kawaguchi** of Japan. Yoichiro Kawaguchi was born on Tanegashima Island in 1952. He received his Master of Fine Arts from Tokyo University of Education in 1978. Currently he is Associate Professor of Computer Graphics Art at Art & Science Lab, Department of Art, Nippon Electronics College, Tokyo.

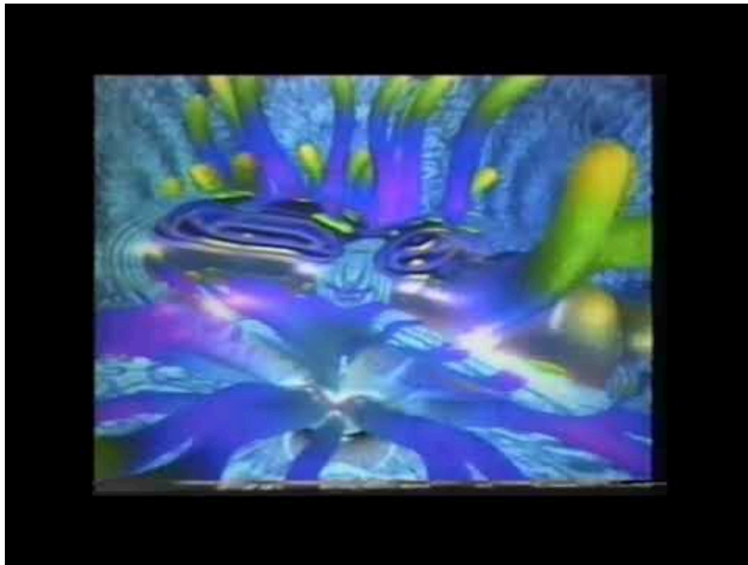
His early work was a collaboration with computer science researchers, who developed the LINKS computer, on which a lot of his work was produced. He used a technology called “**metaballs**” to get the soft, fluid, artistic forms of his organic shapes. Many of his algorithmic approaches to his art were taken from the growth patterns exhibited in seashells and spiraling plants.

Kawaguchi has exhibited at Biennale di Venezia 1986, Japan Pavilion EXPO 86, Vancouver, Ars Electronica, Linz 1986, AUSGRAPH '89, Sydney, and SIGGRAPH 90, Dallas. He has won numerous awards, e.g. “Eurographics '84”; Grand Prix PARIGRAPH '87; First Prize “Imagina '91”.

Yoichiro Kawaguchi was awarded a Distinction by the Prix Ars Electronica jury for his entry Eggy in the category Computer Animation.

Kawaguchi had a long term collaborative relationship with Toyo Links, who developed hardware (LINKS-1) and software (TRACY) for raytracing meta-ellipsoids. Toyo Links also had a relationship with Hitoshi Nishamura and Prof. Omura at Osaka University. Toyo Links became Links Corp in 1988, and then started Imagica. They made a famous movie with creature motion, called BioSensor.

Movie 9.2 Interview with Yoichiro Kawaguchi



An episode from the UK Channel 4 series “283 Useful Ideas From Japan” first shown in 1990. The interview is in Part 2, which can be seen at

<https://www.youtube.com/watch?v=6qKjd0QXQO4>

Part 1 can be seen at

<http://www.youtube.com/watch?v=nJH0fLTR7YU>

Gallery 9.2 Yoichiro Kawaguchi Artwork



Frame from *Eggy* (1990)



Kawaguchi artwork (1997)



Kawaguchi artwork (1996)

9.8 Ed Emshwiller



The following is from a tribute to [Ed Emshwiller](#) from the CalArts web site:

“Ed Emshwiller, the highly regarded video artist and dean of the School of Film/Video at the California Institute of the Arts, passed away July 27, 1990 from cancer at the age of 65.



Ed Emshwiller

Emshwiller was an influential figure in the experimental film movement that helped expand the horizons of American filmmaking in the 1960's and his work was frequently shown in museums and festivals. He studied art at the University of Michigan, the Ecole Nationale Supérieure des Beaux-Arts in Paris and the Art Students' League. He was an [abstract expressionist](#) painter and award-winning science-fiction illustrator before turning his attention to film and video. Many of his experimental films, including *Relativity*, *Totem*, *Three Dancers* and *Thanatopsis* have received awards and screenings at film festivals in New York, London, Berlin, Edinburgh, Cannes and a number of other cities. He produced or collaborated on a number of multimedia productions at Lincoln Center, Museum of Modern Art, Guggenheim Museum, The Los Angeles Film Festival, among others. In early 1979, he produced the ground-breaking three-minute 3-D computer work entitled *Sunstone*, made at the New York Institute of Technology with the help of Alvy Ray Smith as software programmer.

The same year, Emshwiller became dean of CalArts' film/video school. In addition to his duties as dean, he served as provost from 1981 through 1986. Robert J. Fitzpatrick, who was president of CalArts at the time of Emshwiller's appointments, said then, “Ed has demonstrated extraordinary gifts as an artist throughout his career... To his own surprise and our great benefit, he has shown a special talent for administration and leadership as dean of the School of Film/Video. He is the only person I know who could successfully combine triple careers of artist, dean and provost.”

Emshwiller was always looking for ways to push film and video's boundaries. This year, in fact, he was

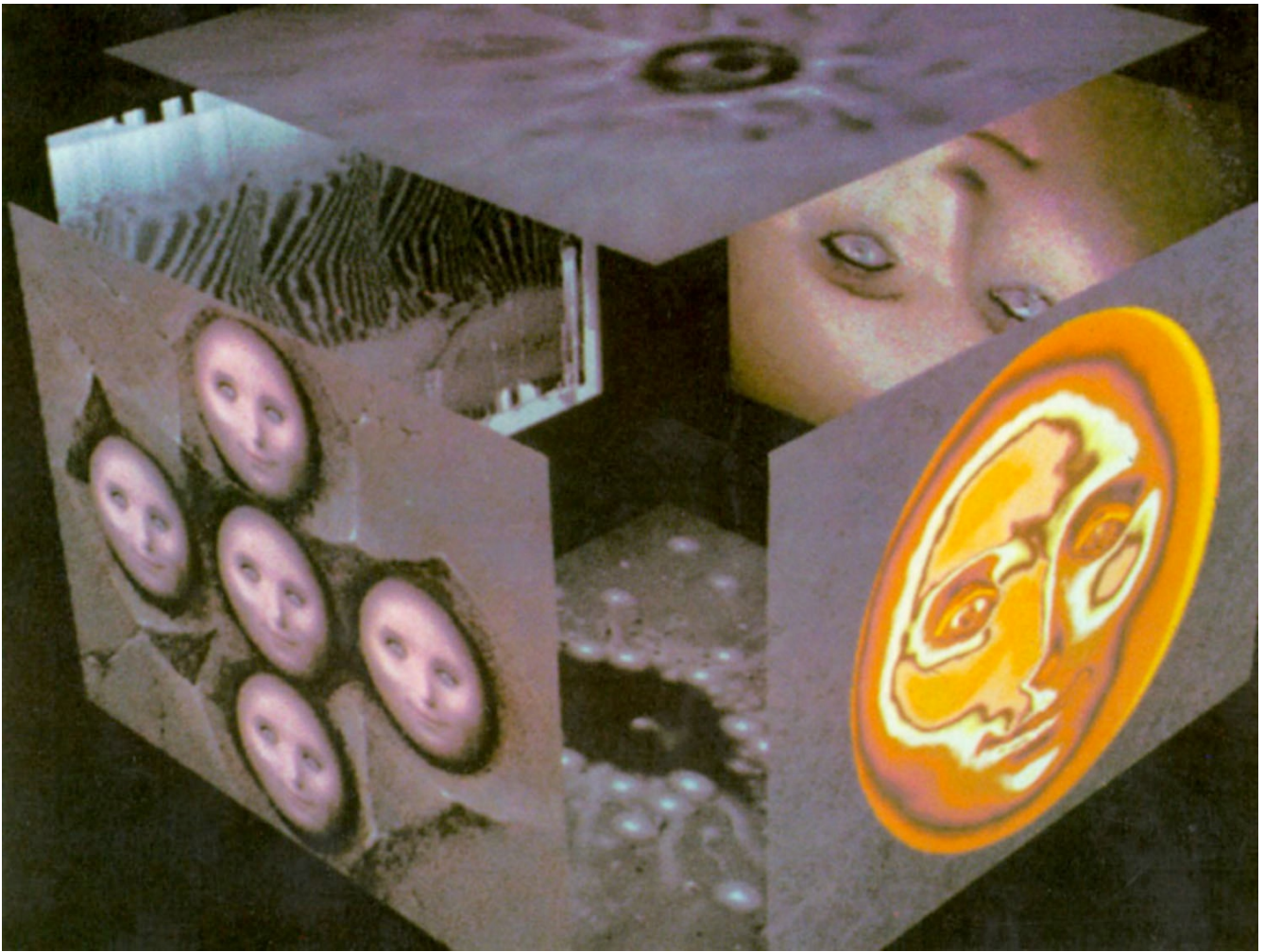
working with composer Morton Subotnick in, as Emshwiller described it, “interactive and three-dimensional performance with sound/image generation and various controlling devices.”

With Subotnick, Emshwiller created *Hungers*, an electronic video opera, for the 1987 Los Angeles Arts Festival. *Hungers* used live performance and interactive devices that changed the sound of the music according to the environment. No two performances were ever the same. In a similar fashion, their new work was going to play with video so that the images would change from performance to performance.

To Emshwiller, the innovative technique allowing for change was a way to ‘get film out of its can’. “The chaos theory, a slight deviation from a plan, will take you into a whole new realm of possibilities, and that’s one of the things, I think, exciting, not only philosophically, but also in terms of practice for devising performance.”

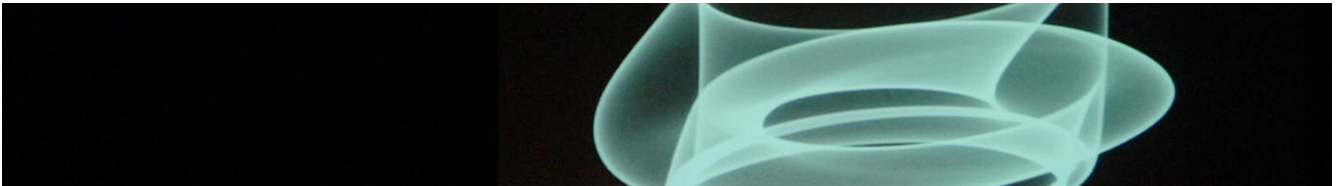
He received grants from the NEA, the Rockefeller, Ford and Guggenheim Foundations and the Corporation for Public Broadcasting. Emshwiller was a great influence in experimental film and video not only as an artist but also as an administrator. He was a member of the board of trustees of the American Film Institute, board of directors of the Filmmakers Cooperative, board of directors of the Association of Independent Video and Filmmakers, board of directors of the Independent Television Service, media panels of the NEA and the New York State Council for the Arts.

According to Ed’s wishes, his heirs donated to CalArts all his film equipment – valued at around \$100,000 – and his complete archives. The latter, which occupies nearly two hundred feet of shelf space in CalArts’ special archival room, includes all his original films, outtakes, slides and notes on past and planned projects.”



Frame from Sunstone- Movie can be seen in Chapter 5 – Section 1

9.9 Other Artists



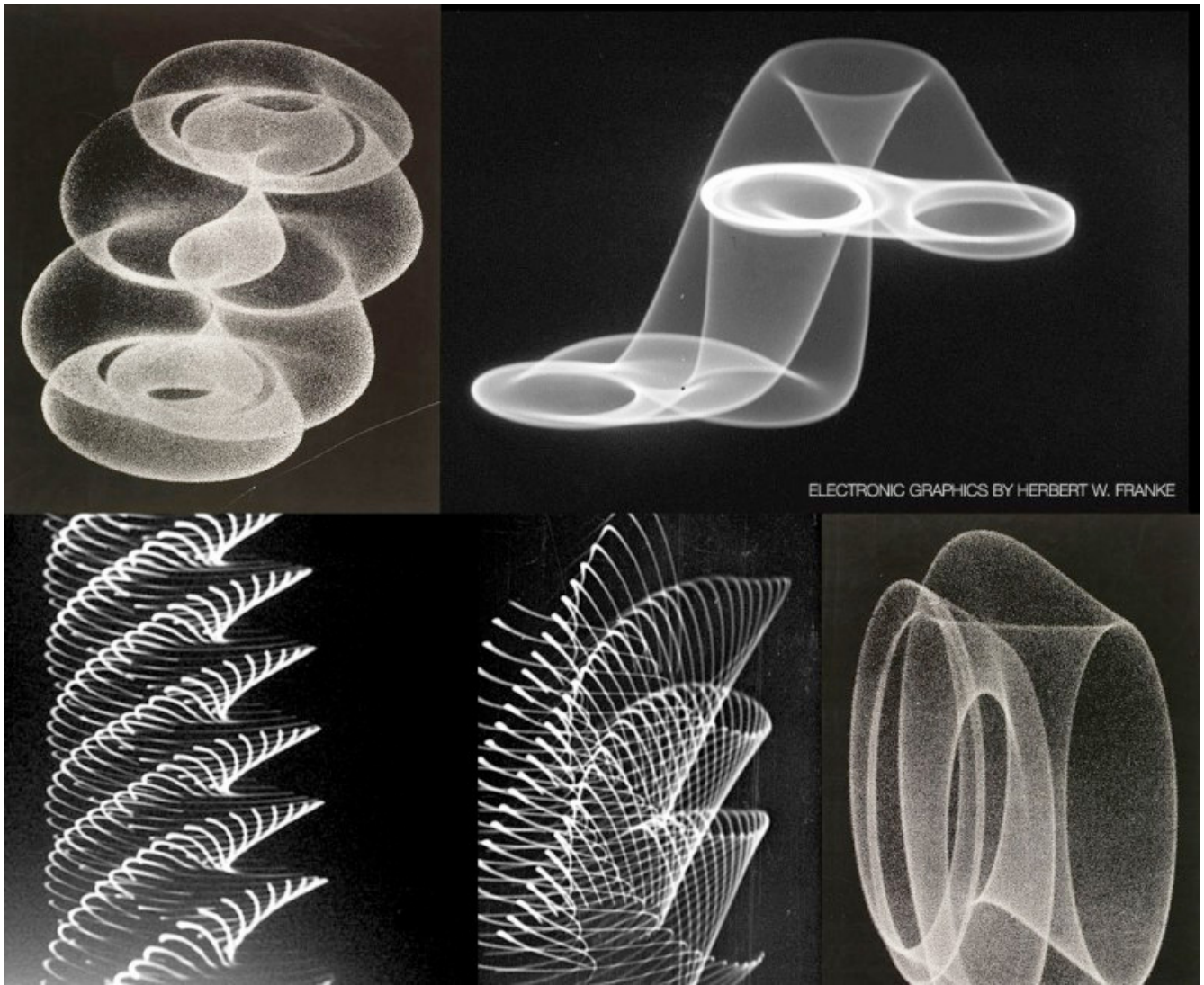
Several other early artists deserve mention at this point. Herbert Franke, Frieder Nake and George Nees from Germany, and Harold Cohen, Duane Palyka, Joan Truckenbrod, Darcy Gerbarg, and Colette and Charles Bangert from the United States each has contributed immensely to the evolution of computer art.

Also, video artists Nam June Paik, Bill Etra, Frank Dietrich, Jane Veeder, Vibeke Sorensen and Copper Giloth advanced that important component of the digital art movement.

Herbert Franke



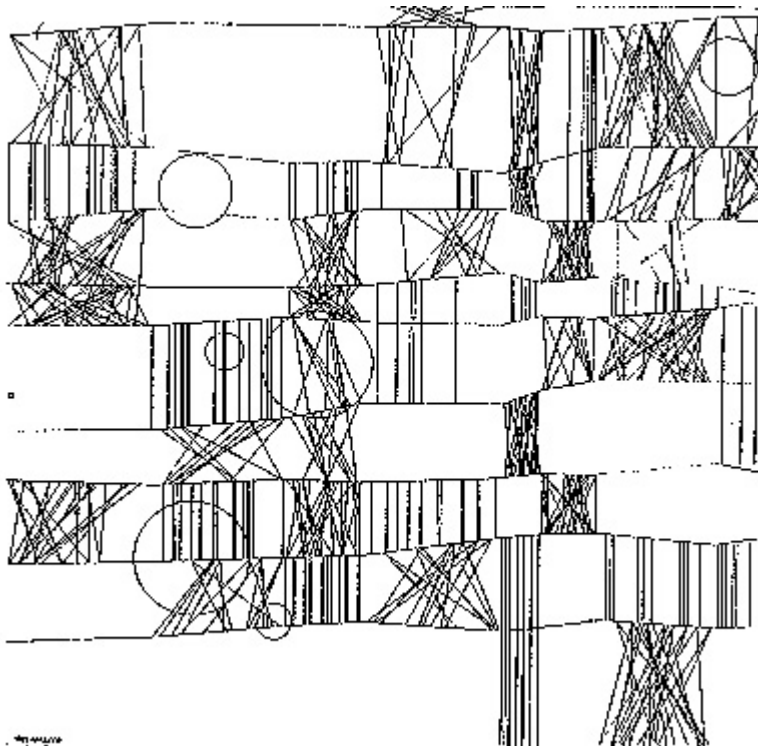
Herbert Franke



Frieder Nake



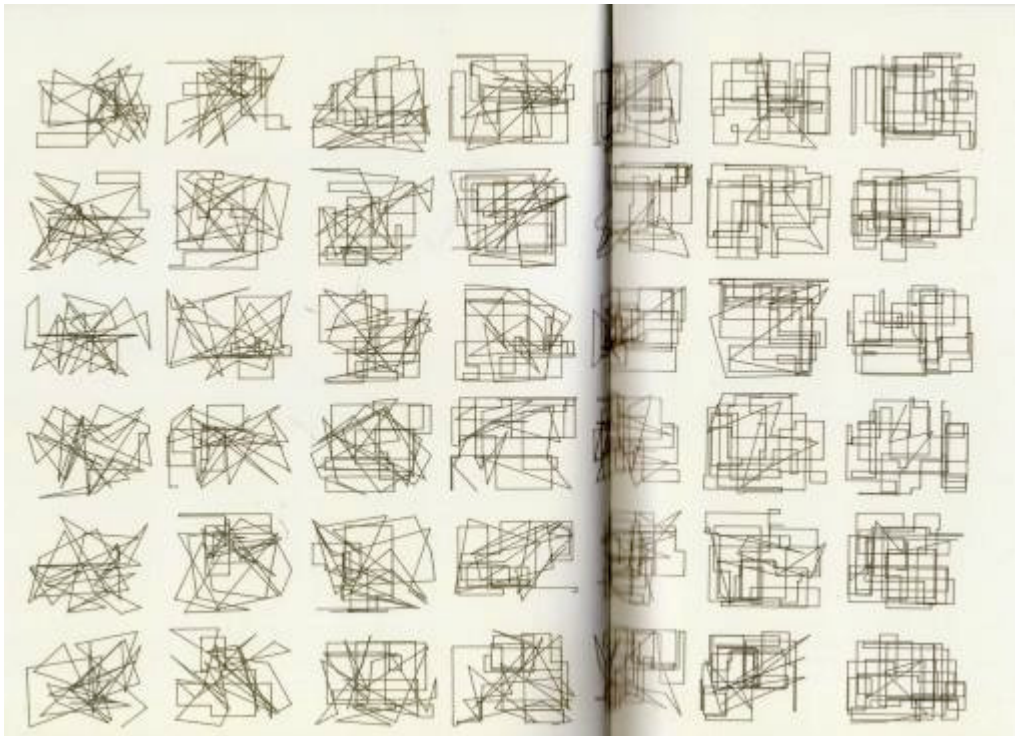
Frieder Nake



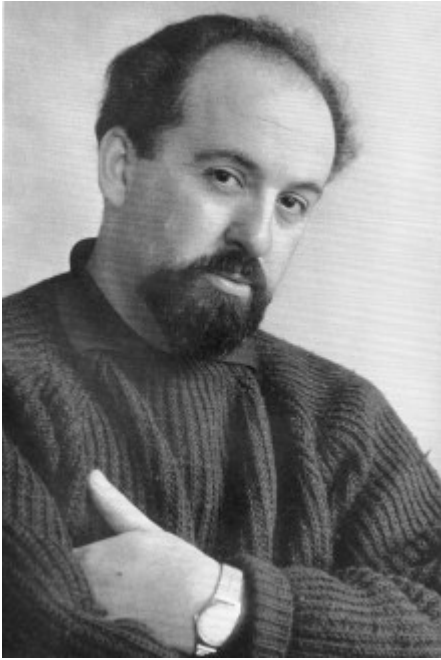
George Nees



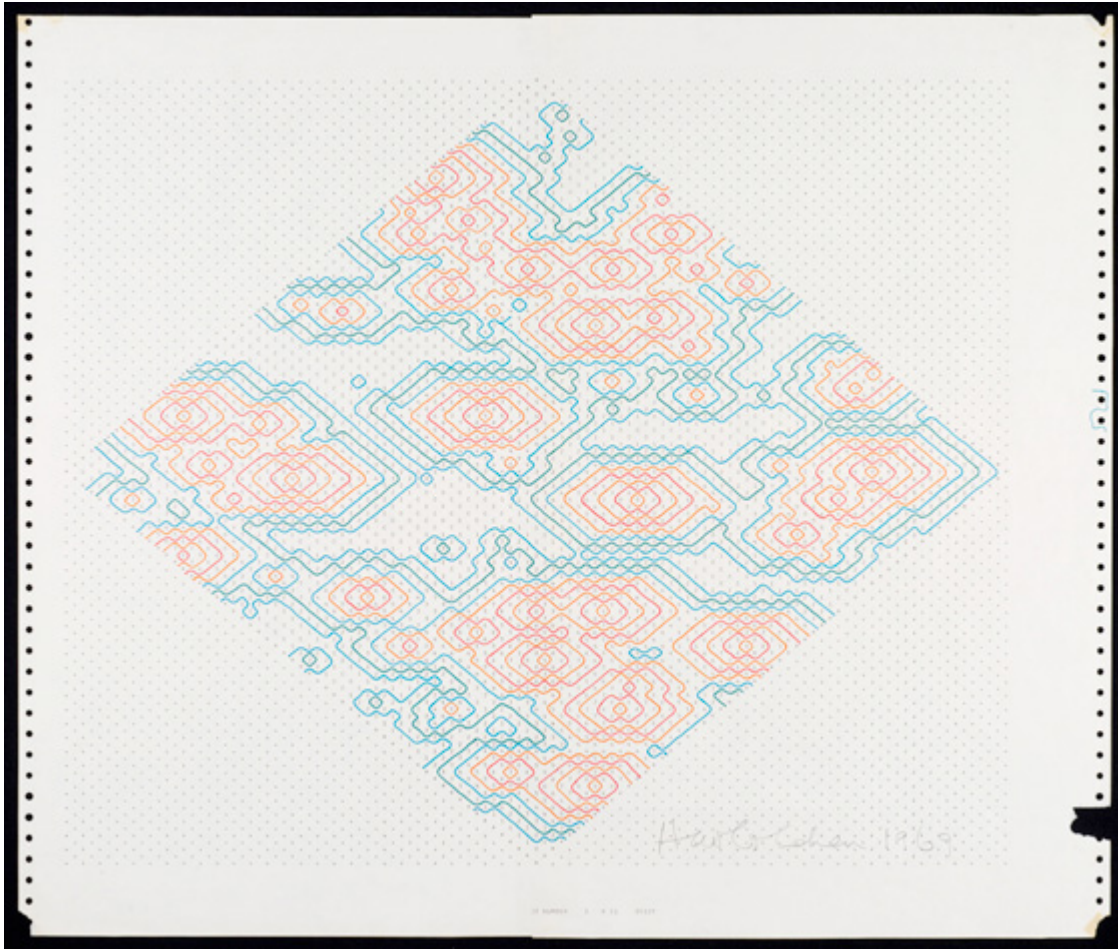
George Nees



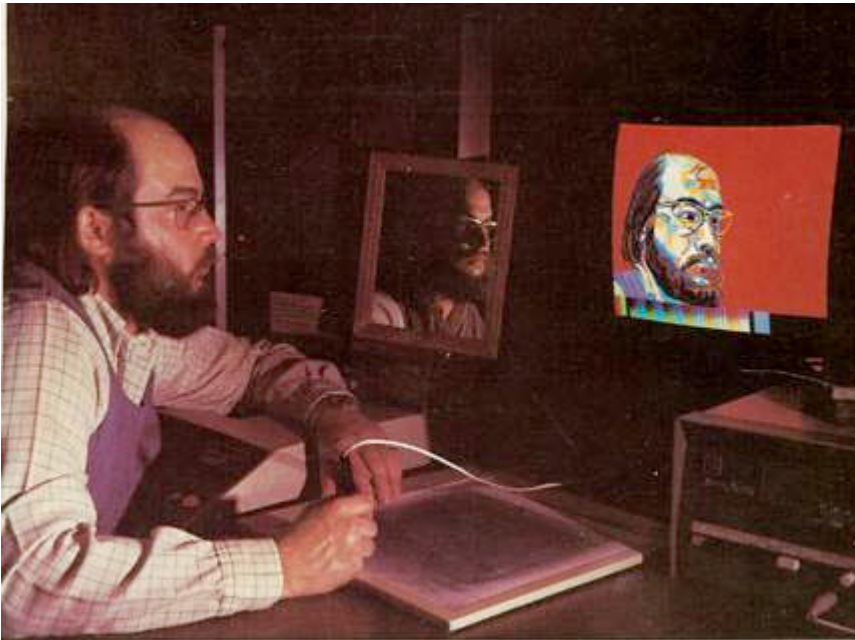
Harold Cohen



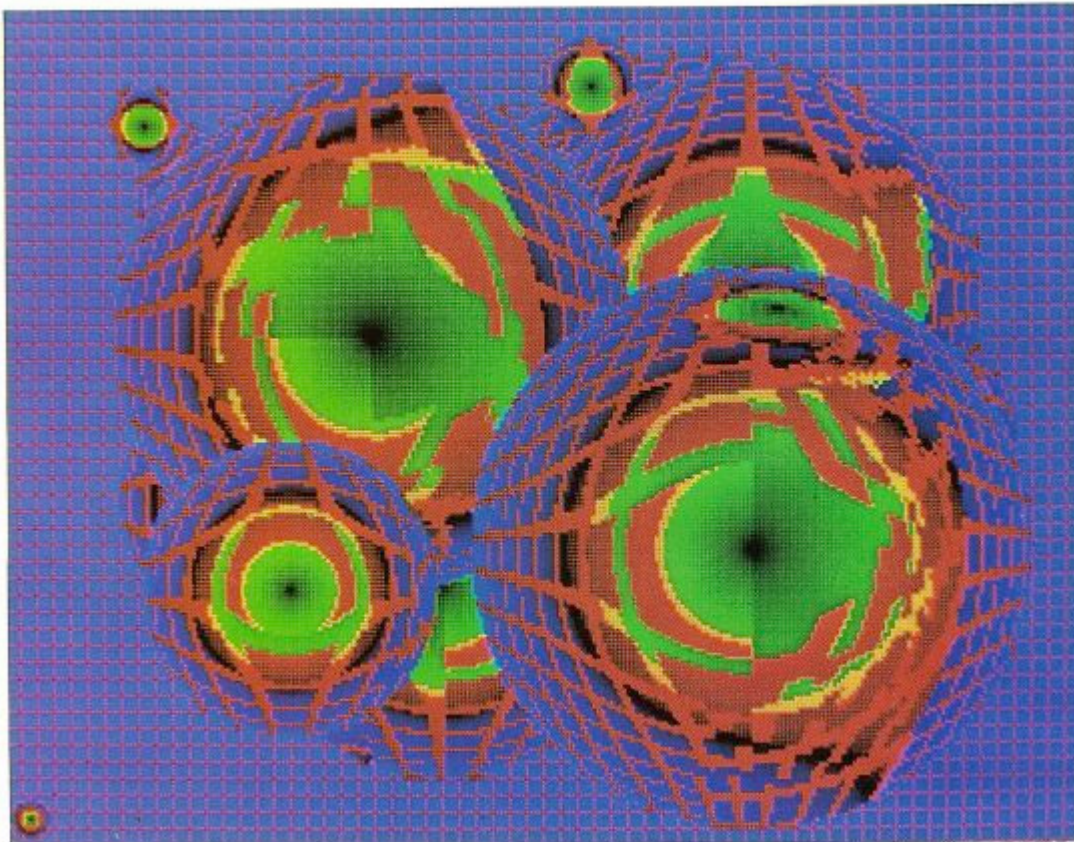
Harold Cohen



Duane Palyka



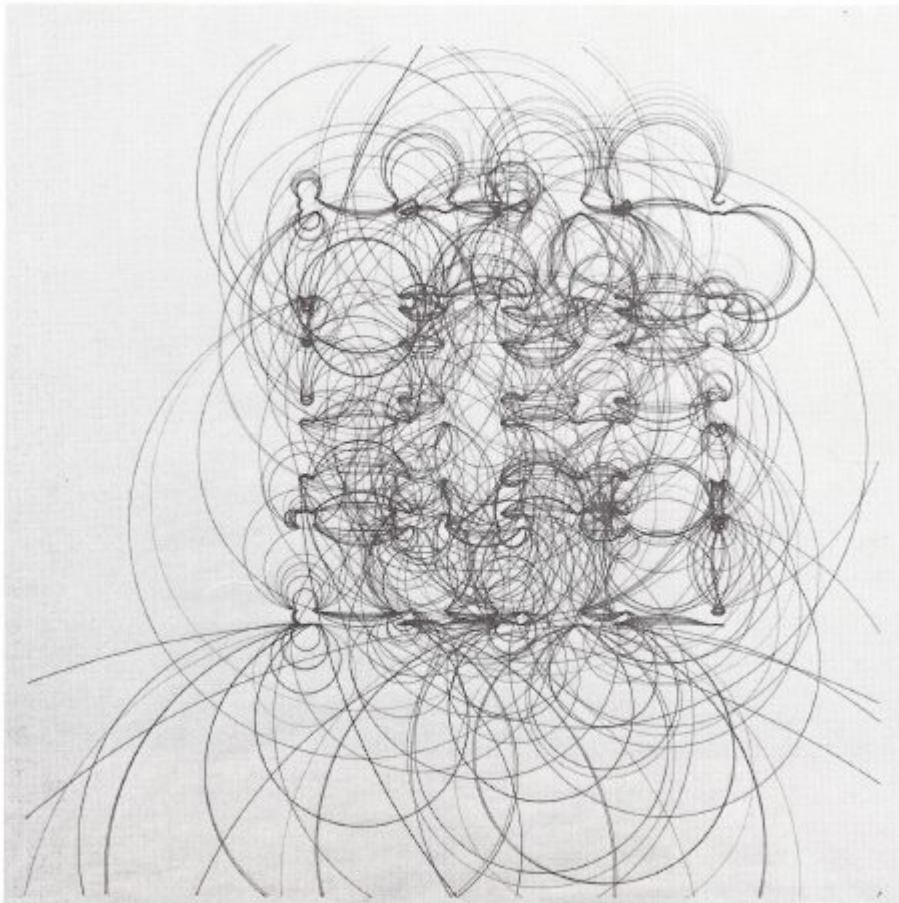
Duane Palyka



Colette and Charles Bangert



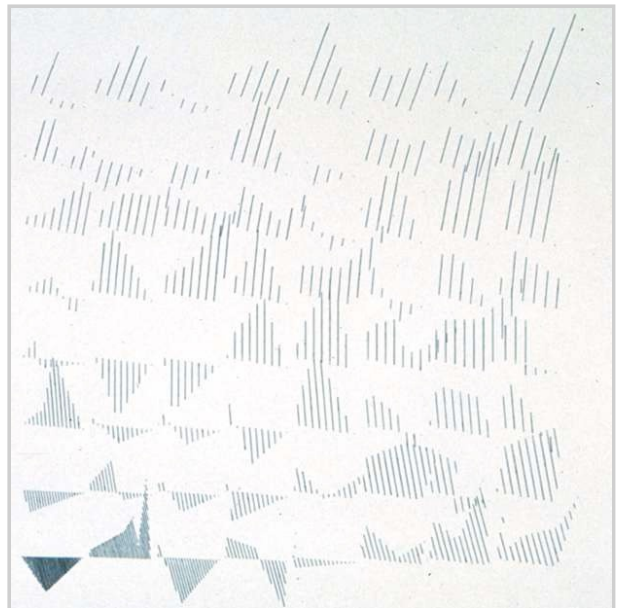
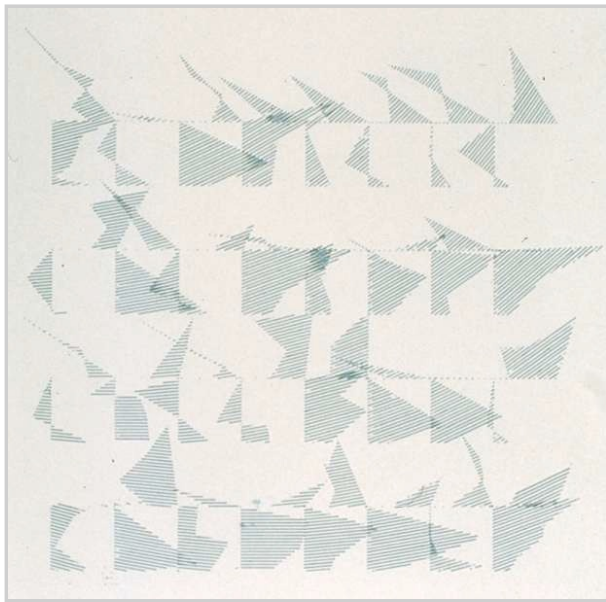
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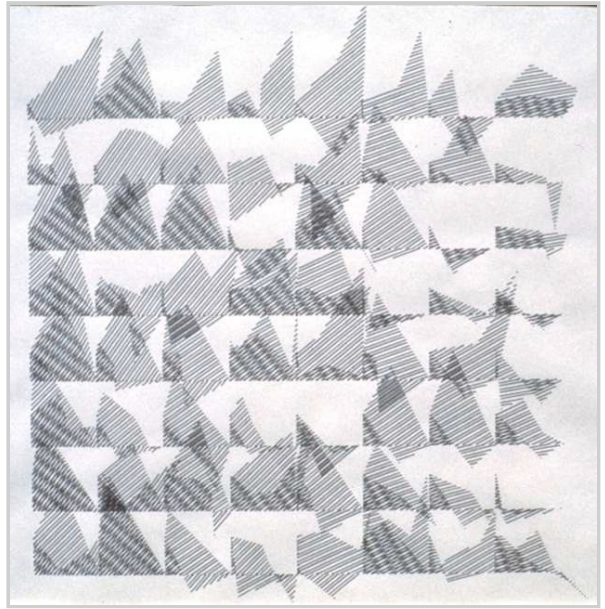
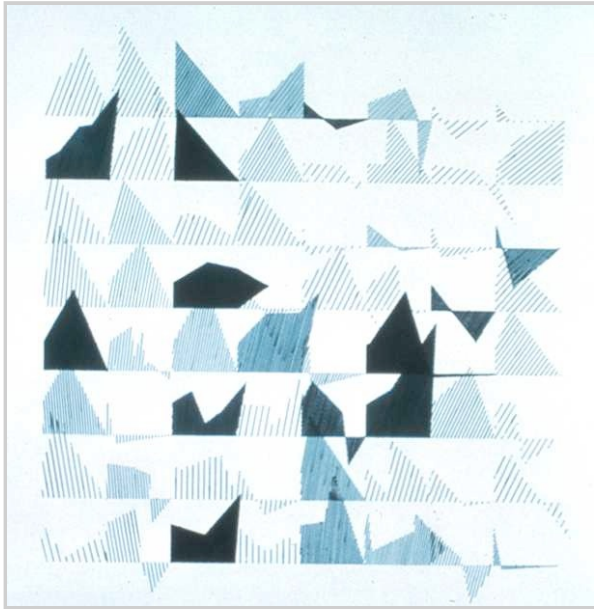


Joan Truckenbrod



Joan Truckenbrod

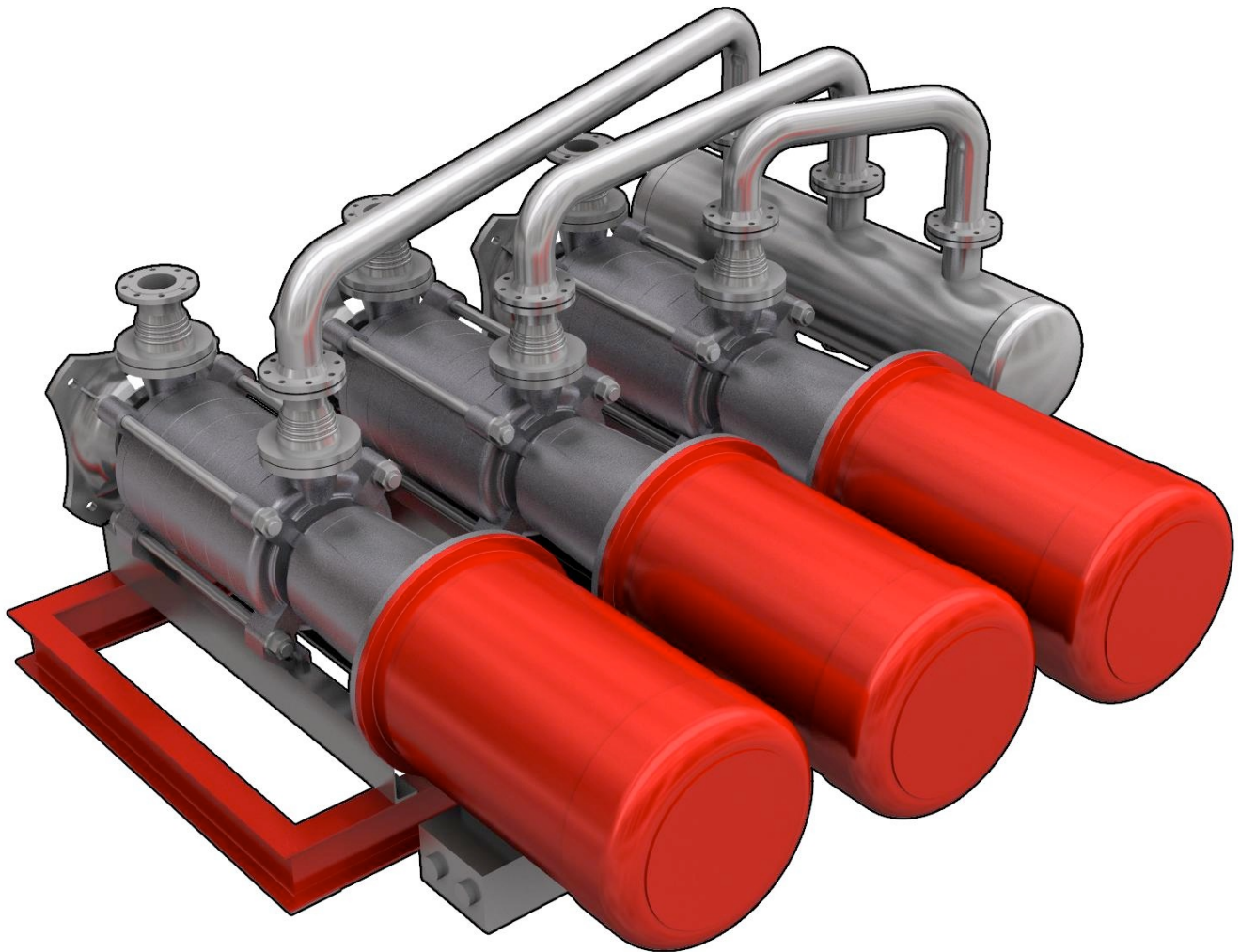




Chapter 10: CAD/CAM/CADD/CAE

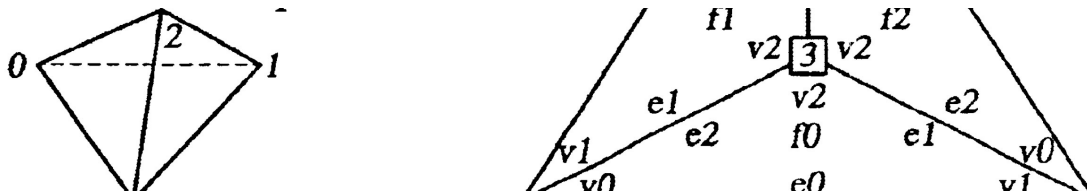
CAD/CAM/CADD/CAE

Computer-aided design software packages range from 2D vector-based drafting systems to 3D solid and surface modelers. They can be used for conceptual design activities, all the way through developing patterns for manufacturing.



CAD generated mechanical component

10.1 Introduction



As is the case with most of computer graphics, the Computer-Aided Design (CAD) discipline can trace its beginnings to the Sketchpad system developed by Ivan Sutherland in 1963. Sutherland was able to connect the display capabilities of the CRT, with the computational abilities of the computer, and the interactive process made possible with the light pen to create a system for designing mechanical parts. His system was described in a 1963 AFIPS conference paper. At the same conference, his advisor, Prof. Steven Coons of MIT published an article that laid out the relationship of the computer-aided design system as it evolved from the automatic programmed tool (APT) that was developed from the milling machine that was designed for use with the Whirlwind computer (both of these articles are referenced in the bibliography box at the end of this section.)

As was discussed in Chapter 2, the work of Sutherland prompted the automotive and aerospace companies to take notice and start their own projects to try to harness the power of the computer for their design needs. One of the most notable programs was the DAC (Design Augmented by Computer) project at General Motors (Chapter 3), which was a joint project with IBM. Two of the main individuals involved in this project were Fred Krull and Dr. Patrick Hanratty, whose contributions will be discussed later.



Apollo CAD system

The late 60s saw a flurry of activity in the CAD-related sector. Besides the turnkey companies described below, several other companies started creating and marketing software or hardware for this industry. David Evans and Ivan Sutherland founded Evans and Sutherland Computer Corporation (E&S), which was one of the leaders in high end graphics workstations used in the CAD arena. Other equipment was developed by IBM, Adage, GE, DEC, CalComp and others (see Chapter 3.) One of the main players at this time was Calma, originally a manufacturer of digitizers used in mapping and integrated circuit manufacturing. (In the mid-80s Calma was acquired by General Electric and then sold to Prime Computer.)

On the software side, MAGI released its SynthaVision solids software, which is considered by many to be the first commercial solid modeler program. Charles Eastman, at the Institute for Physical Planning at Carnegie Mellon, developed the *GLIDE* system with Max Henrion and the *General Space Planner (GSP) System*, a software system for solving space planning problems. Eastman and Kevin Weiler also published a seminal paper on the use of *Euler operators for geometric modeling*. Pierre Bezier and Steven Coons contributed important approaches to free-form surface applications for the CAD industry. The **CSG** modeler PADL-1, and later PADL-2 were developed by the *Production Automation Project* at the University of Rochester. Bruce Baumgart introduced a data structure, called the *Winged Edge data structure*, that provided an efficient representation for 3D objects.

Pierre Bezier wrote of his *remembrances of the early CAD activities* in the IEEE Annals of the History of Computing in a 1998 issue.

Sutherland, Ivan, *SKETCHPAD: A Man-Machine Graphical Communication System*, AFIPS, SJCC 23 (1963), pp 329-346.

Coons, Steven, *An Outline of the Requirements of a Computer-Aided Design System*, AFIPS, SJCC 23 (1963), pp 299-304.

Definitions:

CAD – computer-aided design

The use of computer programs and systems to design detailed two- or three-dimensional models of physical objects, such as mechanical parts, buildings, and molecules.

CAM – computer-aided manufacturing

The process of using specialized computers to control, monitor, and adjust tools and machinery in manufacturing.

CAE – computer-aided engineering

Use of computers to help with all phases of engineering design work. Like computer aided design, but also involving the conceptual and analytical design steps.

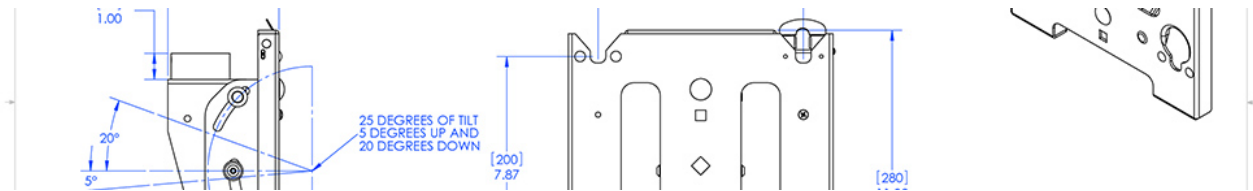
CADD – Computer Aided Drafting and Design, Computer-Aided Design & Drafting, or Computer-Aided Design Development

The use of the computer to help with the drafting of product plans.

– The American Heritage® Dictionary of the English Language, Fourth Edition

CAD pioneer Joel Orr has developed a web site devoted to a community-based accounting of the history of CAD at <http://joelorr.squarespace.com/community-caddcam-history-proj/>

10.2 MCS / CalComp / McAuto



MCS

Patrick Hanratty's contributions began in 1957 with PRONTO, the first commercial numerical-control programming system. After the completion of the DAC program, Hanratty started his own company, focused on the development of integrated and interactive computer aided drafting, design and manufacturing. His company, MCS (Manufacturing and Consulting Services, Inc.) was instrumental in the early evolution of the commercial software CAD environments. In addition to selling products under its own name, in its early years MCS also supplied the CADD/CAM software used by such companies as McDonnell Douglas (Unigraphics), Computervision (CADD5), AUTOTROL (AD380), and Control Data (CD-2000) as the core of their own products. In fact, according to MCS web site, industry analysts have estimated that 70% of all the 3-D mechanical CADD/CAM systems available today trace their roots back to MCS's original code. The company's first product, ADAM (Automated Drafting and Machining), was released in 1972, ran on 16-bit computers, and was one of the first commercially available mechanical design packages. Dr. Hanratty founded United Computing in 1969. More will be said of United Computing contributions later in this chapter.

In 1976, MCS introduced AD-2000, a design and manufacturing system for the first 32-bit computers. In 1986 they introduced ANVIL-5000, a 3-D mechanical CADD/CAM/CAE system that, for over a decade, was the most powerful, fully integrated CADD/CAM/CAE software available, running on all classes of engineering computers from high-end workstations to personal computers.

CalComp

California Computer Products, Inc. (CalComp) was a manufacturer of digital plotters, disk drives and other “plug compatible” computer equipment. CalComp was incorporated Sept. 17, 1958, and introduced the world’s first drum plotter (the Model 565) in 1959. They were involved primarily with the production plotters until about 1968, when they began selling disk drives manufactured by Century Data Systems of Anaheim, California. The legendary CalComp 1040-series pen plotter was introduced in 1984. For a while, CalComp distributed IsiCAD software, now owned by FIT Systems. CalComp was bought by Sanders Associates in 1980. In 1986, CalComp became a unit of Lockheed after the company purchased Sanders Associates.¹



Engineers working with CalComp workstation

In 1973, CalComp filed a claim against IBM for preventing CalComp from competing in the disk drive market. The company claimed that IBM had monopolized the market through premature introduction of new central processing units and disk drives, price cuts on existing disk products, leasing policies and other unfair marketing practices over a period of ten years (1963 – 1972). The courts eventually ruled in 1977 that IBM’s pricing, marketing and design changes did not constitute an attempt to monopolize the market.

McAuto

Because of its special internal needs, the aircraft industry has produced some of the world’s leading CAD programs. These include proprietary software developed at Boeing, CADAM by Lockheed, McAuto by McDonnell Douglas and CATIA by Marcel Dassault in France.

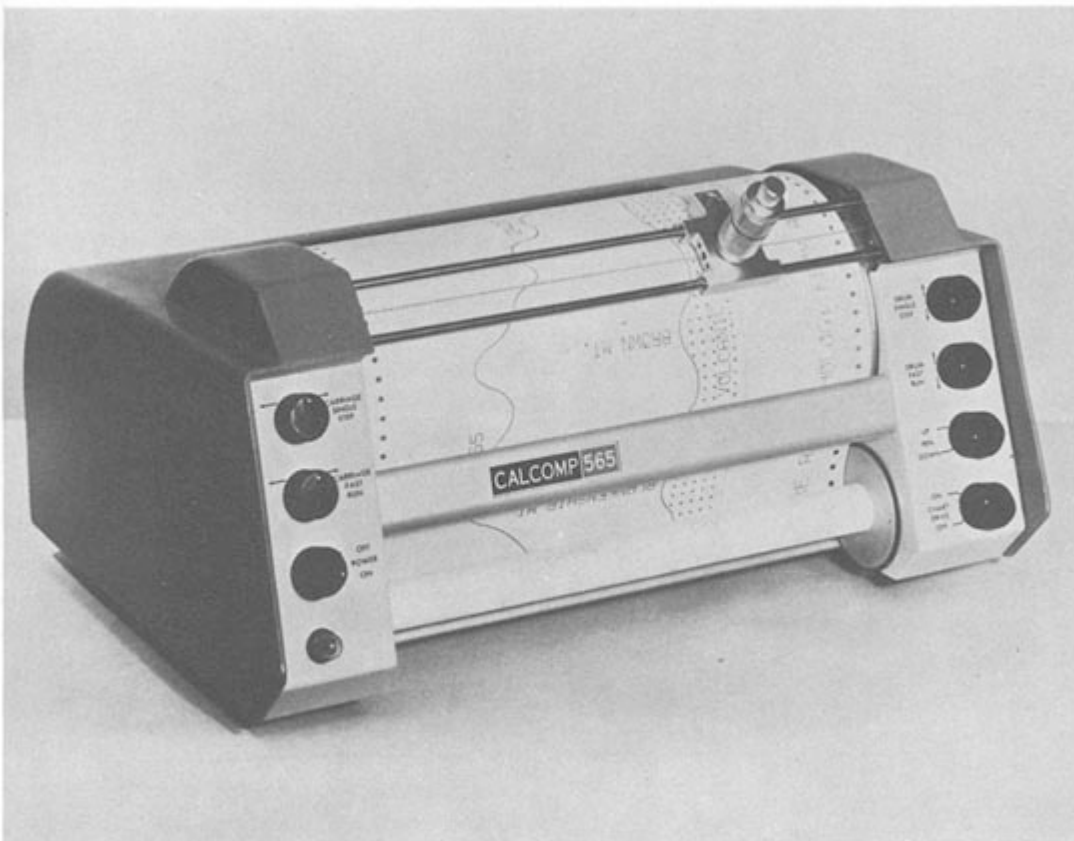
McDonnell Douglas Automation Company (McAuto) was founded in 1960. Their engineers closely watched the DAC program and the ITEK Electronic Drafting Machine optics design efforts, the latter resulting in the Control Data Digigraphics commercial CAD system. McAuto played a major role in CAD development with the introduction of the sophisticated CADD program. CADD was the primary product of McAuto, and it was only available on large IBM mainframes using expensive Evans & Sutherland Picture System display terminals. The software was optimized for the design of aircraft structural components, and even though CADD was possibly the most sophisticated CAD/CAM system available at the time, it had a few major problems that prevented it from being widely used. Besides the obvious reliance on very expensive hardware, McAuto was also prevented from selling CADD to anyone who might be considered a competitor of any of the various aerospace divisions of the parent corporation. The few commercial CADD customers included companies like Timex and Cessna Aircraft

1. Images from this section are from CalComp promotional documents or manuals.

(they built aircraft, but not in competition with MDC). The biggest non-MDC user of CADD was the Northrop Corp., but even they were restricted from using the software for anything other than the F-18 program, a joint development with McDonnell Aircraft. In 1976 McDonnell Douglas acquired United Computing, developer of the Unigraphics CAD/CAM/CAE system.



CalComp Workstation



1. CalComp model 565, 12-inch drum plotter.

From Computer Desktop Encyclopedia
Reproduced with permission.
© 1996 CalComp, Inc.



CalComp 738 flatbed scanner

10.3 Auto-trol / Applicon / ComputerVision



Auto-trol

Auto-trol was one of several companies that crossed the Computer-Aided Design and Computer-Aided Design & Drafting boundaries. Established in the Denver area in 1962, Auto-trol's first product was a digitizer manufactured in the garage of the company founder, Bill Barnes. Mr. Barnes named the company Auto-trol as a shortened version of automated control, which he had called a product he developed in the 1950s. In its early years, Auto-trol manufactured hardware and software for drafting, marrying its original digitizer and flatbed plotter with minicomputers and display terminals.

In 1973, the Hillman Trust purchased Auto-trol. That same year, Auto-trol emerged as a pioneer in the fledgling CAD industry by announcing Auto-Draft, one of the first turnkey graphics systems available. Throughout the 1970s, the CAD industry expanded at a rapid rate, and Auto-trol expanded along with it. In January 1979, Auto-trol's initial public offering was completed. Also in 1979, Auto-trol became the first company to market technical publishing applications to be used to produce the complex technical illustrations needed for service manuals, parts catalogs, and engineering documentation.

Applicon

Fontaine Richardson was one of the first graduates of the University of Illinois computer science program, after which he went to MIT to join the Lincoln Labs group. In the summer of 1969, Richardson and three of his colleagues left Lincoln Labs and founded a company to commercialize computerized electrical engineering design tools. They called the new company Applicon. "Starting an application software company at the time was kind of crazy, kind of half-cocked," recalled Richardson. Only a handful of companies, including the Norden Division of United Aircraft, GM, and Lockheed, were doing this sort of work.

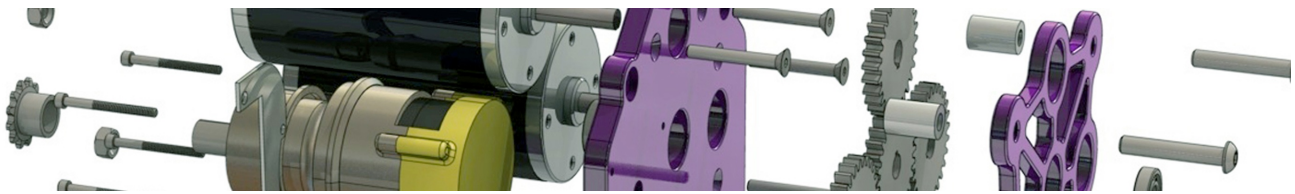
Applicon built a suite of four products: one was for designing IC photomasks, one was for digital circuit simulation, one was for frequency domain circuit synthesis, and one for microwave circuit analysis. All were

to be sold via timeshare, except for the IC photomask program, which required a stand-alone workstation or computer. They decided, because of economic concerns, to concentrate on the IC program, called the Design Assistant. Its first customer was Matsushita in Japan. The company grew from there, expanding to include printed circuit boards and hybrid circuits. Another package was added for three-dimensional designs (mainly for the automotive industry). They produced more and more applications, using the interactive screen design concept, and when Richardson left in 1980, after selling the company to Schlumberger and then merging it with MDSI which Schlumberger had acquired earlier, it was running at revenues of \$100 million per year.

Computervision

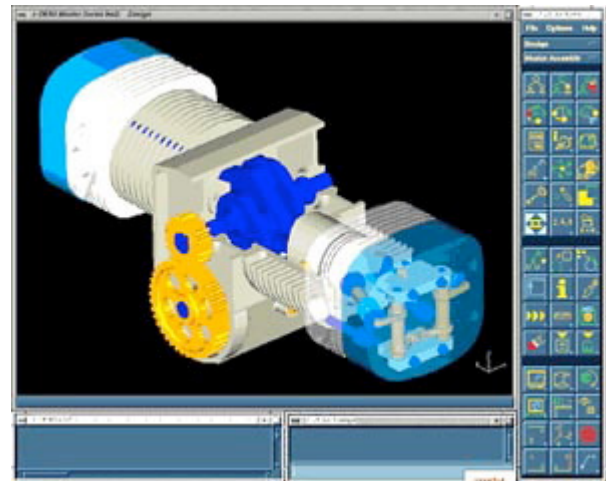
Computervision was created in 1969 to produce systems for production drafting and in the same year it sold the first commercial CAD system to Xerox. In 1978, Computervision introduced the first CAD terminal using raster display technology. In the late 1970s, Computervision made a costly decision to build their own computer system. Once the new 32-bit computer systems replaced the old systems, Computervision stopped their proprietary hardware development and switched to Sun Microcomputers. Prime Computer bought Computervision and their CAD software for mainframes and workstations in 1988. Just after the purchase Prime ran into financial trouble, canceling projects and making staff reductions. Prime tried to change into a UNIX workstation producer but the company was dying. VersaCAD Corp., previously known as T&W Systems, was also bought out by Prime Computer, Inc. In 1997, Computervision was purchased by Parametric Technologies, becoming a wholly owned subsidiary, and its CADD5 software joined the Pro/Engineer CAD/CAM/CAE software as a Parametric offering.

10.4 SDRC / Unigraphics



SDRC

In 1967, after leaving his teaching position at the University of Cincinnati's mechanical engineering program, Jack Lemon established the Structural Dynamics Research Corporation (SDRC). "I established the company to help solve problems that plagued manufacturers," said Lemon. "At the time, Computervision and Applicon were the software leaders, but they focused their efforts on the 2-D drafting marketplace. Our vision was to integrate design, **FEA (Finite Element Analysis)**, testing, and systems to overall product design. We were among the first to integrate 2-D drafting with **CAE**. This effort prompted the need for solid modeling. This was the impetus behind Geomod, a product that provided capabilities to do FEA more efficiently to increase productivity."



Screenshot from SDRC Workstation

Later, while still with SDRC, Lemon's development team introduced Superb FEA, Modal Plus, a modal testing analysis and analysis program, and SuperTAB, the first commercial modeling package that ran on DEC workstations. SDRC first brought their products to market in the early 1970's. At that time, both Ford Motor Company and General Motors started using SDRC software for pre and post process analysis. SDRC first introduced their I-DEAS software in 1982. Developed by SDRC's internal product development organization, I-DEAS was created to address the growing MCAE (Mechanical Computer-Aided Engineering) marketplace.

In 1993, after eleven years of continued growth, SDRC introduced the I-DEAS "Master Series." This new generation of software products for mechanical design automation was completely reconfigured. Automotive

manufacturers in particular used I-DEAS to design any automotive component or assemblies that were beneath the Class 1 surfaces of an automobile. The product also proved itself valuable for designing other aspects of automobiles, such as drive trains, engines, transmissions, chassis components (such as brakes and suspensions, etc.), and seats. In addition to the automotive/transportation industry, I-DEAS was also used in aerospace and defense, electronics and consumer products, industrial equipment, and energy and process. But the lion's share of the users (and SDRC revenue) came from the automotive industry. In 2001 news was released that EDS intended to purchase all of the assets of SDRC. EDS wanted to build a new business unit around SDRC and their previous acquisition UGS, which continued to be known as UGS and operates as an EDS subsidiary.

Unigraphics

United Computing was founded by John Wright in Torrance, California. The first product released by United Computing was UNIAPT, which was a minicomputer based version of APT (Automatic Programmed Tool), a part programming language used to compute tool paths for milling machines. The unique thing about UNIAPT was that it was one of the first CAM products that was sold to the actual end users. Up until this time most companies created their NC programs using time-sharing services from large providers such as McAuto.

In 1973 United purchased the ADAM (Automated Design and Manufacturing) code from Hanratty's MCS. United paid for exclusive rights to the software for both the U.S. and the rest of the world, except for Japan. (However, Hanratty also sold "exclusive" ADAM licenses to both Computervision and Gerber.) MCS updated the software, calling it AD-2000. Licenses for AD-2000 were sold to Autotrol, Graftek, and Control Data, among others.

In 1973 the ADAM software was ported to a General Automation SPC-16 (an early 16 bit mini-computer) with a Tektronix display and an added menu-driven user interface. This was implemented as a single-user system and given the name Uni-graphics (the hyphen was removed in 1974). In 1981, Unigraphics introduced the first solid modeling system, Uni-Solids. It was based on the University of Rochester's PADL-2, and was sold as a stand-alone product to Unigraphics. It provided basic 2D modeling & drafting functionality and supported 14 layers. One of the selling points was that it was a graphical "front-end" for the UNIAPT system.

In 1976 United Computing was acquired by McDonnell Douglas. The company remained in Carson, California but was operated as a wholly owned subsidiary of St. Louis based McAuto, the Automation division of MDC. That same year the GRIP programming language was introduced. It was originally intended to address a request for support of parametric modeling. While it would be years before there were tools that adequately addressed this need, GRIP turned out to be one of the most popular and widely used modules ever offered with Unigraphics. For many years GRIP was considered by many customers to be the most significant differentiator between Unigraphics and the other CAD systems available.

After the problems with getting a stable version of Unigraphics released, McDonnell Douglas decided to close down United Computing and make formal financial arrangements with John Wright and the other founders. The remainder of the organization became part of the newly formed CAD/CAM division of McAuto.

In 1979 Unigraphics Solutions acquired Engineering Animation Inc. (EAI) of Ames, IA. EAI products included the line e-Vis and Vis-View software. EAI had been a longtime partner with Unigraphics Solutions, supplying tools used in Unigraphics' ProductVision software.

In 1988 Unigraphics acquired Cambridge, England based Shape Data Ltd. (developers of Romulus, Romulus-D, and Parasolid) and began commercializing the Parasolid kernel as a stand-alone product. Parasolid was an extremely powerful B-rep solid modeling kernel that allowed the joining of boundary represented surfaces together as a solid. In 1999 Unigraphics Solutions Inc. announced that it had reached an agreement to purchase Applicon, Inc.

10.5 Intergraph / Bentley / Dassault



Intergraph



Intergraph logo on building

In 1970 M&S Computing was founded by two engineers from the NASA space program. It became known as Intergraph (from Interactive Graphics) in 1980. Intergraph became a publicly owned company in 1981. In the beginning it was a consulting firm that supported government agencies in using digital technology. Among these technologies were application-oriented user interfaces that communicated with users in the language of their applications, rather than in programming terminology. The first Intergraph computer graphics system to apply these computing concepts was used by the federal government for designing printed circuit boards. Composed of unaltered stock parts from various vendors, the terminals consisted of a single-screen Tektronix 4014 display terminal with an attached keyboard and an 11-inch by 11-inch “menu” tablet that provided the operator with a selection of drawing commands.

Intergraph grew to be the largest computer graphics company in the world with about 100 offices worldwide and corporate headquarters in Huntsville, Alabama. Its flagship CADD product, IGDS (Interactive Graphics Design Software), was developed in the 1970's. In 1983 Intergraph started shipping InterAct and InterPro. InterAct, with its sculptured surfaces, won two of the three national design awards for new products. These terminals were powered by VAX and MicroVAX processors from DEC.



Intergraph Workstation

The terminals used microprocessors to control the display of the graphics image locally but still relied on the VAX processor to manage the Intergraph application products that created and manipulated the graphics database. Their first standalone workstation, the InterPro 32 was introduced in 1984.¹



Intergraph Display (1978)

In the 1990s, Intergraph built their

products around the PC, powered with Intel processors. Intergraph claimed that after several years of mutually beneficial work, in 1996 Intel began making unreasonable demands for royalty-free rights to Intergraph patents already being used in Intel microprocessors. When Intergraph refused, Intel abused its monopoly power by engaging in a series of illegal coercive actions intended to force Intergraph to give Intel access to the patents.



Intergraph Workstation (1981)

1. Images from this section are from Intergraph promotional documents or manuals.



Intergraph iPro

With no other source of suitable high-end processors available and with its hardware business under serious threat because of Intel's actions, Intergraph sought court protection by filing a lawsuit on November 17, 1997. The lawsuit asserted claims against Intel in three areas: illegal coercive behavior, patent infringement, and antitrust violations. Intel and Intergraph settled the suit in 2002. Under terms of the settlement agreement, Intel paid \$300 million to Intergraph, the lawsuit was dismissed, the companies signed a cross license agreement, and Intergraph sold certain unrelated patents to Intel.

However, significantly impacted by Intel's punitive actions, Intergraph's ability to compete in the PC and generic server market was impaired. In 1999 Intergraph exited those businesses. Intergraph completed the exit from the hardware business by selling the Zx10 workstation and server product line to SGI and the graphics accelerator business (Intense3D) to 3Dlabs. Intergraph announced its intention to structure all aspects of the company around vertically focused business units that provided technical software, systems integration, and professional services.

In 2001 Intergraph again sued Intel charging Intel with infringement on two Intergraph patents that define key aspects of parallel instruction computing (PIC). This patented technology was developed by Intergraph in 1992 when the company's Advanced Processor Division was designing Intergraph's next generation C5 Clipper microprocessor. In October of 2002 Intergraph won that \$150M lawsuit.

Timeline of Intel/Intergraph legal disagreements

1997 – After several years of mutually beneficial work, Intel began making unreasonable demands for royalty-free rights to Intergraph patents already being used in Intel microprocessors. Intergraph filed suit against Intel in an Alabama court, alleging patent infringement, antitrust violations, and illegal coercive behavior.

2000 – Due to Intel's actions, Intergraph was forced to exit the hardware design and manufacturing business.

2001 – Intergraph files suit against Intel for infringing on the company's Parallel Instruction Computing (PIC) patents.

2002 – Intel pays \$300 million in an agreement to settle the 1997 Clipper patent case. Intel pays Intergraph \$150 million to settle the 2001 PIC patent case.

2004 – Intel agrees to pay \$225 million to the Intergraph Corporation to settle remaining claims that its Itanium chip infringed on Intergraph's patents. The settlement brings the total amount Intel has paid or will pay to Intergraph to \$675 million.

Bentley

Bentley Systems, Incorporated was founded by Keith and Barry Bentley in 1984. The company's first product,

MicroStation was based on Intergraph's IGDS product and provided leading-edge CADD capabilities on a personal computer. Originally named PseudoStation, the software developed by Bentley Systems allowed users to view IGDS drawings files without needing Intergraph's software. In 1987, Intergraph Corporation acquired exclusive sales and marketing rights to MicroStation which became a worldwide standard for large-scale engineering projects on all platforms. After Intergraph purchased 50% of Bentley Systems, a new version of MicroStation added proprietary extensions to the IGDS and renamed it DNG. In 1994, the distribution arrangements were restructured and MicroStation marketing and sales were transferred back to Bentley, and the company grew from a software development house to a fully independent business. Their single MicroStation product has expanded into a broad family of over twenty products for plant engineering, building engineering, mechanical engineering, and GeoEngineering.

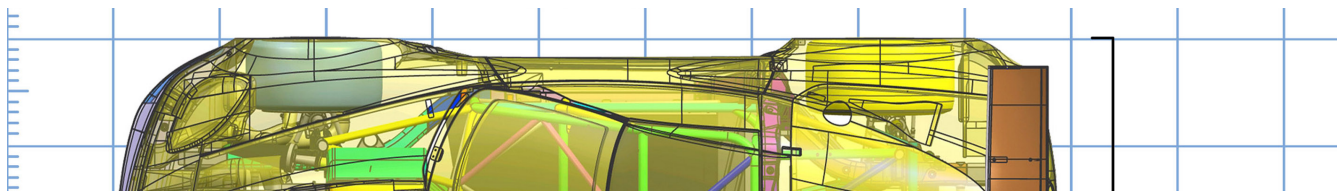
Dassault

In 1975 Avions Marcel Dassault (AMD), later Dassault Systemes, purchased CADAM (Computer-Augmented Drafting and Manufacturing) software equipment licenses from Lockheed, becoming one of the very first CADAM customers. By 1977, AMD assigned its engineering team the goal of creating a three-dimensional, interactive program, the forerunner of CATIA (Computer-Aided Three-Dimensional Interactive Application). Its major advance over CADAM was the 3rd dimension. In 1984 drafting capabilities were added to CATIA, enabling it to function independently of CADAM. By 1985 CATIA Version 2 contained fully integrated drafting, solid and robotics functions, making it the aeronautical applications leader. By 1988 CATIA Version 3 contained AEC functionality and was ported to IBM's UNIX-based RISC System/6000 workstations. CATIA thus became the automotive applications leader as well.

Founded in December 1993, SolidWorks Corporation introduced the first powerful 3D CAD software available for a native Windows® environment. The product was based on the Parasolid kernel. They have released new major product lines every year since 1995, most recently SolidWorks 2004 software, representing over 285,000 software seats to date. Solidworks received a U.S. patent for the SolidWorks FeatureManager™, now the standard CAD user interface found in every CAD application today. The company was acquired by Dassault Systemes in 1997 for \$300M in stock. SolidWorks serves customers in industrial, medical, scientific, consumer educational, technology, and transportation markets.

In 1998, Dassault acquired the French Matra Datavision company, creators of the EUCLID systems for **free-form surface modeling**, NC control and injection molding simulation. The EUCLID Styler, Machinist, Strim and Strimflow products enhanced the CATIA product in these areas. They later partnered with IBM as a strategic international business partner.

10.6 Autodesk / Micro-Control Systems



Autodesk



Autodesk employees (founder John Walker in center)

AutoCAD is a Computer Assisted Design (CAD) software package for 2D and 3D design and drafting. It originally ran only on Microsoft operating systems. Versions for Unix and Apple Macintosh were released, but these met with limited market acceptance and were later dropped. Initially for mechanical engineers, it was extended and was very widely used by architects and other design professionals. Its file formats (DWG and its ASCII equivalent, AutoCAD DXF) became the default standard for CAD packages. Version 1.0 was released in December 1982.

Autodesk was founded in 1982 by John Walker. He and the other 15 co-founders set off to develop five different desktop automation applications. They did this with the notion that one of the applications would take off and be developed further. That product turned out to be AutoCAD, which was based on a CAD program written in 1981 by Mike Riddle called MicroCAD, changed later to Interact. It was shown at the COMDEX trade show in Las Vegas as the first CAD program in the world to run on a PC.



Autodesk products



AutoCAD running on PC

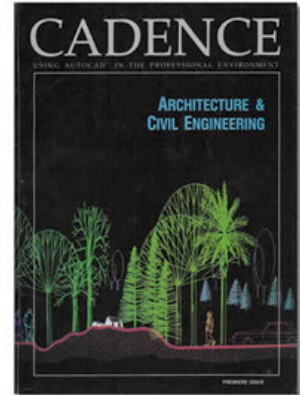
Software and the Generic CADD program.¹

Micro-Control Systems

In 1985 Peter Smith and Livingston Davies founded Micro-Control Systems and released CADKEY, the first 3D PC CAP product. 3D was still very hard to work with on a PC and it was not until a later release that CADKEY was able to become a serious player as a 3D wireframe layout tool and for drafting. That same year Diehl Graphsoft, Inc. was founded and the first version of MiniCAD was shipped. MiniCAD became the best selling CAD program on the Macintosh.

AutoCAD 2004 was released in March 2003. A lower-cost version, AutoCAD LT was first introduced in 1993. Compared with its more expensive sibling, LT lacked the AutoLISP programming language and other programming interfaces, some 3D capability, and a few other features.

In 1986 CADENCE magazine was established for the AutoCAD user community. It would become the world's largest independent CAD publication. In 1989 Autodesk purchased Generic



CADENCE magazine cover

Some other relevant CAD items:

- In 1978 the Computer Graphics Newsletter, a two year old publication founded by Joel Orr, became Computer Graphics World magazine.
- In 1979 Boeing, General Electric and NIST developed a neutral file format as a contract from Air Space called IGES (Initial Graphic Exchange Standard). It became the industry standard format and the most widely accepted format for transferring complex surface information, such as NURBS curves (see Chapter 7 for more information.)
- CoCreate Software Inc., was established in 1984 as a division of Hewlett-Packard Company with the charter to expand the scope and focus for development of computer-aided design (CAD) and computer-aided manufacturing (CAM) software products. In 1996, CoCreate became a wholly-owned subsidiary of Hewlett-Packard Co. and expanded its product offerings to include collaboration software solutions
- In 1988 Martin Newell (formerly of the University of Utah) founded Ashlar Incorporation and released Ashlar Vellum CAD software.

1. The image at the header is a Corvette Racing Next-Generation C6.R. This CAD (computer-aided design) illustration shows the overall layout of the GT2 Corvette C6.R's components, with a GM small-block V8 engine mounted behind the centerline of the front wheels and a 6-speed sequential-shift transaxle between the rear wheels (Richard Prince/GM Racing Photo).

Chapter 11: CG Production Companies

CG Production Companies

Computer Generated Imagery, or CGI, became a mainstream product in the advertising, television promotion, and motion pictures special effects industries, and a new business model of production of this imagery was born from it.



Dolphins: The Ride, IMAX Ridefilms, Rhythm and Hues (1998)

11.1 Introduction



The year 1987 marked a very critical time in the history of computer graphics and animation production. Rapid and major changes in technology, in some cases coupled with some questionable business practices, resulted in the demise of a number of major graphics production studios, including Robert Abel and Associates, Digital Productions, Omnibus, and Cranston/Csuri Productions (already discussed in Chapter 6). At the same time, the work of these companies had raised the bar for image quality, and the advertising, television promotion and film industries were beginning to realize the impact of this new medium. Concurrently with these changes, and in some cases as a result of them, the industry reorganized itself into a major contributor to the rapidly emerging image synthesis market.

This chapter highlights some of the companies that were born of this time of change. Most of these companies attracted the significant talent that was a major part of the success of the folded enterprises listed above.

- ILM
- Pixar
- deGraf/Wahrman
- Metrolight
- Rez.n8
- Rhythm & Hues
- Kleiser Walczak
- Kroyer Films
- Sogitec
- R/Greenberg
- Lamb & Co.

- Xaos
- Blue Sky Studios

11.2 Industrial Light and Magic (ILM)



Lucasfilm Logo

George Lucas was born and raised in Northern California. He attended the University of Southern California film school. Always considering the Bay Area his home, Lucas returned to Northern California to pursue his film career. In 1971 he formed his own independent production company, Lucasfilm Ltd., in Marin County, just north of the Golden Gate Bridge.

In July of 1975, with the *Star Wars* saga already written and design work begun the previous year, Industrial Light & Magic (ILM) was established¹ to produce the visual effects for *Star Wars*. That same year Sprocket Systems was established to edit and mix *Star Wars*. It was later to become known as Skywalker Sound. In 1977 *Star Wars* opened and became the largest grossing film of all time to that date. It received six Academy Awards for original score, film editing, sound, art and set decoration, costume design and visual effects, as well as a Special Achievement Academy Award for sound effects creations.



X-Wing Fighter

With the release of *The Empire Strikes Back* in 1980 and a new home in San Rafael, ILM began to establish itself as the leader in visual effects production. The same year, ILM began to work on its first non-Lucasfilm picture, *Dragon Slayer*.

1. Portions excerpted from <http://www.lucasfilm.com/inside/>



Scene from *The Abyss*

Throughout the 1980s, ILM continued to receive recognition for its visual effects work, earning 10 Visual Effects Academy Awards during that decade. Included among the films honored are: *The Empire Strikes Back*, *Raiders of the Lost Ark*, *E.T. The Extra-Terrestrial*, *Return of the Jedi*, *Who Framed Roger Rabbit* and *The Abyss*. In *The Abyss*, ILM made further breakthroughs in computer graphics with its creation of the pseudopod, the first wholly computer-generated character [in a motion picture].

Skywalker Sound was also honored with 5 Academy Awards during this period for Best Sound and Best Sound Effects Editing on films including *The Empire Strikes Back*, *Raiders of the Lost Ark* and *E.T.* In 1987, construction was completed on the Technical Building at Skywalker Ranch, Lucas's film production facilities in central Marin, allowing Skywalker Sound to move into the 145,000 square-foot facility.'

Terminator 2: Judgment Day in 1991 was another milestone in the history of Lucas Digital. Additional advancements and achievements in the field of computer graphics were realized. Both ILM and Skywalker Sound were rewarded with Academy Awards for their work on the film.

In 1992 George Lucas was honored by The Academy of Motion Picture Arts and Sciences with the Irving Thalberg Award. This award is voted by the Academy Board of Governors to a creative producer whose body of work reflects a consistently high quality of motion picture production and is given only in years when the Board feels there is a deserving recipient. Steven Spielberg presented the Thalberg statue to Lucas at the Academy Awards Ceremony on March 30th.

The following year, in 1993, a new corporate structure was set up among Lucas's various companies to allow for management flexibility and accountability. Three separate companies were the result of the restructure:

- Lucasfilm Ltd. – Film and Television production, THX and Licensing/Toys
- LucasArts Entertainment Company – Games and Learning
- Lucas Digital Ltd. LLC- Industrial Light + Magic & Skywalker Sound



Kitchen scene from *Jurassic Park*

That same year, ILM completed the visual effects for *Jurassic Park*, creating computer graphic animals which blended flawlessly with the live action footage while Skywalker Sound was in charge of creating the audio effects. Again, both units were recognized with Academy Awards for their work in Sound, Sound Effects Editing and Visual Effects.

The nineties saw continued success and awards for both companies. Notable films that benefited from their expertise included *Forest Gump*, *The Mask* and *Twister*. In 1997, the twentieth anniversary date of *Star Wars*, all three movies in the *Star Wars* trilogy were rereleased. New and refined digital footage was inserted and the sound was enhanced. Record crowds greeted familiar characters with applause and delight and *Star Wars* once again became the largest grossing movie of all time.

Lucas hired effects expert John Dykstra to head a new production facility, located in old warehouses in Van Nuys, California. After completing *Star Wars* he relocated ILM to the Bay Area. They are located in San Rafael, California, but have several other campuses, including in the Presidio Park in San Francisco (information about the campuses can be found at <http://www.lucasfilm.com/inside/campuses/>)

After ILM finished *Star Wars*, Lucas contracted Triple-I for several CG effects tests, including animating X-wing fighters (Art Durinski and Gary Demos produced the tests) for *The Empire Strikes Back*. Lucas was impressed but couldn't come to contractual terms with Triple-I. Instead he made the decision to establish his own CG division, and recruited most of the researchers and management from NYIT, including Alvy Ray Smith and Ed Catmull, to staff the new division.



Frames from the *Genesis Effect*

The initial years were spent in research, developing film scanners and recorders, software for CG compositing, rendering architectures capable of film work, and computer assisted film and sound editing. The first production work came for the Genesis sequence for *Star Trek II, The Wrath of Khan* (see discussion in the Pixar section.)

Many of the CG team reorganized to form Pixar and Lucas reformed the Lucasfilm CG division as the ILM Computer Graphics Division, but as it grew in importance it became the prominent component of ILM, and the distinction as a separate name and division disappeared. Lucas Digital was the umbrella company for ILM and Skywalker Sound. The

other Lucas companies were Lucasfilm, LucasArts, Lucas Licensing, and Lucas Learning.

In the early days of the company, they also established a CGI commercial production division. This group accounted for a large percentage of ILM's income during this time, but saw its importance diminish with a downturn in the economy and a cutback by customers for CG advertising work. As a result, ILM decided to close the department in mid-2002.



Stained glass Knight from Young Sherlock Holmes

One of the early images made by the group was called *Road to Point Reyes*. The rights to much of this ILM hardware and software technology was sold to Steve Jobs in 1986, as Pixar was founded (see next section).

The computer group associated with the graphics group developed a system to do film editing, which was called EditDroid. This development effort was headed by Ralph Guggenheim, who also came from NYIT. EditDroid was the first non-linear editing system. It was based on SUN hardware coupled with a laserdisc system and 3/4" tape recorders. It had a custom touchpad used to make the cuts, and its interface used a timeline approach.

The SoundDroid was a similar custom computer system based on the Audio Signal Processor computer the group first built. It had an interface with a touchpad that permitted cutting and editing sound clips. Afterwards Lucas created a company called DroidWorks which would develop and sell these systems, but being custom solutions they were quite expensive. Eventually Lucas licensed and sold much of the technology to Avid in 1993.

Other innovations that have come out of the ILM efforts include:

The Lucasfilm Computer Graphics Group developed several industry leading hardware and software systems. The *Pixar Image Computer* was developed for compositing operations. The internal frame buffer was a special built hardware component that was controlled mainly by SUN machines and driven via command line. In 1984 it was used to composite the stained glass knight for the movie *Sherlock Holmes*. It was also coupled with the ILM built laser film scanner and recorder. They also developed a high quality renderer suitable for photorealistic film-resolution work. The scanline rendering algorithm was called REYES (Renders Everything You Ever Saw). The group developed shading trees which eventually became RenderMan's Shading Language.

One of the



Road to Point Reyes

- the expansion of morphing by Doug Smythe, based on the system first developed by Tom Brigham, formerly of NYIT, for use in the movie *Willow* (they received an Academy Technical Achievement Award in 1992 for the software *morf*)
- The *Dinosaur Input Device* was later renamed the Digital Input Device or Direct Input Device. The DID was an armature, very similar to those ones used in **stop motion** but it also had electronic encoders at the joints. The encoders would translate the positions of the joints into the computer where the data could be used to move the skeleton of a CG dinosaur. The traditional stop motion animator could pose the armature (and hence the CG dinosaur) and set keyframes. ILM received an Academy Technical Achievement Award in 1996 awards for this development.
- John Knoll (who was a **motion control** technician) and his older brother Thomas Knoll (a PhD candidate at the University of Michigan doing work in image vision) developed Photoshop in 1987. It was designed for Macs, based on the functionality of the Pixar Image Computer, and was used on *the Abyss*.
- The group led by David DiFrancesco eventually developed a laser film scanner and recorder in one unit in 1980, and in 1983 the unit was incorporated into the Pixar Image Computer. The first project to use the system was *Young Sherlock Holmes*. Several other facilities were also developing film scanners including Triple-I, CFC, PDI and RFX. All the facilities were recognized with Academy Awards in 1994 for their pioneer work in film scanning.
- ViewPaint was ILM's proprietary 3D paint system. It allowed the user to paint color texture maps on 3D models, and also allows for the creation of displacement maps, transparency maps, specular maps, etc. ILM received an Academy Scientific and Engineering Award in 1996 for ViewPaint.
- Caricature is ILM's proprietary animation software, developed by Cary Phillips of the R&D group. It was developed to meet the challenges of the facial animation for *Dragonheart*. The tool became so successful that animators started it using more extensively, not only for facial animation but also all sorts of secondary animation, like the breathing and skin jiggling of the dinosaurs in *The Lost World*. Cary Phillips received an Academy Technical Achievement Award in 1998.

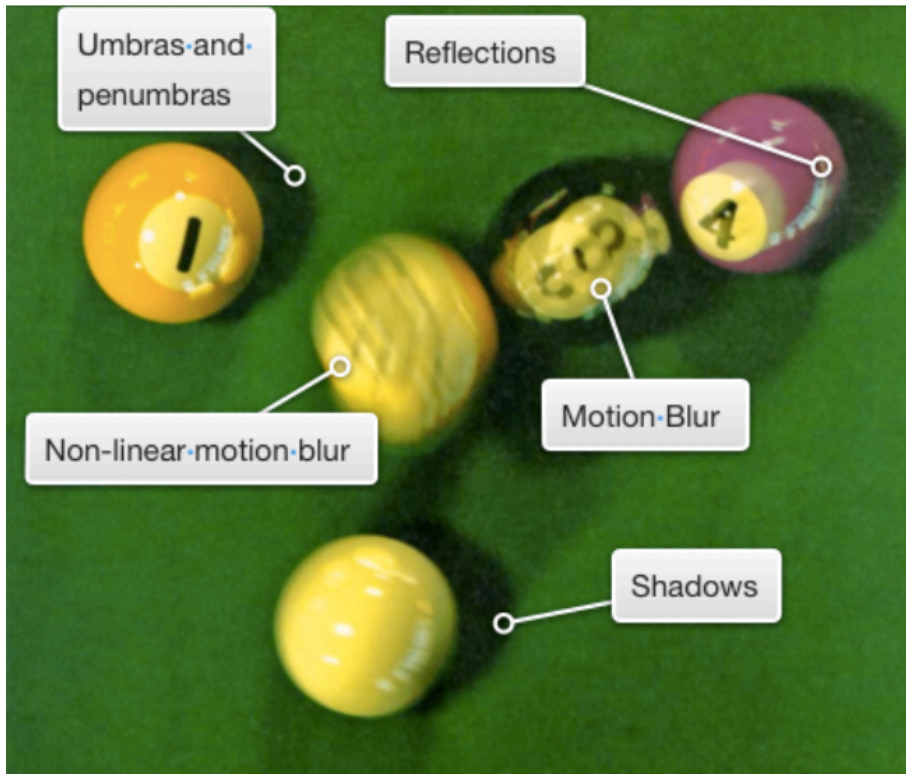


Poster for *Willow*

ILM has significantly influenced the entire CGI industry, through its innovative software and hardware research and development, its incredible film work, and also through the companies that have grown with former ILM people. Some examples of such companies are:

- Apogee was the FX facility created by John Dykstra, the original Star Wars supervisor. Dykstra decided not to move to Northern California and opened shop in the old ILM facilities of Van Nuys. There he worked on several projects: *Star Trek The Motion Picture*, *Firefox* and *Invaders From Mars*. In 1993 Apogee closed.
- After the completion of *Star Wars* Hoyt Yeatman and Scott Squires in 1979 founded Dream Quest Images. Some early projects included *The Adventures of Buckaroo Banzai Across the 8th Dimension* and *Blue Thunder*. DQI was bought by Disney to serve as their in-house FX facility in 1994. Disney reorganized and brought together the CG group of Feature Animation with DQI and renamed them The Secret Lab in late 1999, which closed in 2002.

- Boss Film was founded by former ILM supervisor Richard Edlund in 1983. Some early projects included *Ghostbusters*, *Die Hard* and *Poltergeist 2*. Edlund closed the facility after its last two projects, *Air Force One* and *Starship Troopers*.
- Phil Tippett was the stop motion master at ILM. In 1983 he decided to leave ILM and work on his own in a facility that would eventually become Tippett Studio. Some early projects include *Dinosaur!*, *Robocop*, and *Willow*. Tippett Studio is located near Berkeley, California.
- Digital Domain was founded by filmmaker James Cameron, makeup FX wizard Stan Winston and former ILM President and GM Scott Ross. Some early projects included *True Lies* and *Interview With a Vampire*. DD remained the second largest FX facility and was located in Venice Beach, California, where they worked on both large film projects like *Titanic*, small FX films like *A Beautiful Mind*, countless commercials and special projects like *T2 3D*.
- Sony Pictures Imageworks was started as a small in-house FX unit for Sony Pictures. In 1995 Sony offered Ken Ralston a position as its president to lead the expansion of the effort. Many other ILMers followed, including Lincoln Hu (Director of Technology at ILM) who became Senior VP and Chief Technology Officer at Imageworks.
- While Weta Workshop was founded in 1986 by Dan Taylor, Weta Digital wasn't formed until 1993. Several former ILMers, including Wes Ford Takahashi traveled to New Zealand to setup the basics of the new digital division. Weta Digital worked on *Contact* and owner Peter Jackson's *Lord of the Rings*. For *the Two Towers* former ILM supervisor Joe Letteri joined the production as the supervisor.
- Former ILM CG artist Henry LaBounta joined PDI as their VFX supervisor in PDI's CAFE (Computer Animation and Feature Effects). CAFE worked in many VFX projects like *The Peacemaker* and *The Legend of Bagger Vance*, Steven Spielberg's *A.I. Artificial Intelligence* and *Minority Report*. Due to the success of *Shrek*, PDI decided to close CAFE and concentrate on feature animation projects and commercials.
- Many former ILM members have joined Electronic Arts, like supervisors Dave Carson, Henry LaBounta, and Habib Zargarpour, and top CG artist Jay Riddle.
- Other notable facilities out of ILM include Complete Pandemonium (Steve "Spaz" Williams and Mark A.Z. Dippé), FreedomZone (Ellen Poon), The Orphanage, formed by Rebel Unit members Stu Maschwitz, Scott Stewart and Jonathan Rothbart, Tweak Films (R&D Lead Jim Hourihan and TD Chris Horvath), Digital Fauxtography (Terrence Masson), and DVGarage (Alex Lindsay).



This image was created by the ILM Graphics Division to test the theories described in a famous paper by Rob Cook, Distributed Ray Tracing, and to make certain that they were production ready to use in the André and Wally B. movie they were preparing for the SIGGRAPH 84 film show.



Frame from André and Wally B.



Frame from *André and Wally B.*

Movie 11.1 Star Wars to Star Wars



From *Star Wars to Star Wars: The Story of Industrial Light & Magic* (1999) – a TV documentary of the history of the company, hosted by Samuel L. Jackson? <http://www.youtube.com/watch?v=AFNTe7speqk>

Movie 11.2 Jurassic Park



Excerpted from “Industrial Light and Magic: Creating the Impossible” documentary.? http://www.youtube.com/watch?v=NxfxsjCR_-o

Movie 11.3 André and Wally B.



Alvy Ray Smith originally conceived the idea for this short, which represented André as a robotic style “android”. John Lasseter was brought on to ILM to help realize the film, and he changed the character to a more organic form. It was rendered on the new ILM REYES system, which integrated **motion blur**, a lighting approach developed by Rob Cook, a particle system plant generation approach developed by Bill Reeves, and a new animation system called Motion Doctor realized by Tom Duff. It was rendered on all of the VAX computers at ILM, some borrowed machines at MIT, and several Crays from Cray Research in Minnesota. a Mitchell camera filmed it one frame at a time from the monitor. It premiered at SIGGRAPH 84, with George Lucas and his the girlfriend Linda Rondstat in attendance.

<https://www.youtube.com/watch?v=C-L-WA-nQzI>

Note: It was announced on October 30, 2012 that Lucasfilm, Ltd. including LucasArts, Industrial Light & Magic, and Skywalker Sound, would be purchased by Disney from George Lucas for \$4.05B in cash and stock.

Disney Announcement from USA Today

The *Mac Rebel Unit* was a group within ILM that used Macs to do their jobs. Its name is taken somewhat jokingly from being a smaller band of “rebels” amid the large “empire” sized Unix and Linux based groups. The unit was started by Dennis Muren and was primarily composed of artists. Among the work that they did was painting of texture and image maps, digital matte paintings, some compositing, rotoscoping and even some 3D work. The Art Department and the *Star Wars* prequels pre-visualization unit were also Mac based. Among the tools the Rebel Mac unit used were Photoshop, Commotion and Electric Image. (From the ILMFan.com web site FAQ).

An excellent accounting of the development of Lucasfilms, including the efforts at NYIT that would ultimately become Pixar, can be found in the book Droidmaker- George Lucas and the Digital Revolution, by Michael Rubin, which is available as an eBook from the iTunes store.

An article written by Alvy Ray Smith in the IEEE Annals of the History of Computing, for their 1998 special on Graphics Remembrances, details the presentation by the CG effects team to convince George Lucas to utilize CGI in his films ([George Lucas Discovers Computer Graphics](#))

[The Reyes Image Rendering Architecture](#)

[Distributed Ray Tracing](#)

[The Making of the Genesis Sequence](#)

(Video – <http://www.youtube.com/watch?v=Qe9qSLYK5q4>)

[Stained Glass Sequence from Young Sherlock Holmes](#)

(Video – http://www.youtube.com/watch?v=uOsxXi-tu_U)

[The Visual Effects of Willow](#)

[Pixar Image Computer article](#)

[The Genesis Demo: Instant Evolution with Computer Graphics](#), Alvy Ray Smith, American Cinematographer (1982)

Links for Richard Edlund and Boss Films

- http://www.callicosfx.com/Behind_The_Scenes/Boss_Films/boss_films.html
- [Interview with Richard Edlund of Boss Films](#)
- [1997 NY Times Article](#)
- [1998 Dow Jones Article](#)

In late 1981, the home and arcade game company Atari approached George Lucas with a proposal to bring high quality graphics technology to the game design world, and in 1982 Lucasfilm and Atari joined forces.

Lucasfilms hired UNIX expert Peter Langston who assembled a team of programmers (including David Fox and David Levine) to work on two proof-of-concept prototype games, Ballblazer and Rebel Rescue (Rescue on Fractalus!). Loren Carpenter contributed an approach to generating fractal mountains, and the prototypes were so successful they became the first products of the new Lucasfilm Games division in 1984. The games were developed in the UNIX environment, and copies were leaked and appeared on a games BBoard before they were released.

<http://www.atarihq.com/othersec/library/lucasflm.html>

11.3 Pixar



P I X A R

Pixar logo

The origins of Pixar were at the heart of the graphics lab at NYIT. This group was largely moved to ILM after Lucas recruited Ed Catmull to develop a computer graphics group there in 1979. As was discussed in the previous section of this chapter, many innovative hardware and software technologies were developed at ILM, including what was called the Pixar Image Computer.

On February 3, 1986 Steve Jobs paid \$5M to ILM to purchase the rights to the technology, and invested another \$5M to capitalize a new company that could utilize the technology in production. The new company was called Pixar, Inc. ILM retained the rights to use the technology in house, and continued animation work there. The *Pixar Image Computer*, which was intended for the high-end visualization markets, such as medicine, was eventually sold to Vicom Systems for \$2M (a *video* showcasing the Pixar Image Computer can be viewed at <http://www.youtube.com/watch?v=ckE5U9FsgsE>.) At that time, 18 Pixar employees were also transferred out.

According to Alvy Ray Smith in a series of documents on his *web site*, George Lucas decided to refocus his efforts, so Smith and Ed Catmull contacted several venture capitalist groups, and several individuals and/or companies (including a partnership of General Motors' EDS computer services company, owned by H. Ross Perot, and a unit of Dutch electronics conglomerate Philips NV) to try to find funding to finance the spinoff, before Jobs came forward with his investment.



Pixar image computer

Ed Catmull became head of the new company and Alvy Ray Smith became Vice President. Most employees of the division at ILM (40 in all, including Malcolm Blanchard, Loren Carpenter, Rob Cook, David DiFrancesco, Ralph Guggenheim, Graig Good, John Lasseter, Eban Ostby, Tom Porter, Bill Reeves, and others) left for *Pixar*.

The early years of the company were tough, from a financial perspective. The sales of the Pixar Image Computer were slower than anticipated, resulting in the Vicom sale. The cost of computing frames of animation (particularly for film) was still very high, so the company did animation for advertising, including fairly well-known CGI ads for Listerine, Tropicana and Lifesavers (several won Clio Awards.)



A Simple Model of Ocean Waves ?A. Fournier and W.T. Reeves

Movie 11.4 Listerine – 1994



Clio Award-winning ad created by Pixar, directed by Jan Pinkava (Geri's Game) and produced by Darla Anderson (A Bug's Life).
<https://www.youtube.com/watch?v=48tlwbuctYQ>

This commercial production effort by Lasseter's group kept a small revenue stream coming in to the company, but additional funding was needed. Steve Jobs continued to provide these needed funds by converting the equity of the employees who originally owned a percentage of the company, ultimately putting in \$50M and becoming the dominant stockholder.¹

In 1990 Pixar moved their headquarters to Richmond, just across the bridge from San Rafael in Marin County. In 2002 they again moved, this time to a large campus on 15 acres in Emeryville. A description of the Emeryville HQ of Pixar from the architect's web site can be found [here](#).

Image production during these formative years also included work on animated *short film productions*, most notably *Luxo Jr.* (1986), *Red's Dream* (1987), *Tin Toy* (1988), *KnickKnack* (1989) and *Geri's Game* (1997). Pixar won Oscars for *Tin Toy* in 1988 (*Luxo Jr.* was nominated in 1986) and *Geri's Game* in 1998.

1. Alvy Ray Smith documented the history of Pixar in an article called *Pixar History Revisited - A Corrective*, in which he takes on the myths that Jobs started, or bought Pixar. <http://www.alvyray.com/Pixar/PixarHistoryRevisited.htm>

Software created by Pixar in the first few years (or expanded from that developed at the ILM division) included the REYES (Renders Everything You Ever Saw) renderer, CAPS (developed for Disney), Marionette, an animation software system that allowed animators to model and animate characters and add lighting effects, and Ringmaster, which was production management software that scheduled, coordinated, and tracked a computer animation project. The film recording technology mastered by David DeFrancisco was incorporated into a new laser film recorder called *PixarVision*.

The applications development group also worked to convert the REYES technology to the RenderMan product, which was commercialized in 1989. Saty Raghavachary, a graduate of Ohio State’s graphics program and a software developer at Dreamworks, summed up the development clearly in notes for a course on RenderMan at the Siggraph 2006 conference:

The researchers had the explicit goal of being able to create complex, high quality photorealistic images, which were by definition virtually indistinguishable from filmed live action images. They began to create a renderer to help them achieve this audacious goal. The renderer had an innovative architecture designed from scratch, incorporating technical knowledge gained from past research both at Utah and NYIT. Loren Carpenter implemented core pieces of the rendering system, and Rob Cook wrote the shading subsystem. Pat Hanrahan served as the lead architect for the entire project.

The architecture embedded in RenderMan was presented in a paper by Cook, Carpenter, and Ed Catmull at Siggraph 87.² ACM SIGGRAPH Computer Graphics, Volume 21 Issue 4, July 1987, Pages 95-102, and the shader was documented in a 1990 paper by Hanrahan and Jim Lawson.³ The system was used in the creation of the Academy Award winning *Tin Toy* in 1988. A sequence of images, which has become quite famous, was created to demonstrate the capabilities of the software, and the stages of the rendering pipeline. Called the “Shutterbug” series, it has been used countless times to teach students the concepts of rendering.

RenderMan, or Photorealistic RenderMan (PRMan) as it is properly known, is actually a formal specification, or an interface description to provide a standard for modeling and animation programs to specify scene descriptions to rendering software. In February, 1989, nine months after Pixar promoted the scene description language, InfoWorld magazine **announced** the commercialization of the RenderMan imaging technology. Autodesk was the first licensee, wanting to include it in their AutoShade product.⁴

The group received Academy Technical Awards in 1992 for CAPS, 1993 for **RenderMan**, 1995 for digital scanning technology, 1997 for Marionette and **digital painting**, and 1999 for laser film recording technology.

Steve Jobs discontinued the applications development effort in 1991, ostensibly because of a fear of competition with the NeXT product development efforts. As a result, nearly 30 people were laid off, including Alvy Ray Smith, who with two others then founded Altamira, with support from Autodesk. This reduced the total number of employees to about its original number of 40. At that point, the developers who were working on CAPS for

2. Cook, Rob, Carpenter, Loren, and Catmull, Ed. The Reyes Image Rendering Architecture,

3. Hanrahan, Pat, and Lawson, Jim. A Language for Shading and Lighting Calculations, ACM SIGGRAPH Computer Graphics, Volume 24, Issue 4, September 1990, Pages 289-298

4. In their July, 2013 issue, *fxguide* magazine published an interview with Ed Catmull and Loren Carpenter on the 25th anniversary of the release of the RenderMan 3.0 interface. It can be read online at <https://www.fxguide.com/featured/pixars-renderman-turns-25/> A podcast of the interview with Ed Catmull accompanies the article at <https://www.fxguide.com/fxpodcasts/fxpodcast-257-pixars-ed-catmull/>

Disney and Photorealistic RenderMan, and Lasseter's commercial animation department were all the employees left at Pixar.

At that point, Disney executives and the leadership team at Pixar signed a \$26 million deal with Disney to produce three computer-animated feature films, the first of which was *Toy Story*. In an [article in Fortune Magazine](#) Brent Schlender reported

In 1991, Lasseter felt the Pixar technology was robust enough to make an hour-long computer-animated TV special. He pitched the idea to Disney, hoping the big studio would help fund the project. Jeffrey Katzenberg, who was running Eisner's film business, was already enamored of Lasseter's style. (Now a principal of DreamWorks, Katzenberg contends that the director is Pixar's biggest asset.) Katzenberg and Eisner came back with an unexpected counteroffer: How about making a full-scale movie that Disney would pay for and distribute?

Not surprisingly, Jobs, who'd been absorbed by the trials and tribulations at Next, suddenly started paying more attention to his other company. He got involved in the negotiations with Disney, and hired one of Hollywood's most respected entertainment lawyers to help hammer out a deal. The result was a contract for Pixar to make three feature films. Disney would pick up most of the production and promotion costs, as long as it had complete control over marketing and licensing the films and their characters. Pixar would create the screenplays and the visual style for each picture and receive a percentage of the box-office gross revenues and video sales.

Jobs has to be given a lot of credit for sticking with the company. At several points, he considered selling it (it is reported that one potential buyer was Microsoft), but he ultimately realized, as *Toy Story* was wrapping up and Disney confirmed a Christmas release, that the company had tremendous potential and backed away from the desire to sell it.

In 1995 Pixar went public with an offering of 6,900,000 shares of stock. Shares opened at \$47, more than double their offering price of \$22, and at the closing price of \$39 per share, the company had a market value of about \$1.5 billion.

After successes with *Toy Story*, the Pixar interactive group developed two CD-ROMs, but were refocused in 1997 in order to concentrate the corporate effort on making films. In 1997 the two organizations (Pixar and Disney) announced a five picture agreement, including a sequel to *Toy Story*. Pixar produced the 1998 animated feature *A Bug's Life*, which set box office records, *Toy Story 2*, *Monsters, Inc.* and *Finding Nemo*.



Scene from Toy Story



Scene from A Bug's Life

Pixar and Disney went through a period of several public

disagreements, particularly around the production and quality of *Toy Story 2*, as well as Disney's ownership of story and sequel rights, and Jobs' not so quiet disdain for Michael Eisner. They attempted to come to an agreement, but both companies held firm on their demands. Pixar's contention was reported in the media:

Pixar had complained that the terms of the distribution deal were tilted too heavily in Disney's favor. Under the deal, Pixar was responsible for content, while Disney handled distribution and marketing. In exchange, Pixar has split profits with Disney and pays the studio a distribution fee of between 10 percent to 15 percent of revenue. Based on its blockbuster success, Pixar has argued that it should keep the profit itself and cut the fees its studio partner charges.

Talks broke down in 2004, and Wired Magazine reported that *Pixar Says Goodbye to Disney*. Following that, Jobs reportedly entered into distribution discussions with Time Warner, Sony and Viacom, though no agreement was settled on. Talks with Disney resumed after Eisner left Disney in 2005.

Disney announced in early 2006 that it had agreed to buy Pixar for approximately \$7.4 billion in an all-stock deal. Jobs gained a seat on the Disney board of directors and gave him 7% ownership. Lasseter, became Chief Creative Officer of both Pixar and the Walt Disney Animation Studios, as well as the Principal Creative Adviser at Walt Disney Imagineering, which designs and builds the company's theme parks. Catmull retained his position as President of Pixar, while also becoming President of Walt Disney Animation Studios.

Movie 11.5 Luxo, Jr.



The iconic Luxo lamp is manufactured by Luxo ASA, an Oslo, Norway based company. The lamp stands as Pixar's most famous symbol, was the subject of their 1986 produced short *Luxo, Jr.*, is used in their movie opening sequence logo, and an oversized statue of the lamp graces the entry courtyard of their headquarters in Emeryville, California. <https://www.youtube.com/watch?v=6G3O60o5U7w>

The collection of short films, trailers and outtakes produced at Pixar can be seen at their corporate website

at

http://www.pixar.com/short_films/Theatrical-Shorts

Home Designing.com has a photo tour of the Pixar headquarters at

<http://www.home-designing.com/2011/06/pixars-office-interiors-2>

An interview with the Pixar executives can be viewed at

<http://www.youtube.com/watch?v=YjSExqtiIyg>

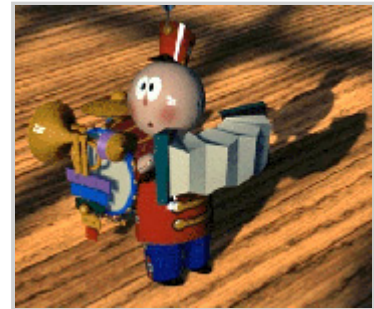
Gallery 11.1 Frames from Pixar Shorts



Luxo, Jr.



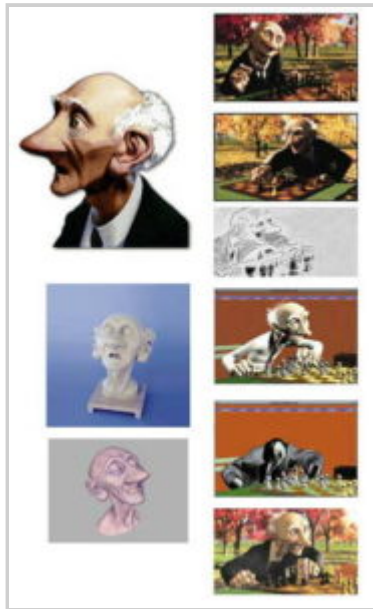
Red's Dream



Tin Toy

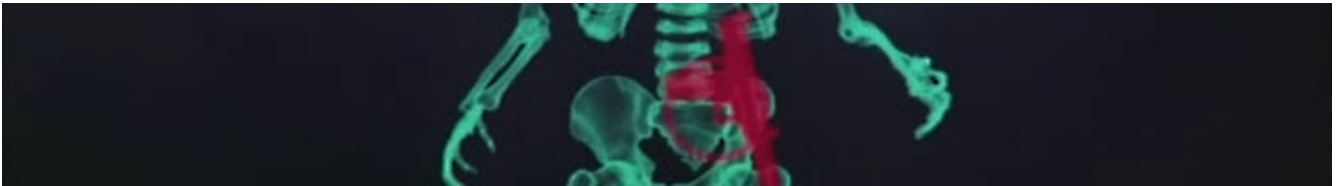


Knick-Knack



Geri's Game

11.4 Metrolight / Rezn8



Metrolight



Metrolight Logo

Founded in 1987 by James Kristoff (former President of Cranston/Csuri Productions), Mits Kaneko (JCGL), and Dobbie Schiff (former Director of Sales at Cranston/Csuri Productions), MetroLight brought many experienced animators and designers to work on projects in film and television. Originally called Northern Lights Studios, the company started in the former Robert Abel & Associates facility in Hollywood, with some of the old Abel equipment and a number of former Abel and CCP employees (including Tim McGovern, Doc Baily, Neil Eskuri, Al Dinoble, Con Pederson, Jim Hillen, Jim Rygiel (Abel), Steve Martino, Mark Steeves, Jon Townley, and Tom Hutchison (C/CP).)



Scene from World of Discovery

The company used SGI 3130 workstations and Wavefront software, as well as the equipment obtained from the Abel operation when they closed. After developing their own code to supplement and later supersede the capabilities of Wavefront, they opted to integrate the Alias and Maya code into their pipeline.

Beginning work in broadcast television (they continued a relationship with some clients that they had at CCP), they expanded into theaters with a series of computer animated trailers for AMC Theaters.

These spots, featuring the character “Clip”, gave the cinema chain a distinctive “look” and began its long business association with MetroLight. MetroLight made a

mark in feature film with 1990's *Total Recall*. The project required animating “skeletons” as characters passed through a futuristic security device capable of detecting anything from a weapon to a slipped disk. The effects were directed by Tim McGovern (who worked at Abel on *Tron* and *Brilliance*, and later helped found Sony Pictures Imageworks).

Originally planned to utilize motion capture, the scene had to be reconsidered after the data from the capture session was found to have some integrity problems. Instead, the studio rotoscoped film that was shot in low light during the capture. Tim and Metrolight won an Academy Award for their work on the Skeleton X-ray sequence in that film, which once again involved human motion and CG characters. The work was recognized for the fluid and realistic motion of the film's nine humans and one dog.



Scene from *Total Recall*

While continuing work in commercials and film, Metrolight explored the possibilities of CGI in music videos and interactive software. They also worked in the location entertainment field, with productions for theme park rides, and experimented with CG for games. They also wrote the 2D MetroCel software, under the direction of Mits Kaneko, who ran a very successful 2D production company in Japan. The **ink and paint** software, called Annie, was developed by the MetroCel division, headed by former C/CP software developer Mark Steeves. It was used for the *Ren & Stimpy* TV series, and was later sold to Michael Milken's 7th Level. Steeves and Martino also left for 7th Level when the software was sold.

Movie 11.6 Metrolight demo

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/metrolight91-1.m4v>

Commercial demo reel from Metrolight Studios in Los Angeles

Rez.n8 Productions



Paul Sidlo

ReZ.n8 was formed in 1987 by Paul Sidlo (formerly creative Director at Cranston/Csuri Productions) and Evan Ricks. They quickly gained a reputation as a world leader in conceptualizing, designing and producing state-of-the-art computer graphics, animation and special effects for major corporations and the entertainment industry, including broadcast, theatrical and commercial markets. ReZ.n8 won numerous awards, including Emmys in 1995 and 1998 for the NFL on Fox Sports graphics and in 1992 and 1994 for broadcast design for the CBS Olympic Winter Games. ReZ.n8 received BDA Awards in 1996 for designing the Pro-Sieben web site and in 1997 for CBS Sports content graphics. ReZ.n8 was nominated for a 1998 BDA Award for its work as the sole provider for all graphics used in the CBS telecast of the 1998 Olympic Winter Games.



Rezn8 Graphics

ReZ.n8's production manager supervised computer generated effects work for such large-scale productions as *Titanic*, *The Fifth Element*, and *Dante's Peak*. They had a fully integrated computer production environment featuring a state-of-the-art Windows NT network, which they received much attention around, as well as Mac and Unix networks and top-of-the-line SGI servers. Clients previewed the results of their work in a state-of-the-art multimedia facility, which featured a high-definition projection theater, surround sound and real-time interaction.

For many years, ReZn8 produced the on-air graphics for the Olympics. The magazine *Digital Studio* featured them in a 1998 [cover story](#). In 2010 ReZn8 was purchased by Stereo Vision Entertainment, Inc.

Gallery 11.2 AMC Theaters (Metrolight)



“Clip” Artwork by Bill Selby



“Clip” from AMC promotion



AMC Theaters Promo

11.5 deGraf-Wahrman / Kroyer Films



deGraf/Wahrman

DeGraf/Wahrman was founded in 1987 by former Robert Abel & Associates employee Michael Wahrman and former Digital Productions director **Brad deGraf** after the folding of DOA. Tom McMahon of Symbolics helped finance the company and provided equipment and software, including a Symbolics 3600 and the suite of S- software.

Brad deGraf studied architecture at Princeton and Mathematics at the University of California at San Diego. He started his career as lead software designer and programmer at SAIC for the US Army National Training Center, and became Head of Technical Direction at Digital Productions before opening deGraf/Wahrman and serving as Director of Production. After deGraf/Wahrman, from 1992 through 1994, he was Director of Digital Media at Colossal Pictures, which he and his partners spun off to create Protozoa.



deGraf and Wahrman created Mike Normal, or “Mike the Talking Head”, the first live performance of a virtual character. It was shown live at the Electronic Theater at SIGGRAPH 88 in Atlanta. deGraf also created “Moxy” on the Cartoon Network, the first virtual character for television, and Peter Gabriel’s Grammy award-winning video, “Steam”.

Mike Normal



Scene from Peter Gabriel video Steam

Theme park work included “The Funtastic World of Hanna-Barbera”, for Universal Studios Florida, “Journey to the 4th Dimension” in Japan, and “Robocop: The Ride” for Iwerks Entertainment Turbo Tours. He also worked on numerous feature films. He later was founder, and CEO of Dotcomix.

Michael Wahrman worked in computer animation research and production since 1982. He worked at Robert Abel and Associates, where he helped design the production system and engineered the development of the raster system used for *High Fidelity*. Wahrman worked with Craig Reynolds of Symbolics on the SIGGRAPH 87 film *Stanley and Stella – Breaking the Ice*, which featured the Boids software developed by Reynolds. Wahrman was awarded an Academy Award for Scientific and Technical Merit for his contributions to the Wavefront Animation System.



Moxy

His motion picture credits include *Starship Troopers*, *Event Horizon*, *What Dreams May Come*, and the Dream Pictures Studio full-length animated feature film *Hopper*. He was the senior visual effects advisor on the rebuild of the Hayden Planetarium and to the Digital Galaxy Project of NASA

From a 1988 Computer Graphics World article:

Mike the talking head is a step towards animators being able to directly control their characters rather than drawing their actions. Silicon Graphics and deGraf-Wahrman Inc are working together to produce a new type of animation tool to allow animators to work with their characters in the same manner as puppeteers work with puppets. The two companies hope to produce a real time, full rendering system with the ability to take input from different sources. The input will be able

to change the expression of the character as well as its colour and the materials it is made out of. The image will be able to be scaled, rotated and distorted, and will be able to mouth words. To create the original face to work with, a real person, Mike Gribble, was used as a model. His face was scanned in using a 3D digitizer to get about 256,000 points of digital data. These points are converted to polygon data which makes shading of the image possible. To give accurate data without redundancy, the polygons were smaller in areas which required greater detail and larger in the flatter areas, like the cheeks. The talking component of Mike was achieved by scanning in the real Mike as he mouthed each phoneme. Phonemes are the subparts of words used in pronunciation. To simulate speech, the implementors developed code to interpolate between phoneme positions. Possible input devices include data gloves and speech recognition systems. The glove could be used in a similar manner to a puppeteer's hand inside a puppet. The speech recognition system could have Mike mouthing the words as a person speaks into a microphone.

Robertson B. (1988) *Mike the talking head*.

Computer Graphics World 11, (7): 57.

Dotcomix: Capturing Animated Motion On The Net, by Lee Dannacher, Animation World Magazine – Issue 5.03 – June 2000

Steam – Peter Gabriel music video

(Video – https://www.youtube.com/watch?v=Qt87bLX7m_o)

Stanley and Stella: Breaking the Ice

(Video – <http://www.youtube.com/watch?v=3bTqWsVqyzE>)

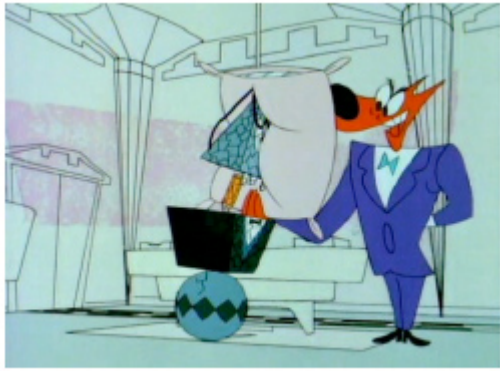
Kroyer Films



Kroyers

Founded by Bill and Sue Kroyer in 1986, Kroyer Films specialized in combining CG and hand animation. **Bill Kroyer** worked as a traditional animator for Disney in the late 70s and worked with Robert Abel and Associates in 1982.

The studio produced such projects as the animated feature film, *FernGully*, *The Last Rainforest* for 20th Century Fox, the 1988 Academy Award-nominated short film *Technological Threat* and the title sequences for *Honey I Shrank the Kids*, *Troop Beverly Hills*, *National Lampoon's Christmas Vacation* and the *Making of Me* for the World Health Pavilion at Epcot Center in Disney World, and the TV series *UltraCross*.



Other employees of Kroyer included Kendra Haaland (Disney – *Hercules*) and Kevin Bjorke, who went to ILM and earlier worked with Kroyer at DP/Abel.

Technological Threat

From the SIGGRAPH 89 Panels, here is a short slide presentation by Bill Kroyer on [the making of Technological Threat](#)

Interview with Bill Kroyer [Creating the Memories](#), from Animation World Magazine, April 1996

Movie 11.7 Technological Threat



<https://www.youtube.com/watch?v=PLAGn3isH4o>

11.6 Rhythm and Hues / Xaos



Rhythm and Hues Studio



Rhythm & Hues Studio Logo

Founded in 1987 by former Abel and Associates employees John Hughes, Keith Goldfarb, Charlie Gibson and Pauline T'so, and Omnibus technical director Larry Weinberg, R&H was one of the most reputable CG firms in the industry and a leading producer of character animation and visual effects for the entertainment industry. The company's work was prominently featured in movies, commercials and theme park attractions.

Based in Marina del Rey, California, the studio's facility was a creative home for more than 300 artists and staff. In 1995, Rhythm & Hues was honored with the Academy Award for Best Visual Effects for its work on *Babe*, named one of the Top Ten films of the 1990's by the Associated Press. The Commercial Division was well known for its work on the Mazda *Cool World* commercials, as well as the Coca Cola *Polar Bear* campaign. The studio was the recipient of top awards from both national and international competitions including the CLIOS, The New York Festivals, the International Monitor Awards, Monte Carlo's Imagina Awards and The Emmy Awards. In addition, R&H received two Scientific & Technical Academy Awards.



Babe



Coca Cola Polar Bears

Their facility housed live action and animation directors, animators, painters, modelers, producers, programmers, writers, technical and production support. They contributed work for the *Nutty Professor*, *Spawn*, *Mouse Hunt*, *Babe*, *Waterworld*, *Batman*, *Ace Ventura*, *Bedazzled*, *Little Nicky*, *Fighting Like Cats and Dogs*, *Red Planet*, *the Sixth Day* and others. They also contributed shots to *Hollow Man* (Sony), *X-Men* (Fox), *Frequency* (Lead house, New Line) and *Fantasia 2000*, for Walt Disney Studios. They are also well known for the Coca Cola bears that raced into our TVs during the Olympics, as well as the theme park rides Seafari and the Jetsons at Universal Studios, Florida.

Besides their film, television and theme park work R&H produced 3D CG for games, including *Eggs of Steel* for PlayStation.

In 1999 R&H bought VIFX, and former Abel employees Richard Hollander rejoined Richard Taylor and Bill Kroyer.

<http://www.rhythm.com>

Movie 11.8 Ads from R&H

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/RHads-2.m4v>

Several ads from R&H (1988)

Movie 11.9 Making of Coca-Cola Bears

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/makeBears-1.m4v>

Rhythm and Hues produced the innovative polar bear sequences for ads from Coca-Cola. This video depicts the making of one of the ads.

Xaos

Founded as Eidolon by Arthur Schwartzberg and Michael Tolson, it was renamed Xaos in 1989. Tolson's software development was key in the look of the company's work that was organic looking images of high complexity.



Scene from *Lawnmower Man*

Their most recognized production was of sequences in the 1990 film *Lawnmower Man*; they also produced a number of exquisite scenes for the MTV Liquid Television series. The look of the latter images was reminiscent of the products marketed by Xaos Tools, a not-so-successful Tolson/Schwartzberg spinoff.

Xaos, who unlike many of their peer companies of the time, was largely a Windows NT based company. Other work included animation for *The Pagemaster*, a Grateful Dead music video titled *Infrared Roses* and IDs for MSNBC and the Sci-Fi channel.

The following article about the company was from a news release by Intergraph – *Xaos Theory: The Science of Particles, Pixels, and Profits at Xaos, Inc.*

The word “Chaos” is not the first thing that comes to mind when you visit Xaos , Inc. in San Francisco. The spacious, high-ceiling facility resembles a well-kept artist’s loft with lots of natural light – a welcome departure for animators accustomed to working in darkened cubicles. In this cheery environment outfitted with Intergraph TDZ 2000 workstations and RenderRAX renderers, Xaos animators have produced some of the industry’s most compelling content for commercials, broadcast, feature films and large-format cinema.



Liquid Television promotion frame

Xaos was the creative force behind the Emmy Award-winning works ” Liquid Television MTV,” and MSNBC’s station IDs, as well as a long list of memorable commercials for major clients such as Nabisco, Sprint, Kellogg’s, and MasterCard. Film projects include the title sequence for *Jumanji* and ground-breaking visual effects for *Lawnmower Man*. Xaos is also emerging as the premier content creator for large-format 70mm films, including CG work on *Everest* and other IMAX features for National Geographic and Discovery Channel Pictures. ??*Thinking Big* ??”Creating content for IMAX and other large-format films puts your entire system to the test – from the workstations to the network to the renderfarm. The benefit of using Intergraph’s TDZ 2000 and RenderRAX is that we don’t have to trick anything out to work in that resolution.” — Michele Frazier, executive producer of commercials and broadcast, Xaos , Inc.

Xaos worked on a total of seven large-format films in the last year – an impressive number considering that only 175 of such films have been produced in the entire 28-year history of the format. Among Xaos’s accomplishments in the field include the CG sequences in *Everest*, a production whose Hollywood blockbuster-style profits have ignited new interest in large-format films. After the success of *Everest*, large-format companies such as IMAX, once relegated to producing science and nature documentaries, are working to take large-format out of the museums and into a multiplex near you.

Thinking Big

Creating content for large-format films places tremendous demands on Xaos’ workstations, networks, storage, and renderfarm. Each 70mm frame is composed of 4096 x 3003 pixels – four times that of standard 35mm film. The frames render out to a huge 48 MB per frame, while stereoscopic 70mm doubles disk and bandwidth requirements by requiring a separate image for each eye.

Xaos handles the task using Intergraph TDZ 2000 workstations connected to a [render farm](#) of Intergraph RenderRAX modules via a 100base-t switched network. Each multiprocessor RenderRAX unit is equipped with 1 GB of memory –

almost a bare minimum for rendering large-format frames, according to Mark Decker, technical director at Xaos . “If you have a texture that’s going to fill the entire 4K-pixel frame, the texture has to pretty close to 4K pixels or you’re not going to see enough detail,” he explains. “So we have to load a lot of our large textures into RAM all at once while we’re rendering them.”

The tremendous success of Everest has inspired even staid institutional filmmakers to introduce more dramatic elements into their films, and computer animation is seen as one way to do that. Xaos has taken this as an opportunity to position itself as not just as a service house, but a creative collaborator who helps the client understand the digital medium and recommend how it can be used. “We often advise clients on shots, beyond just giving them a bid and quote, but actually working with them on the script,” says Christina Schmidlin, executive producer of feature films at Xaos , “It makes it more interesting to us, and provides added value to the client.”

And Now a Word from Our Sponsor...

“The commercial marketplace is important to us because it keeps you sharp – it’s very demanding and can be very problematic. Landing a commercial project sends an electric shock through the facility. It’s like – ‘Incoming!!!’” — Arthur Schwartzberg, president, Xaos , Inc.

To keep their artistic edge and diversify their client base, Xaos seeks a balance between commercial projects and large-format films. Unlike large-format projects, which often begin planning six months to a year before production, commercial projects move through at light speed, according to Arthur Schwartzberg, president of Xaos . “With commercials, you get a call and they say, ‘We’re doing a project, we’ve narrowed it down to five houses, send your reel’, says Schwartzberg. “Then they call you the next day and say ‘OK, we’ve narrowed it down to three, let’s have a conference call!’ A day later you may (or may not) get the job, and it’s due in two weeks. It’s a lightning bolt.”

To strengthen relationships with commercial clients, Schwartzberg is expanding Xaos’ network of reps, being careful to choose people that understand the visual effects business. “Most reps are typically more live-action oriented because they represent live action directors,” he explains. “It’s important to us that they’re experts in visual effects so they can represent our work more effectively.”

In the high-stakes, high-pressure environment of commercial production, Schwartzberg considers his close relationships with Intergraph, Kinetix, and other vendors to be crucial strategic assets. Xaos has had plenty of time to nurture these relationships, as one of the first CG companies to abandon the Unix platform and move totally to Intergraph and Windows NT. “In retrospect, it was visionary,” says Schwartzberg, “But at the time, it was a very bold move.”

It’s a move that Xaos never regretted. “With Intergraph – I don’t know if it’s southern hospitality or what – but the whole company is infused with an attitude of value-added assistance,” he says. “That’s the kind of thing you can’t know when you’re shopping for systems. The box is cool – you buy it. But you don’t really know until later what that value-added service and attitude might be.” Richard Marco, systems administrator at Xaos , found out to his satisfaction. “I’ve been able to count on Intergraph for any kind of assistance. I’ve been extremely happy with the support. As the lone system administrator at Xaos , that makes my life a lot easier.”

The Particulars of Particles

“Intergraph’s TDZ 2000 is well designed in terms of the overall system design. The data flow is very efficient so you’re not wasting as much time moving data around within the system. Other than that, what can you say? The graphics are incredible, the drivers are solid, and the machine never crashes.” — Mark Decker, technical director, Xaos , Inc.

Xaos was an early pioneer in developing **particle animation** engines, and was the creator of a famous sequence entitled “Wet Waltz,” which features a dancing character that throws off droplets of water in all directions while swirling through the scene. One of the most powerful features of Xaos’ particle system is the ability to manipulate particles with a variety of forces after they are emitted from an object. Xaos is using this ability on a current IMAX project, in which animations are used to show how currents move in the ocean as they hit an underwater mountain. The effect is achieved with an off-screen rectangle emitting particles that simulate water flows. Xaos animators use the particle engine to populate the scene with various forces to make the currents bend, curl, and twist in vortexes as they hit various parts of the geometry in the scene.

Several years ago, Xaos integrated their proprietary particle code into a plug-in for 3D Studio MAX, providing a smooth user interface that artists can interact with. “Before we made it a plug-in, the software was very powerful, but not always very intuitive for the artists to work with,” says Mark Decker, technical director at Xaos . “Now you can see the object

emitting particles. You can move the object around while viewing the forces that affect the particles. It's much more intuitive than writing scripts."

On the other hand, Xaos engineers are not limited by the user interface. Their ability to access the code to achieve unique effects for clients is a competitive asset for the company and a key to their signature look.

Getting Down to Business

"This business is tough. It's exciting, it's sexy, it's cool, it's artistic – but it's tough. My attitude is 'Who wants to just struggle along?' We're taking a more aggressive stance about our future." — Arthur Schwartzberg, president, Xaos, Inc.

Arthur Schwartzberg has that unique combination of talents required for running a successful content creation business. He's part visionary, part businessman, part artist, part salesman. One of the founders of Xaos, Schwartzberg left in 1991 to form Xaos Tools, a software company. Last year Schwartzberg returned to Xaos with a Steve Jobs-style mission to refocus the company after a few "Xaotic" years. Apparently, Xaos's artistic vision was as sharp as ever, but some of the business aspects had been allowed to founder. "Like any business, you have to produce quality work, but that's not enough," explains Schwartzberg. "You also have to be proactive in sales and marketing, and when I first returned to Xaos, there was very little of that going on."

According to The Roncarrelli Report on computer animation, the CG industry continues to enjoy huge growth, but only a few companies have significant profits to show for it. Schwartzberg intends to remain among those few. He has aggressively maneuvered Xaos into a position to bid on much larger projects, some of them with multimillion-dollar budgets. The company is also looking at ways to move into content ownership – a practice unheard of a few years ago, but becoming an increasingly viable option for CG houses such as Xaos. "Until now, we've been a 100% service bureau – we do the job, we get paid, it's in the can, we move on to the next job," says Schwartzberg. "Owning a stake in the content is a way to go beyond that treadmill."

Xaos is finalizing a deal in which the company will serve as visual effects producer and coproducer on a large-format film project. Under the arrangement, Xaos discounts a percentage of their fee in exchange for an equity investment in the film. By doing so, the company hopes to establish more ongoing benefits in the form of royalties, ownership, and branding.

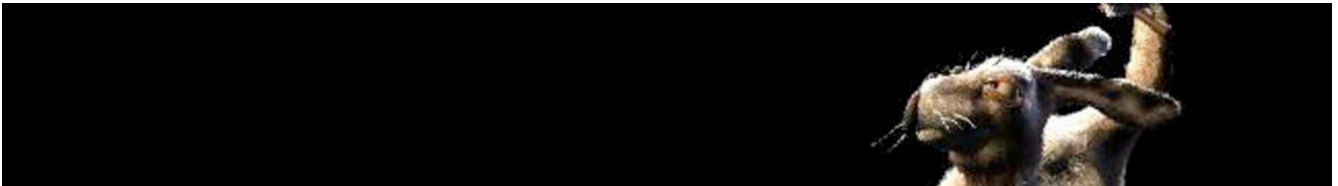
When it comes to computer hardware and software, Schwartzberg doesn't believe in cutting corners. "Our business is incredibly labor intensive — we spend 65% of our resources on labor," he says. "So if you have to spend a few thousand dollars more on technology that can boost your productivity – I consider that purchase to be intelligent and cost-effective." Consequently, Xaos' next hardware purchase will be top-of-the-line Intergraph workstations with Wildcat 3D graphics.

Schwartzberg reflects on how quickly the industry has changed in just a few years, when "high-end" was synonymous with proprietary Unix-based systems. "There was a time when we would never even think of using Intel-based systems – it would be embarrassing to tell that to a client," admits Schwartzberg. "Interestingly, nobody ever even asks anymore – it's become a complete non-issue. They just say 'send us your reel.'"

Movie 11.10 Scenes from Lawnmower Man

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/lawnmower-1.m4v>

11.7 R/Greenberg Associates / Blue Sky Studios



R/Greenberg Associates

Started by Robert Greenberg and his brother Richard in 1977, R/Greenberg Associates¹ made a CG name for itself “flying” the opening titles for *Superman*.



Superman opening title

Bob Greenberg’s R/GA Digital Studios created work seen in *Superman*, *Zelig*, and Diet Coke commercials. The dancing cars in the Shell Oil ads, the flying dagger in *The Shadow*, and the effects for *The Last Action Hero* were the work of R/GA Digital Studios, the company behind graphics for over 2,000 commercials and 300 feature films.

At its peak, R/GA had 175 employees and grossed \$35 million. Restructured in 1992 to resemble a flexible network of nodes, R/GA was made up of seven independent companies. Each specialized in one area of visual imagery, from print to interactive entertainment. If a project used more than one medium, the companies turned to each other for help. The result: a one-stop visual-effects house.

1. Text extracted from a Wired Online article, *Real Virtual*, by David Bennahum

R / G R E E N B E R G A S S O C I A T E S

**TELEVISION:
COMMERCIALS & TAGS**

- Panasonic Technics Campaign
Grey
- First Interstate Bank Campaign
Stepson Associates
- Texaco
Benton & Bowles
- Whirlpool Campaign
D'Arcy MacManus & Messus
- Hershey's
Doyle Dane Bernbach
- HBO Campaign
Ted Bates
- Union Carbide/Eversady
William Esty
- Mobil Magnifications Campaign
Doyle Dane Bernbach
- General Motors
N.W. Ayer
- Embassy Telecommunications
Ohrmayerff & Geislar
- Sony Beta Hi-Fi
Backer & Spielvogel
- Gillette
BBDO
- IBM
Doyle Dane Bernbach
- Alan
Doyle Dane Bernbach
- Newsweek
Foote Cone & Belding

*** INCLUDES
LIVE ACTION**

**FEATURE FILM:
PROMOTION, TITLES
& VISUAL EFFECTS**

- The Verdict
20th Century Fox
- The World According to Garp
Warner Bros.
- Jaws 3-D
Universal Studios
- Mike's Murder
The Ladd Company/Warner Bros.
- Gandhi
Columbia Pictures
- Tootsie
Columbia Pictures

IN PRODUCTION:



Live action, graphics & special optical effects for: Atari campaign/DOB; Ideal Toys/Twene, Silverstein, Rotter; Timex campaign/Grey; Technics/Grey; Nissan/William Esty; Shell/Ogilvy & Mather; General Electric/BBDO; MCI/Ally & Gargano; Hallmark/Y&R; Diet Pepsi/BBDO; Benjamin Moore/Warwick, Pitzer/Dornbus; 101 Park Avenue/H.J. Kalkow; Nothing Lasts Forever titles/MGM/UA; Mike's Murder titles & promotion/The Ladd Company/Warner Bros.; Space Hunter titles & promotion/Columbia Pictures; Gnostyoke promotion/Warner Bros.; The Big Chill promotion/Columbia Pictures; The Right Stuff promotion/The Ladd Company; Brainstorm promotion/MGM/UA; Ladyhawke promotion/Warner Bros.; Siskwood/ABC Motion Pictures; special visual effects/Woody Allen project

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Ad from 1983 Computer Pictures Magazine

Also in 1992, Bob Greenberg opened RGA/LA to compete with West Coast firms like Industrial Light & Magic. Soon after, R/GA mastered the difficult task of placing a young Clint Eastwood next to President Kennedy for Columbia's *In the Line of Fire*. But it wasn't the first time Greenberg brought the dead and the living together on celluloid – he'd done it before in Woody Allen's *Zelig* and in Diet Coke ads pairing Paula Abdul, Groucho Marx, Gene Kelly and Cary Grant.



R/Greenberg paired Paula Abdul with Cary Grant for this 1992 Coke ad.

Bringing the dead to life was part of R/GA's next big creative push in advertising. Interactive advertising, according to Greenberg, could benefit from taking celebrity endorsement to the next step, where celebrities communicate with customers on an individual basis, creating a personal dialog. Greenberg negotiated with the estates of famous actors for the rights to reanimate them as high-cachet virtual hosts. The first interactive ad, for Chrysler, was released at Time Warner's interactive test site in Orlando, Florida. Another, for the US Postal Service, is scheduled to follow.

Movie 11.11 Superman Opening Sequence

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/Superman-1.m4v>

Blue Sky Studios

“Blue Sky Studios, Inc. was founded in February 1987 by a group of people who had met at MAGI/SynthaVision while they were working on Disney's TRON. Each brought a range of talents and experience that proved valuable in dealing with the emerging business of computer animation. David Brown, the company's current President and CEO, had been a marketing executive with CBS/Fox Video. Alison Brown (no relation), now Vice President of Marketing and Sales,

came from advertising and special effects. The company's creative director, Chris Wedge, was an animation artist and teacher. The most unusual member of the group, and the man responsible for the distinctive look of its films, is Eugene Troubetzkoy, who holds a Ph.D. in theoretical physics from Columbia University. He and former NASA engineer Carl Ludwig developed the proprietary software and renderer that give Blue Sky its competitive edge. "

From *Ray Tracers: Blue Sky Studios* ?By Susan Ohmer, Animation World Magazine?, May 01, 1997

The basic technology used to generate images at MAGI/SynthaVision was "ray casting", sometimes inaccurately called ray tracing, which was developed by MAGI engineer Robert Goldstein in the late 60s. Eugene Troubetzkoy was one of the principal software engineers at MAGI, and he reformulated Goldstein's approach for CGI purposes. When Blue Sky was established, Troubetzkoy implemented a similar approach into the Blue Sky software environment, called CGI Studio. This approach to handling the geometry, coupled with the focus on realistic lighting in the software has allowed Blue Sky to create some of the most stunning imagery in the production industry.

Michael Ferraro oversaw the development of the object oriented language and environment, and Chris Wedge, after returning from Ohio State's graduate ACCAD program, provided much of the artistic direction.



Joe's Apartment

Wedge realized a dream in producing a short film entitled *Bunny*, which earned him an Academy Award for Best Animated Short Film. *Bunny* showcased the entire approach to Blue Sky's unique image generation environment, producing incredible lighting environments using radiosity approaches. In 2002 they produced the feature length animated film *Ice Age*, which broke box office records for domestic release.

Blue Sky produced animation for advertising and television, and ventured into the film production arena with their effects contribution to the David Geffen movie *Joe's Apartment*, based on the MTV short film of the same name. They have also produced effects for *Fight Club* (1999, Fox 2000), *Star Trek: Insurrection* (1998, Paramount); *Alien Resurrection* (1997, 20th Century Fox); *A Simple Wish* (1997, Bubble Factor/Universal Pictures), and *Titan A.E.*

In
1998,



Scrat (from Ice Age)

In 1999, Twentieth Century Fox bought controlling interest in Blue Sky through their effects division, VIFX who they had purchased earlier, and they merged the two to create Blue Sky/VIFX. Richard Hollander, one of the original founders of VIFX/Video Image, was made President of the new venture, and Blue Sky's former President, David Boyd Brown, took on the position of CEO. The company was headquartered in Marina Del Rey, but Blue Sky's New York facility continued to function. They employed a total of approximately 250 people.

In 1999, VIFX was sold to Rhythm and Hues, and Blue Sky reverted to their previous structure as Blue Sky Studios, still under Fox ownership. David Brown passed away in 2003.

<http://blueskystudios.com/our-story/>

Movie 11.12 Bunny



Bunny (1988)

<https://www.youtube.com/watch?v=Gzv6WAlpENA>

Gallery 11.3 Scenes from Bunny



Scene from Bunny

Scene from Bunny

Scene from Bunny

11.8 Kleiser Walczak Construction Company



Kleiser and Walczak

In 1987, Jeff Kleiser (Digital Effects) and Diana Walczak formed Kleiser-Walczak Construction Company in order to build databases as a commercial service. They experimented with CG actors, which they called **Synthespians**. Synthespians were a new brand of animated three-dimensional characters with a high degree of life-like motion. Forged from the imagination of a human sculptor, according to Kleiser-Walczak, “these synthetic actors were brought to life through the process of computer generated imagery (CGI) and human motion capture to create a wholly unique style of animation with vast application to the entertainment industry.”



Dozo

Two of the best animations involving Synthespians are *Don't Touch Me*, starring the computer-generated singer Dozo, and *Sextone for President*.

In 1990, the company produced twelve minutes of high-end cosmic simulation for the PBS series *The Astronomers*. This project caught the attention of Doug Trumbull (2001: *A Space Odyssey*, *Close Encounters*, *Blade Runner*, *Silent Running*, *Brainstorm*), who awarded the company a



Nestor Sextone

multimillion dollar contract to set up a facility on-site at the Trumbull Company in Lenox, Massachusetts, to produce films for Luxor Las Vegas. Kleiser-Walczak provided all the computer animation, digitally composited with live action in **Vistavision** at 48 frames per second and a 2 1/2 minute stereoscopic film that was entirely computer-generated.



Scene from Kevin Costner's *500 Nations*

In 1992, Kleiser-Walczak teamed up with John Grower's Santa Barbara Studios to simulate four ancient North American cities for the Pathways/Kevin Costner production of *500 Nations*. In 1993, Kleiser and Walczak partnered with Randal Kleiser, who directed Disney's *Honey, I Blew Up the Kids* to produce numerous visual effects shots combining live action and computer animation. They also produced animation for German director Roland Emmerich's *Stargate*, Paramount's *Clear and Present Danger*, Disney's *Honey, I Shrunk the*

Theater, *Judge Dredd*, and a stereoscopic logo-opener for IMAX films.



Scene from *X-Men*

Michael Jackson chose Kleiser-Walczak to design an album cover and video jacket for his anthology album, *HISTORY*. For this project, Diana Walczak supervised a four-camera shoot of Jackson and created a highly detailed sculpture of him for digitization and rendering.

In 1997 the company relocated its main facility to the Massachusetts Museum of Contemporary Art in North Adams, Massachusetts where they opened Synthespian Studios, a production facility designed specifically to create computer-generated characters.



Mortal Kombat Annihilation

Movie 11.13 Maya Demo

<http://www.youtube.com/watch?v=a3KnzIdm7Aw>

Movie 11.14 Sextone for President

<http://www.youtube.com/watch?v=H9aYZ9KCWpk>

Movie 11.15 Don't Touch Me, starring Dozo

<http://www.youtube.com/watch?v=8ovn8qRezPA>

Movie 11.16 Kevin Costner's *500 Nations*

https://www.youtube.com/watch?v=24IA_viq1ZY

11.9 Sogitec Audiovisuel / Lamb&Company



Sogitec Audiovisuel



Sogitec Logo

Sogitec was very active in the early to mid-80s in CGI production in France. Their productions were innovative, and the image quality was superb. Some of the active participants in Sogitec were Xavier Nicolas, Veronique Damian, and David Salesin, who went to the University of Washington after some time at Lucasfilm and Pixar. Sogitec became a subsidiary of Dassault Aviation in France, and became involved in simulation, but not in CGI directly.



Xavier Nicolas

In 1988, Nicolas formed ExMachina, which proved to be one of the leaders of CGI in Tokyo and Paris. They also worked in location based entertainment and the “Large Screen” entertainment industry, including simulation, 3D and **Imax** formats.

An Animation World Magazine article on Sogitec / ExMachina can be found at [?https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/05/](https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/05/france-cotte.pdf)

[france-cotte.pdf](https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/05/france-cotte.pdf)

Other French animation companies during this same time period were Thomson Digital Image (later purchased by Wavefront), INA (Institut National de la Communication Audiovisuelle), Voir/Captain Video, Imatique, *Fantome*, and Computer Video Film.

A Computer Graphics World article, *The French Touch in Computer Animation*, was written by Judson Rosebush in 1985.

Movie 11.17 Sogitec

Sogitec Demo reel 1985

<https://www.youtube.com/watch?v=S8gMdY9L7Wk>

Movie 11.18 ExMachina “Stand By Me”

<http://www.youtube.com/watch?v=0MjoqsXkErA>

Lamb&Company

Larry Lamb was President of Lamb&Company¹ and the affiliated software company, LambSoft. Lamb founded Lamb&Company in 1980. His contributions to the industry include both early adoption and testing of new software systems and the development of proprietary software code on a large scale. He served on the board of trustees of Minneapolis College of Art & Design (MCAD) and the New Media Advisory Board of the Walker Art Center in Minneapolis.

Lamb operated a continuous but informal ‘test lab’ for new computer graphics tools since the company was founded. Its history parallels the development of computer animation itself. The first tool adopted by Larry Lamb (he says it was before anyone else) was a servo-controlled **Oxberry animation camera**.

Lamb&Company was well known for its character animation, but they started the company animating flying logos. Lamb&Company acquired the first license of Wavefront software, which allowed Lamb&Company to do production internally without relying on film or outside film support services. The Wavefront *Preview* software complemented the Oxberry equipment by allowing staff to pre-visualize the work being done on the computer controlled animation camera.

In 1987, when one of his competitors went out of business, Lamb bought the core animation technology developed at Cranston/Csuri Productions, one of a handful of ‘original’ computer animation companies that folded that year. This substantial body of animation software technology served as the basis for Lamb & Company’s internal

1. Much of the above text was from the Lamb website at [?http://www.lamb.com](http://www.lamb.com)

development efforts. Lamb was also an early adopter of Silicon Graphics hardware as the platform of choice for animation, and later added NT machines to its mix.

In 1989, Lamb & Company began to pursue new ways of doing computer animation and began experimenting with motion capture as a means of augmenting keyframe animation. The goal was to develop a computer ‘puppet’ in order to do high volumes of animation quickly. Two driving needs at the time were the need to produce volume and the need to present personality in the characters. Existing CG looked too ‘algorithmic’, stiff and computer generated. As part of the exploration of tools to accomplish this, Lamb & Company became the first customer for Virtual Technologies Data data glove. Just having the acquisition device did not constitute an animation solution. It was used as a tool to test motion capture theories as a microcosm system for larger motion capture efforts.

In the early 1990’s Lamb bought the Discreet Logic FLAME digital paint and compositing and special visual effects system. In 1992, they also purchased a full body motion capture suit from Ascension Technologies as part of an experimental effort to reduce production costs on a major new animation. It took Lamb & Company six months to create the first long-format computer generated 3D network TV program in the U.S. “*The Incredible Crash Dummies*” (Fox). The need to produce 23 minutes, consisting of 82 scenes with 13 characters on the computer at a time when the computer power was much more limited than today continued the quest for productivity and creativity management tools at Lamb & Company.

The next set of breakthroughs dealt with blending keyframe animation and motion capture data and being able to apply motion data to characters that weren’t exactly the same as the performer in shape and size. The company proved the technology during the experimental production “*Huzzah*“. This production was the first complete capture of an actor’s single performance. In 1997, Lamb & Company spun off LambSoft, a software technology development company whose goal is to productize motion editing and compositing software created as part of the company’s long term efforts around blending motion capture with keyframe animation. In 1998, Lamb & Company was featured on “*Scientific American Frontiers*” hosted by Alan Alda.

Movie 11.19 Incredible Crash Dummies

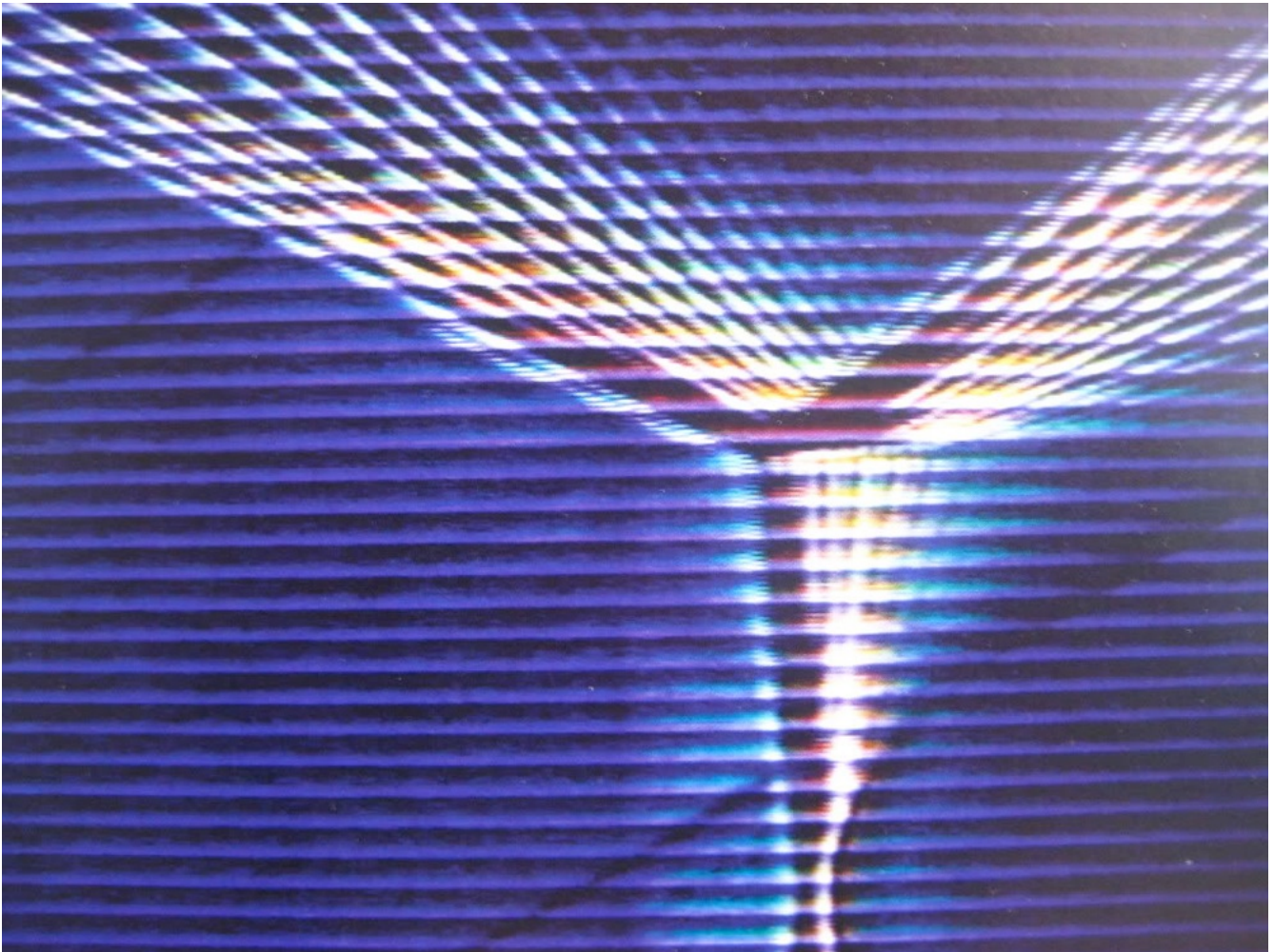


<https://www.youtube.com/watch?v=g-WgF5jGVdA>

Chapter 12: Analog approaches, non-linear editing, and compositing

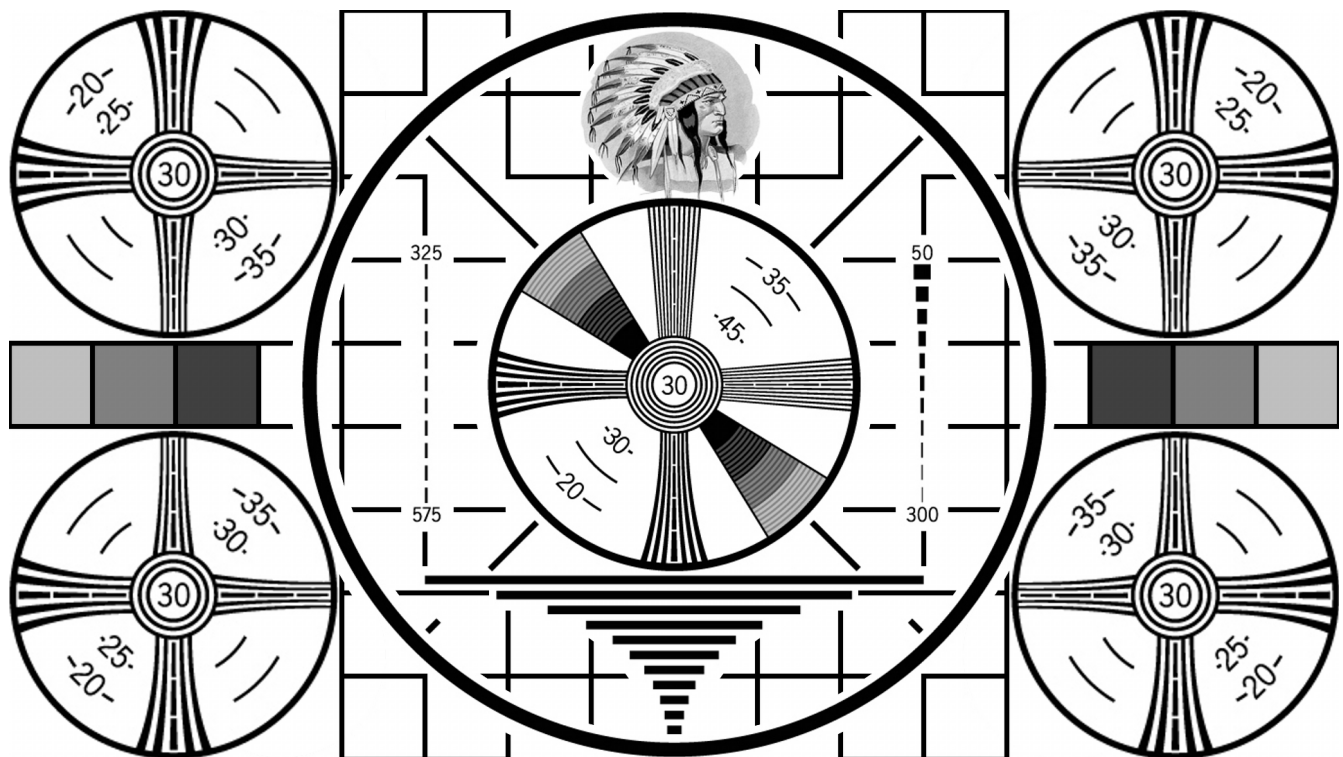
Analog approaches, non-linear editing, and compositing

The development of digital 3D graphics techniques was accompanied by advances in analog approaches. These were typically the real-time manipulation of signals, colorization, movement capture and mapping, and layering or compositing.



Analog generated computer graphics

12.1 Introduction



As seen in the previous section, the 1970s and 1980s saw a proliferation of computer graphics production finding its way into the commercial CG production world. Most of these companies and efforts were built around the evolving digital computer technology, and relied on computer programs and related CG systems to allow the artist to affordably and efficiently create the synthetic imagery. A parallel technology evolution was taking place at the same time, only in the analog world of image-making technology and production. For example, Computer Image Corporation (CIC) developed complex hardware and software systems that included ANIMAC, SCANIMATE and CAESAR. All of these systems worked by scanning in existing artwork, then manipulating it, making it squash, stretch, spin, fly around the screen, colorizing it, scaling or expanding it, etc. Bell Telephone, DuPont, ABC TV, NBC, and CBS Sports were among the many corporations who made use of this style of computer graphics.

12.2 ANIMAC / SCANIMATE



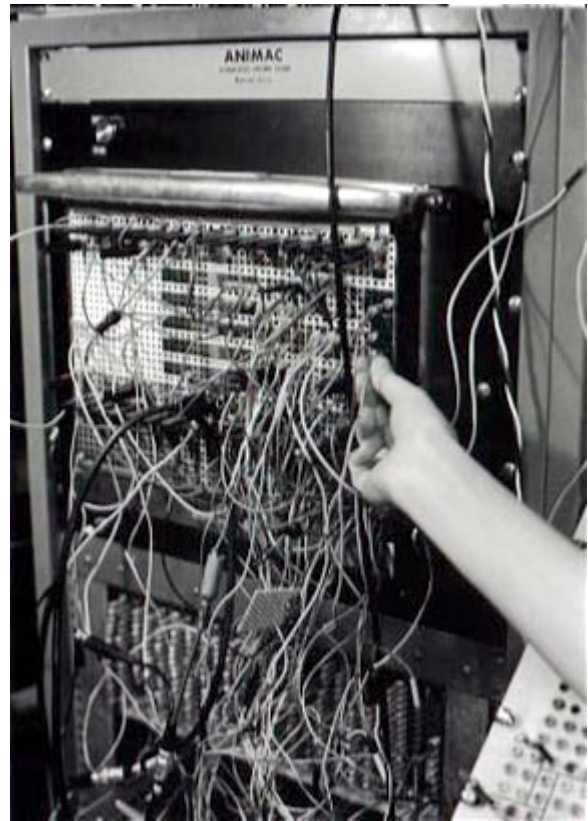
Edwin J. Tajchman (left) & Lee Harrison III receiving the National Academy of Television Arts and Science award for "Outstanding Achievement in Engineering Development"

Perhaps one of the earliest pioneers of this analog computer animation approach was Lee Harrison III. In the early 1960s, he experimented with animating figures using analog circuits and a cathode ray tube. Ahead of his time, he rigged up a body suit with potentiometers and created the first working motion capture rig, animating 3D figures in real-time on his CRT screen. He made several short films with this system, which he called ANIMAC.

Harrison studied at the School of Fine Arts at Washington University in St. Louis. After a stint in the Coast Guard, he joined McDonald Aircraft in St. Louis as a technical illustrator. He returned to Washington University to study engineering, and took a job as an engineer at Philco Corporation in Philadelphia and later as a bio-cybernetic Engineer at the Denver Research Institute at the University of Denver.

It was while he was at Philco that he decided to chase his idea of systematically creating animated figures. His concept was to view a stick figure as a collection of lines that could be independently moved and positioned to form an animated character. Each of the lines would be displayed on a CRT and controlled with a vector deflection of the CRT's electron beam. Each figure would be composed of bones, skin, joints, wrinkles, eyes, and moving lips, all drawn in sequence to create what Harrison called a "cathode ray marionette."

In order to accomplish this task, he founded a company in Philadelphia called Lee Harrison and Associates. His ideas were realized with a hardware system designed and developed by his new company, which he called ANIMAC. Harrison participated in the Ars Electronica Festival, along with computer video artists Bill Etra and Bill Diamond and others, in 1992. A facsimile, entitled *Notes for an Early Animation Device* in which the design and operation of ANIMAC was described, is included in the archives of the Festival. The following is from an interview with Jeff Schier, also published in the Festival proceedings:



ANIMAC Patch Panels

“WE STARTED OUT by developing what later became ANIMAC. At first we called our machine “The Bone Generator” because it made sections of straight lines that could be hooked together and could be individually animated or moved in three dimensional space. To determine what a bone was you had to determine where it was to start in X, Y, Z space, in which direction it went from there, and for how long, in order to determine its length. The parameters that determined which direction it was going in also determined the actual length projected onto the face of the tube. If you saw a bone from the side you saw its full length but if it were pointing toward you, you saw only a portion of it.

A bone was composed of a bi-stable multi-vibrator or a flip-flop. To start it was to essentially put a signal on a line that governed the opening of a lot of sampling gates. The inputs to the gates were the parameters that governed the position and some of the qualities and characteristics of that bone. To program it we had a patch panel. We always had a navel point on our figures and we'd always flip back to the navel point. We'd go up and out an arm and go back to the navel point, go up and out another arm and back to the navel, go up and out to the head. Those were all fly-back bones and we would fly-back by just collapsing the information that was contained on a capacitor.

In order to determine the length of a bone we used time as the basis. We'd start drawing in a certain direction determined by the specific parameters and we'd go in that direction until we'd turned that bone off and then essentially we'd wait there until we drew another bone. The length was determined by plugging a timing circuit into a place which was reset after each bone. When you started a bone you also started that counter and that flip-flop was plugged into the counter that would turn that bone off. It was pretty much all digital. The next bone would be plugged into another count and so forth and you varied the counts depending. A count represented some number of high frequency units that was part of the clock network of the whole machine.

The patch panel was color-coded and it was a big **patch panel** we got out of the junkyard someplace. If you understood the code you could actually see the bones on this patch panel. There would be a certain color like green and the output might be a blue. If you were going to bone number one, you brought a start pulse that was located somewhere and you'd plug into the first bone and then you'd plug in the output of the first bone into the second bone and so forth. The inputs to the parameter gates were not located on that panel. They were located down a little lower on the face of the Animac

and there were hundreds of them. You had all of these hundreds of inputs required to make the thing happen and to change it over time. After this, the main thrust of our development was to make things change over time which eventually culminated in what we called key frame programming where we would turn knobs until we got what we wanted.”



Article in *Audio-Visual Communications* magazine discusses ANIMAC motion capture

The “skin” was added to the bones by superimposing “springs” that modulated the stick vectors with circular sweeps of spinning vectors. The thickness of the bones, or displacement of the rings from the center of the line, was voltage modulated by a “skin scanner.” The scanner was constructed from a “flying spot scanner,” a vector camera pointing at an intensity graph with higher brightness representing a larger bone displacement. The “joints” or connection of bones to skin were formed by drawing the bones in a specified order, the endpoints being momentarily held till the next bone was drawn. A synthetic mouth, lips and eyeballs were created through parabolas and sine waves modulated with precise control from voltage sources. The entire figure was manipulated in three dimensions by passing the control signals through a three dimensional (3D) rotation matrix. These control signals were formed from horizontal and vertical sweep generators, with camera angle, size and position voltages run through rotation matrices constructed from adders, multipliers and sine/cosine generators.

This same camera scanned a texture and superimposed it on the skin surface of the bone.

To give the illusion of depth, an additional camera tracked the intensity of the skin, giving the illusion of an edge by modulating the skin brightness and leaving it in silhouette.



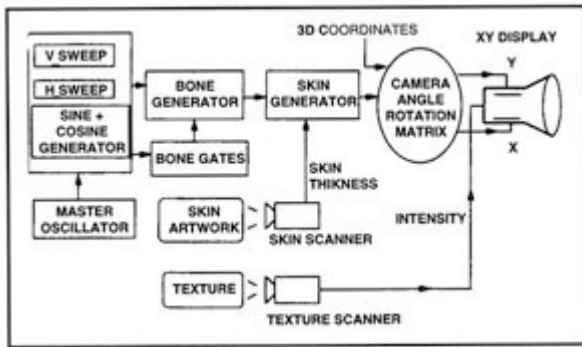
This image composite and the diagram on the next page are from *Notes for an Early Animation Device*, presented at the *Ars Electronica Endo Und Nano Festival*, 1992

Harrison’s motion capture rigging was a prelude of things to come. The animation harness was fabricated from potentiometers and Lincoln Logs used as armatures. Manipulating the harness tied tactile movement with control voltages, making the character “dance” like the person in the harness.

The ANIMAC was largely a proof of concept prototyped with vacuum tubes mounted on 2 by 4’s, using a Heathkit oscillator as the master clock and driving an XY oscilloscope for the display. Harrison’s company went public and was renamed Computer Image Corporation in 1969.

That same year ANIMAC was converted into a transistorized version. To commercialize on the scan processing experiments, the approach for moving the

animated character was used instead for moving logos and high contrast graphics about the screen. The skin was “unraveled” and became small movable rasters called “flags.” The skin scanner was modified to point at the hi-contrast artwork of a logo or corporate graphic. For example, the intensity of the scanned image filled the undulating flag and was flown and spun across the surface of the screen. The multiple bone mechanism was simplified into five flag generators. The XY display was re-scanned by a video camera with 5 levers of colorization and combined with a background graphic for recording onto video tape. The new machine that incorporated all of these modifications was called Scanimate.



ANIMAC System Diagram

Scanimate allowed interactive control (scaling, rotation, translation), recording and playback of video overlay elements to generate complex 2D animations for television. In fact, most of the 2D flying logos and graphics elements for television advertising and promotion in the 1970s were produced using Scanimate systems.

In 1972 Harrison won an Emmy award for his technical achievements. As computer graphics systems became more powerful in the 1980s, Harrison’s analog systems began to be superseded by digital CG rendered keyframe animation, and now are no longer used in production. There are several still running. Dave Sieg brought one to

the SIGGRAPH 98 conference as part of a CG history exhibition.



Dave Sieg in front of his working Scanimate at SIGGRAPH 98

Computer Image went on to develop a system called CAESAR, which stood for “Computer Animated Events with Single Axis Rotation.” CAESAR was targeted at moving cartoon characters’ limbs in an attempt to automate the Saturday morning cartoon production process. CAESAR used most of Scanimate’s analog processing technology with digital parameter storage on a Data General minicomputer. According to Dave Sieg:

CAESAR was never mass produced to my knowledge. A later product, System V was produced, with an improved digital computer, and it replaced Scanimate in several facilities. While at Image West, I also worked on development of a hybrid analog/digital system called VersEFx. But ultimately, the analog image quality produced by such CRT rescan systems could not compete with that of totally digital systems.

Movie 12.1 Scanimate

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/scanimate-1.m4v>

This short video shows the operation of the Scanimate analog graphics system

For more about Scanimate, visit Sieg's historical web site at

<http://www.scanimate.com>

Dave Sieg wrote an article for the SIGGRAPH newsletter about his experiences with Scanimate as part of the *SIGGRAPH 98 History Project* called *Scanimation in the Analog Days: Notes for an Early Animation Device*

A *final paper* on ANIMAC was presented by Lee Harrison at the *Ars Electronica Endo Und Nano Festival*, in 1992

E.J. Tajchman, *The Incredible Electronic Animation Machine: A Computer System Called CAESAR Is Conquering New World for Video Graphics*, Videographics Magazine, Nov 1977, pp 22-24.

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/03/IncredibleElectronic.pdf>

Birger Anderson, *Case Study: A Look at Video Animation*, Broadcast Engineering, May 1979.

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/03/article.pdf>

Jeff Schier wrote in an essay for Ars Electronica in 1996¹ of a visit to and conversation with Lee Harrison:

In my search for the oldest [films] I could find, I stumbled over the film of the ANIMAC, the first and the only machine of its name. "And where is the machine?" we asked eagerly. "On the dump" came the reply!

Once more we realized how hostile the industrial environment could be to a unique machine like this. How many fabulous designs are being destroyed daily just for a few cubic feet of space or the vanity of an engineer promoting his new brood. Of course Lee knew that. "They finally talked me into it!" he said sadly.

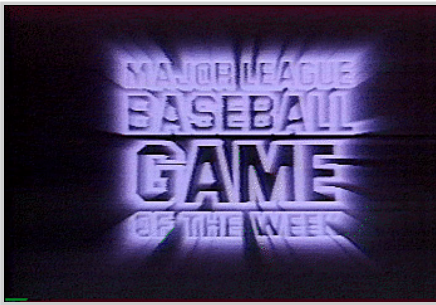
Movie 12.2 Scanimate – a conversation with Roy Weinstock



<http://www.youtube.com/watch?v=n9CQddf-Bdw>

1. http://90.146.8.18/en/archives/festival_archive/festival_catalogs/festival_artikel.asp?iProjectID=9526

Gallery 12.1 Images from SCANIMATE



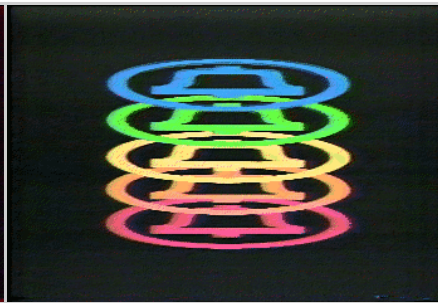
Graphics produced on Scanimate



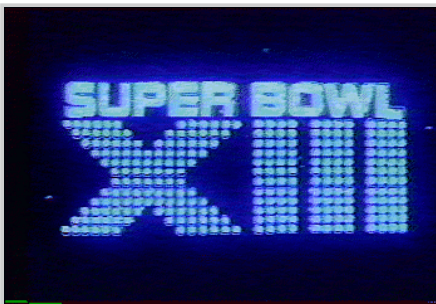
KCOP-TV



Bell Telephone

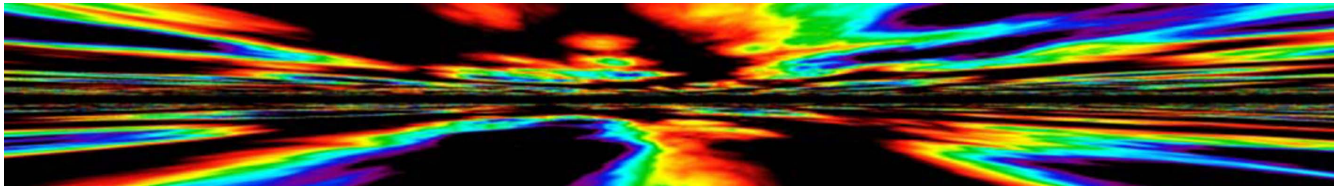


79 World Series



Superbowl Graphics

12.3 Image West / Dolphin Productions / Ron Hays



During the late 1970s and early 1980s, several analog video production companies were contributing animation to television networks and stations and advertising agencies. Some added animation to post-production capabilities, and some rose out of the increased demand for “innovative” graphics. Among the companies were Editel, Klein&, and the Post Group. Three pioneering prominent companies were Computer Image in Denver, Image West in Hollywood, and Dolphin in New York.

Image West



Image West Logo

According to Dave Sieg, in a special article written for the Siggraph 98 conference history project ¹:

In 1977, Computer Image decided it could find a larger market by having a facility in Hollywood, so it borrowed heavily and set up a new company, Image West, Ltd. The company, while very good technically, did not know the Hollywood market well, and was eventually foreclosed by its bank. The bank then approached Computer Image’s largest customer, Omnibus, Inc. from Canada and offered to have them take over Image West. Omnibus agreed, and operated the company until 1982 when it sold Image West and went on to form Omnibus Computer Graphics Inc., using digital technology licensed from the New York Institute of Technology. Image West continued to operate SCANIMATES until 1986 when it discontinued operations.

Cliff Brown was president and David Sieg was Chief Engineer at Image West. Several other technologies were investigated during this period. At Image West, Seig engineered the VersEFX, a system in which full-color transparencies could be used as input. According to Sieg, “Digital oscillators and 3D perspective were incorporated to animate the same video parameters found in Scanimate.” The first system was shipped overseas, and Image West began building a second. At the same time, at Computer Image Corp., Ed Tajchman created the System IV, a digital 3D animation system. Its input was still monochrome video, and it was quite expensive. The

1. Sieg, Dave. Scanimation in the Analog Days. SIGGRAPH 98 History Project. <http://www.siggraph.org/publications/newsletter/v32n3/contributions/sieg.html>

System IV was briefly used in production², but fell victim to the rise of turnkey digital animation solutions, such as the Ampex Digital Optics (ADO), digital paint systems such as the Quantel Paint Box, and 3D animation systems such as the Bosch FGS-4000 that were much less costly. This technology change impacted the company's bottom line and they responded by buying a new Symbolics system with both paint and 3D capabilities, but as with a number of similar production facilities, the innovation caught up with them and they went out of business. They tried a last ditch effort to go public, but failed.

Dolphin Productions



Dolphin Productions Logo

Of the first eight SCANIMATES built by Harrison, six were in the United States. Two were in Denver at his company, Computer Image Corporation. Two Scanimates were in New York at Dolphin Productions (a division of Computer Image), two more were in Hollywood at Image West, and two were overseas in Japan. Dolphin Productions worked closely with PBS's Sesame Street and The Electric Company. Allen Stanley was the President at Dolphin.



The Scanimate installed at Dolphin Productions in 1974

2. Ed Kramer maintains a YouTube channel that contains a number of sample demo clips and discussions of production process, called The Basement Tapes, that can be seen at <https://m.youtube.com/channel/UCa2OzKEXQf1qAH1XOjJ8seA>

Ron Hays Music Image



Ron Hays Logo

The New Television Workshop at WGBH supported the creation and broadcast of experimental works by artists. One of their projects was the Music Image Workshop, which was primarily a project of Ron Hays, who used the Paik-Abe **videosynthesizer** to create elaborate visual scores set to music. It was funded by the Rockefeller Foundation and the National Endowment for the Arts from 1972 through 1974. Hays worked closely with WGBH producer and director, David Atwood, to create both live broadcasts and finished works. Additionally, works by other artists were presented under the auspices of the Music Image Workshop.

Hays later produced a short film with Michael Tilson Thomas, called Space for Head and Hands. It was an improvisation by Hays with piano by Thomas. He also produced animation for the Julie Christie movie *Demon Seed*, and a video art compilation of music, computer graphics and art for Odyssey called Ron Hays Music Image. This animation was produced using the Scanimate system.

Movie 12.3 Image West



Graphics from the 1981 Image West commercial demo reel

<https://www.youtube.com/watch?v=ispW6-7b2sA>

Movie 12.4 Ron Hays Music Image Demo

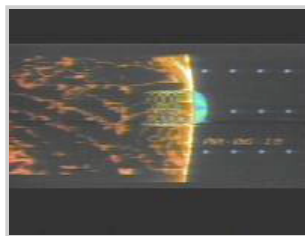
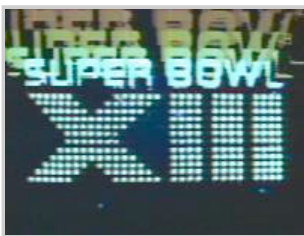
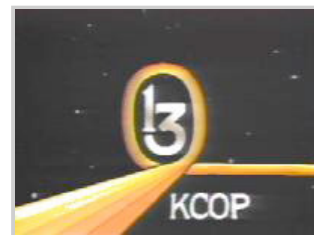


<http://www.youtube.com/watch?v=kACpN3vhFtY>

Gallery 12.2 Image West Collection



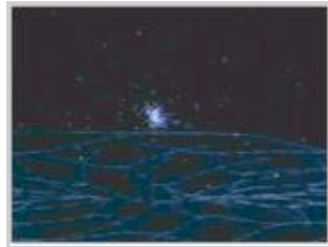
Graphics produced on Scanimate at Image West



Gallery 12.3 Dolphin Studios Collection



Graphics produced on Scanimate at Dolphin **Gallery 12.4** Ron Hays Music Image Collection



Graphics produced by Ron Hays



12.4 Quantel



Quantel was founded by Peter Michael in 1973 in Newbury, UK. It's focus was to create technology for use in television production. Its first product was the DFS 3000, which was the first digital frame-store. The DFS 3000 is most widely known as the device that allowed the first inset video for television broadcast, a video image inset into the main picture showing a close-up of the Olympic torch integrated with video inside the stadium at the 1976 Montreal Olympics. They followed this with a series of digital effects devices, including the DPE 5000 and the DLS 6000.

Movie 12.5 Quantel – PIP

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/olympic-pip-flame-1.m4v>

The Olympic flame was integrated into a video of the stadium in a Quantel box, as the first Picture-In-Picture

The most widely known Quantel product was the Paintbox, introduced in 1981 and still in production at facilities all over the world. The Paintbox was considered one of the first commercial paint systems, and was actually introduced at the spring NAB show in 1980. Quantel obtained patents related to the system, and challenged the entire digital image community with a series of controversial infringement lawsuits. (See the sidebar for more information about these proceedings.) The Paintbox spawned a range of digital technologies from Quantel.

The next device was released in 1982, Called the Mirage, it was the first digital effects machine able to manipulate 3D images in 3D space. It also used an interesting method for transforming one image into another by using a two-dimensional “particle system” to map pixels from one image onto pixels from the second image. As the pixel tiles moved over time, the first image appears to disintegrate and then restructure itself into the second image.

Another radical leap was made in 1986 when Quantel introduced Harry, the world's first non-linear editor. NLEs became fairly standard in the editing business, making linear editing suites largely obsolete. In some ways Harry did for video editors what Paintbox had done for graphic designers, giving them a tool for moving their trade forward by leaps and bounds. The Harry combined several minutes of digital-disk storage with a 2D graphics system and a crude but elegant means to assemble video clips. It was the only digital non-linear editing workstation capable of producing broadcast-quality material for almost a decade.

Other important Quantel contributions can be seen below from their timeline at <http://www.quantel.com>

- 1975: DFS 3000 The world's first digital framestore.
- 1977: DSC 4002 The first portable digital standards converter.
- 1978: DPE 5000 The first commercially successful digital effects machine.
- 1980: DLS 6000 Digital still storage for on-air presentation.
- 1981: Paintbox The industry standard graphics kit.
- 1982: Mirage The first digital effects machine able to manipulate 3D images in 3D space.
- 1986: Harry The first NLE also makes multilayering of live video a practical proposition.
- 1989: V-series The second generation Paintbox. Faster, smaller and more powerful
- 1990: Picturebox Integrates the storage, presentation and management of stills.
- 1990: Harriet Manipulating live graphics over video.
- 1992: Henry The effects editor. Offers simultaneous layering of multiple live video sources.
- 1992: Hal The video design suite. The first dedicated graphics and compositing centre.



Max Headroom

Note: The Paintbox was used extensively in producing the graphics for the 1985 British television series Max Headroom.

There were several other video image manipulation technologies that competed with the Harry. For example, in 1981 Ampex introduced the ADO® system, which created digital special effects, allowing rotation and perspective of video images.

The earliest digital compositing suites for video were Quantel's dedicated hardware systems, like the Harry. Quantel's Domino console first evolved the power to take digital compositing to film resolutions. Many post houses used Quantel systems for their ability to process large dataflows in real time (something that later, open systems running on PCs and offering the flexibility of multiple software use were often less able to provide).

Flame, developed by Australian Garry Tregaskis was the first software-only system to run on the Silicon Graphics platform as the general computing power needed to process layers of video and effects became available. Part of the appeal was that these were hardware units which could also be devoted to other tasks, such as editing and 3D graphics.

A plethora of software products running on Unix and NT systems followed. Some evolved from the proprietary software of production studios like ILM or Digital Domain, or NYPD in Australia, in the case of Digital Fusion. Others were developed from the ground up as commercial products by the creators of non-linear editing, 3D or other graphics systems. Adobe's After Effects, one of the least expensive desktop video compositors, is still basically an adaption of Photoshop with keyframe animation.

Movie 12.6 Max Headroom

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/headroom-1.m4v>

Max Headroom: 20 Minutes into the Future is a 1985 cyberpunk television movie created by Chrysalis Visual Programming Ltd. for Channel 4 in the UK to provide a back story for Max Headroom, a computer generated TV host. The series also ran in the U.S. from 1987-1988.

Dick Phillips wrote about the Quantel lawsuits in a 1998 SIGGRAPH newsletter. The following is an excerpt from the article, which can be read in its entirety at

<http://www.siggraph.org/publications/newsletter/v32n3/contributions/phillips.html>

In fact, it was as recent as 1996 that digital paint systems became the subject of a lawsuit. This is surprising, especially when you consider that [Smith97] points out that the first digital paint program can be traced back to 1969. But it was indeed in January 1996 that Adobe Systems Inc. was sued by Quantel Ltd. for alleged infringement of five of their patents by Adobe's Photoshop product. The stakes were huge; Quantel was seeking damages of \$138 million, to be trebled if willful infringement was determined. Moreover, Quantel was seeking an injunction to stop Adobe from selling Photoshop.

Chapter 13: Flight Simulation

Flight Simulation

Rolfe and Staples, in their 1986 book *Flight Simulation*, note that “the object of flight simulation is to reproduce on the ground the behavior of an aircraft in flight.” Much of this reproduction had to do with believable visual synthesis that mimicked reality.



Scene from Microsoft Flight Simulator

13.1 Phase I-III



Rolfe and Staples, in their 1986 book *Flight Simulation*, note that “the object of flight simulation is to reproduce on the ground the behavior of an aircraft in flight.” This includes the use of physical simulators, with the real and perceived motion that satisfy the motion cues expected by the human pilot, as well as the extremely important visual system, which includes the generation and display of a simulated perspective view of the outside world. These two are inextricably linked, as the visual response can trigger perceptions in the physical reaction, and vice versa. In 1986 there were over 500 simulators in use. We will review a few that have had an impact on the field of computer graphics and animation.

The physical simulator had a mock-up of the cockpit mounted on computer controllable pneumatic devices to simulate motion. The visual component of the simulator generated images that were presented to the training pilot on display devices mounted inside the physical simulator

The early visual systems, dating from the late 1950s or early 1960s, included film systems and closed circuit television systems. The film system used a 35mm or 70 mm film that was shot from a real airplane. Servo driven optics distorted the image to simulate a range of other flight paths responding to pilot interaction. The CCTV system moved a camera with a special optical lens over a physical terrain model, or terrain board. Neither approach was very practical, even though high degrees of realism could be achieved, because variations were not easy to present, and situations that may confront a pilot in flight were limited. These early systems were replaced in the early 1970s with CGI systems, or CIG (Computer Image Generators) as they were often called.

The first computer image generation systems for simulation (Phase I) were produced by the General Electric Company (USA) for the space program. Early versions of these systems produced a patterned “ground plane” image, while later systems were able to generate images of three-dimensional objects.

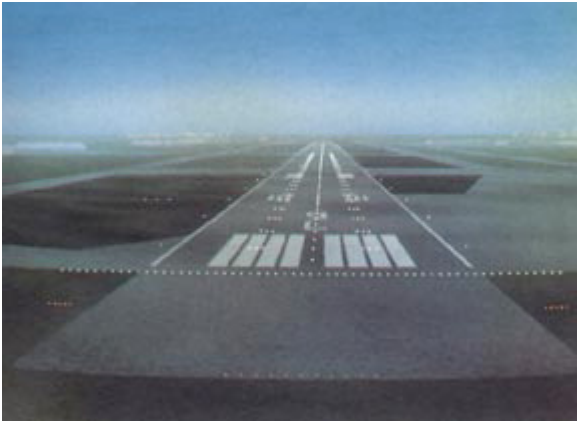


CCTV Terrain Board



The visual component of the simulator generated images that were presented to the training pilot on display devices mounted inside the physical simulator.

Night-only systems usually used vector devices, rather than the raster scan display that gives the image complexity used today. The first of these systems was produced by the McDonnell-Douglas Electronics Corporation in 1971 and was called Vital II (Virtual Image Takeoff And Landing). It was certified by the FAA for commercial flight training for Pacific Southwest Airlines in 1972. The scene was only a night scene of an airport, showing the light pattern of the runways. As an FAA commercial Phase II system, it had to be capable of showing directional lights (only visible from certain directions), flashing lights or beacons, runway end illuminator lights, and vertical approach slope indicators, which are white when the correct approach slope is maintained, and red otherwise.



Daytime simulation



Nighttime simulation

Phase III systems, on the other hand, were required to show day scenes of greater detail. The airport had to be recognizable, and terrain and physical landmarks had to be visible. In order to adequately represent these complex visual images, raster systems were employed.

Military simulation systems require significantly more complexity than the “takeoff/landing” visual simulations for commercial simulators. They require the simulation of complicated maneuvers, perhaps carrier landing, high speed flight, ground attack situations, etc. The vector devices used for many commercial systems were not sufficient, and the industry embarked on serious research and development efforts that both contributed to and took advantage of parallel efforts in CGI for special effects activities for movies, etc.

A Brief History of Aircraft Flight Simulation

Kevin Moore

J.M. Rolfe and K.J. Staples, *Flight Simulation*, Cambridge University Press, London, 1986

A Brief Introduction to the Art of Flight Simulation Ron Reisman

[E1990b_159](#)

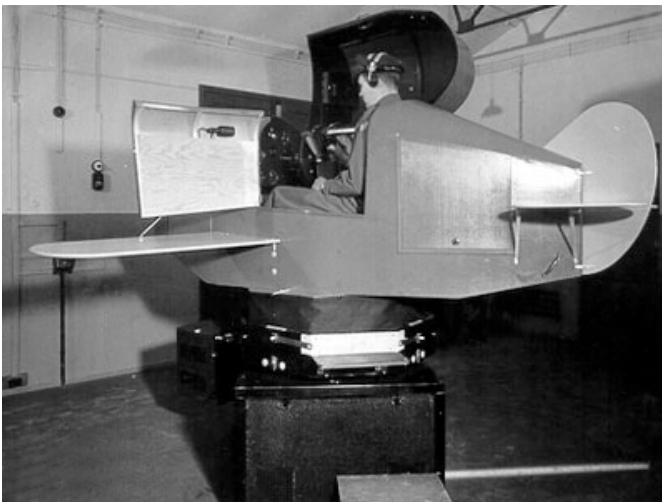
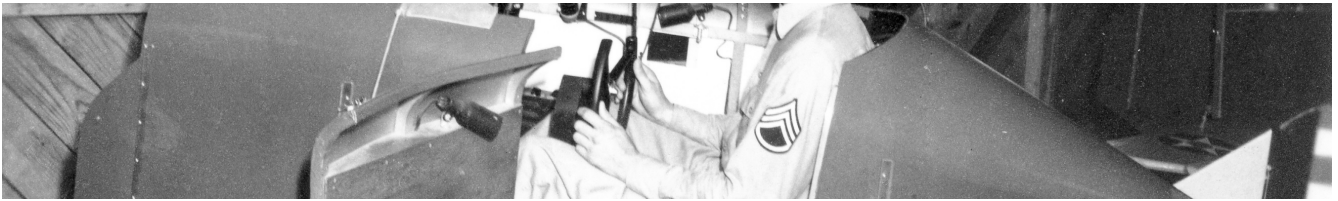
“Computers in Spaceflight: The NASA Experience”

<http://www.hq.nasa.gov/pao/History/computers/Ch9-2.html>

Movie 13.1 Flight Simulation

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/flightsim-1.m4v>

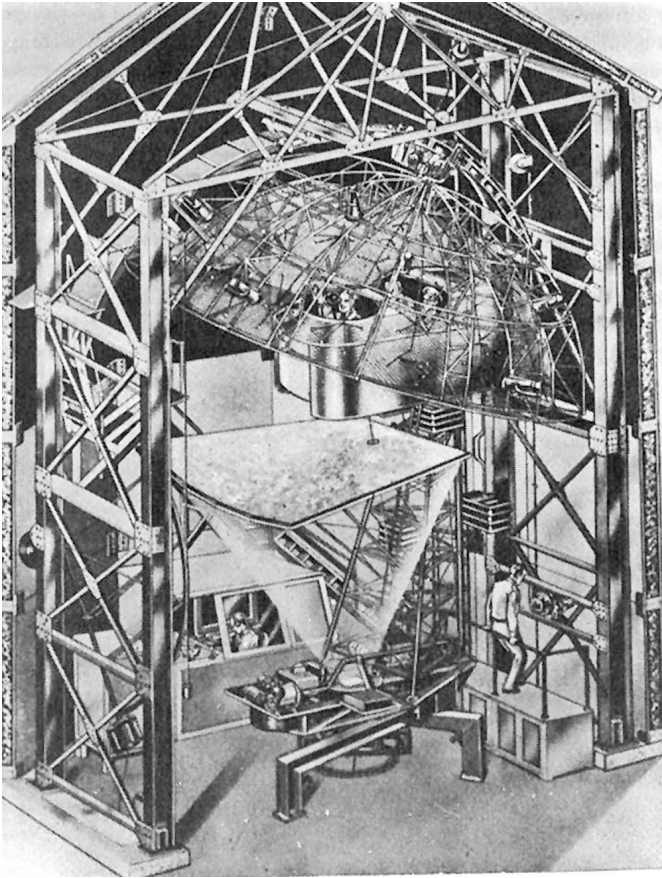
13.2 Singer Link



The Link Trainer provided primarily instrument training.

the cockpit was painted on the walls of the training room.

The Link Company was one of the first companies to develop flight simulators. Edwin Link worked for his father in a piano and organ company in New York, and designed his first “Link trainer”, the Link “Blue Box”, in his basement between 1927 and 1929. The U.S. Army Air Corps recognized the value of the trainer and they pushed the development of Link’s original idea to include more sophisticated control and monitoring devices. It was very successful during the 1930s and into World War II, even used by German pilots as well as U.S. and British pilots. Initially there was no visual feedback. The trainer was used primarily to familiarize the pilot with instruments, and to give some rudimentary motion feedback to control stick manipulation. A first form of visual feedback for a later Link Trainer was a cyclorama. The scene from



The Link Celestial Navigation Trainer is shown here. The pilot and co-pilot can be seen in the fuselage at the top center. Below the fuselage was a screen on which was projected a moving image of terrain. Above was the dome with lights representing stars and constellations of the appropriate hemisphere, and the dome moved on the overhead track to represent the passage of time. Smoke was used to simulate cloud or fog, etc. The device was housed in an air conditioned octagonal silo that was approximately 45 feet high. Click to see a larger version.

In 1939, Link developed a trainer that allowed for cross Atlantic navigation and night training, called the “celestial navigation trainer.” It represented stars on a dome over the physical trainer, and the stars could be relocated to correspond with time as well as changes in location.

With the desire for better motion control of the trainer came the development of analog and later digital control mechanisms. In the early 1960s, Link developed the Link Mark I computer to accomplish real time simulation by computing aircraft equations of motion.

Link merged with the General Precision Equipment Corporation in 1954, and in 1968 was purchased by the Singer Company, of sewing machine fame. In 1981, the same year as Ed Link died, the Link division split into the Link Simulation Systems Division (Maryland) and the Link Flight Simulation Division (California). In 1988 CAE Industries from Canada purchased the Maryland operation, and consolidated it with the Flight Simulation Division in 1990, to form CAE-Link Corporation.



The Link Celestial Navigation System?. You can see the “cockpit” with the navigator and pilot trainees shown above. They were situated right under the projection dome.

In the 1960s, the General Precision Group of Singer-Link began working with NASA to develop simulators for the Gemini space program. Singer held the contract for the simulators under the direction of prime contractor McDonnell-Douglas, which supplied cabin and instrumentation mock-ups. Fully functional simulators came on line at Cape Canaveral and Houston in 1964.

In 1978, the Singer-Link DIG or “Digital Image Generator” was developed. This device is considered to be one of the world’s first-generation Computer-Generated-Image (CGI) systems. In the 1980s, during the height of the Cold War, Singer-Link fielded simulators for numerous military systems, including the B52-G, AH-64 Apache, B-1B, F-16C, P3-C Orion, and S3-B Viking aircraft. Singer-Link also developed a number of ship and submarine trainers for ASW (Anti-Submarine Warfare), Mine Warfare, and Sonar System Training. In the 1990s, Singer developed commercial flight simulators such as the MD88. Singer-Link simulators and the DIG Digital Image Generator were featured in the 1987 NOVA Season 14, Episode 3 show called *Why Planes Crash*.



The Link Celestial Navigation System towers in front of hanger at McCook Army Airfield in Nebraska

Ed Link's breakthrough in demonstrating his pilot trainer finally came when the government contracted with the Army Air Corps to start carrying the U.S. mail. This experiment unfortunately would soon meet with disaster, primarily because Army Air Corps pilots had been trained to fly by watching the ground.

During their first week of mail service Army Air Corps pilots experienced extremely hazardous weather. Tragically, nearly a dozen pilots were killed due to the bad weather they encountered. This tragedy prompted the Army Air Corps to take a closer look at Link's invention that trained pilots to fly by instruments.

On a foggy, misty day in 1934, a group of Army officers awaited Ed's arrival in Newark, New Jersey. Ed was flying in from Binghamton, New York.

The officers, convinced that he couldn't make it in such soupy weather, were about to leave. Just as they were about to leave they could hear the sound of an approaching airplane. Within a minute's time an aircraft circled the field and touched down on the runway. It was Ed Link...he had flown in on instruments and demonstrated that effective flight was possible even during adverse weather conditions.

From the Link website at <http://www.link.com/history.html>

Movie 13.2 Singer-Link



Singer-Link DIG flight simulator visual image demonstration video

<https://www.youtube.com/watch?v=uy8sJ9AxvYI>

13.3 Evans and Sutherland



E&S Founders



E&S Logo

Evans & Sutherland, with its connection to the University of Utah, attracted a large number of the leading CG researchers of the late 1960s and 1970s. They developed algorithmic approaches to high performance image making, as well as the hardware workstations that could support the software. They developed the LDS-1 and LDS-2, followed by a line of graphics workstations, called the E&S Picture System. These were used by most of the CGI production companies

through the 1980s. They also developed the CT-5 and CT-6 flight simulators. After many years of successful marketing, they changed the acronym of their simulation products from CT (Continuous Texture) to ESIG (Evans & Sutherland Image Generator) for their simulation product line.



December 1969:
Ivan Sutherland(left) and Dave Evans(right) with LDS1.

LDS-1

E&S developed turnkey simulation systems for military and commercial training, including systems for air, sea, and land simulation. Their expertise in this area also opened a market for digital theater products, such as planetarium theater systems, domed theater presentations, and digital projection systems. The visualization industry also was partial to E&S products, and they also developed graphics acceleration products for professional workstations and personal computers.



Workers in E&S space at University of Utah.

E&S holds many CG related patents. In the late 1980s, they threatened a number of workstation manufacturers with patent infringement for a number of technologies, most notably clipping.

The following was excerpted from the E&S history page. (A more recent history can be found on their current website at <http://www.es.com/About/History.html>)

“For more than 30 years, Evans & Sutherland has been the power behind the scenes, providing complete visualization solutions for a wide variety of applications. Whether it’s for training simulation, education, entertainment, or business, E&S creates the technology that makes it come alive.

It was 1968 when Professor David Evans, founder of the University of Utah's computer science department, convinced his friend and associate, Dr. Ivan Sutherland, to leave his teaching position at Harvard and join him in a new venture in Utah. That year, the two professors began a collaboration that would shape the history of the computer industry. Their collaboration, based on their theory that computers could be used interactively for a variety of tasks, became Evans & Sutherland Computer Corporation. Established in abandoned barracks on the campus of the University of Utah, the company began by recruiting students from the university and looking for new ways to use computers as tools.

Although E&S is hailed as a leader in computer graphics technology, David Evans contended that developing graphics was only part of the dream. In starting the company, he had a different idea: that computers were simulators. Simulators can replace real objects on occasions when a simulation can be built more cheaply than the physical model can be. "The company began with graphics because we thought they were an essential link between the human user and the simulation."



E&S scientist at the controls of one of the company's display devices.



Scene from the E&S Flight Simulator

The strongly academic environment surrounding E&S provided a uniquely creative and academic work environment that shaped and refined some of the most innovative minds in computer graphics. Many of today's computer graphics visionaries began their careers at Evans & Sutherland. Industry leaders such as Jim Clark, who started Silicon Graphics, Ed Catmull, founder of Pixar Animation Studios, and John Warnock, president and founder of Adobe, trace their roots back to Utah and E&S and the tutelage of Dave Evans and Ivan Sutherland.



Scene from the E&S Flight Simulator

With its emphasis on computers as simulators, training became a natural market for E&S, so the company continued to develop and enhance its simulation systems. Then, in the mid-1970's, E&S established a partnership with Rediffusion, a British simulation company, that gave E&S exclusive rights to provide visual systems for

Rediffusion's commercial flight training simulators. At one point approximately 80% of the world's commercial airline pilots were trained on simulators using E&S visual systems.

Like the computer graphics industry as a whole, E&S saw significant growth and enormous change during its first 15 years. The company stayed on the leading edge of computer graphics technology as it broadened its product line of visual systems for simulation. And, using the technologies developed for simulation, E&S began exploring some new applications such as planetarium systems.

During that time, the company outgrew the barracks on the University of Utah campus, and E&S became one of the first residents of the university's new research park. Employment continued to grow as the company's business base grew. Then, in 1975, Ivan Sutherland left E&S to pursue other interests. He became a research fellow at Sun Microsystems, but he stayed on as a member of the E&S Board of Directors. 1978 marked another milestone for E&S when the company went public.



Scene from E&S Simulation system

In the 1980's, a worldwide recession and changing marketplace brought serious challenges to the company. But E&S continued to lead the simulation industry in providing the highest quality, most realistic visual systems in the world as it looked for new markets for its technology, such as digital projectors for planetariums and entertainment applications.

The early 1990's were a period of change for the company as Dr. Evans retired. In 1994, James Oyler joined E&S as President and CEO. Under Mr. Oyler's leadership, the company continued to lead the visual systems industry for both military and commercial simulation applications as it leveraged its technologies into entertainment, education and workstation applications.

The company's businesses expanded to include visual systems for all kinds of military and commercial training, including systems for air, sea, and land simulation; digital theater products, such as planetarium theater systems, domed theater presentations, and digital projection systems; virtual set products for video and television

producers; visualization products for land developers; and **graphics acceleration** products for professional workstations.

Evans and Sutherland list of patents¹

<http://patents.justia.com/assignee/evans-sutherland-computer-corporation>

and

<http://patents.justia.com/assignee/evans-sutherland-computer-corp>

“Computers in Spaceflight: The NASA Experience”

<http://www.hq.nasa.gov/pao/History/computers/Ch9-2.html>

E&S Tactical Edge (1980)

<http://www.youtube.com/watch?v=06mbwNg1Vw4>

E&S CT5 (1981)

http://www.youtube.com/watch?v=6W-qb_jHRhA

Movie 13.3 E&S History

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/e-s-history-1.m4v>

This video takes you through the history of the Evans and Sutherland Computer Company from its founding at the University of Utah

Gallery 13.1 Scenes from E&S Simulators



Realistic scenes from the E&S Flight Simulator



Fuel tanker



Attack helicopter

1. After threatening several companies with legal action regarding patent infringement in the area of 3D graphics, E&S did a turnaround in 2001 and licensed its patents (it held around 79 such patents) to Nvidia. As PCWorld reported in October of that year, "Graphics chip supplier Nvidia Corp. here today announced a broad alliance with Evans & Sutherland Computer Corp., which has agreed to sell key patents for three-dimensional graphics technologies to Nvidia. Also under the alliance, the two companies said they would cross-license technologies to each other, and Nvidia has agreed to license its Shader Technology to E&S of Salt Lake City, which is a pioneer in 3D graphics."



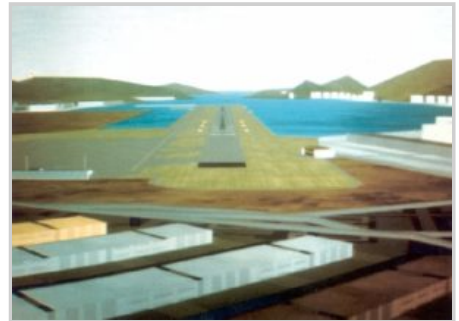
Realistic ground scene



Cockpit



Planetarium simulation



Daylight Scene



Night Scene



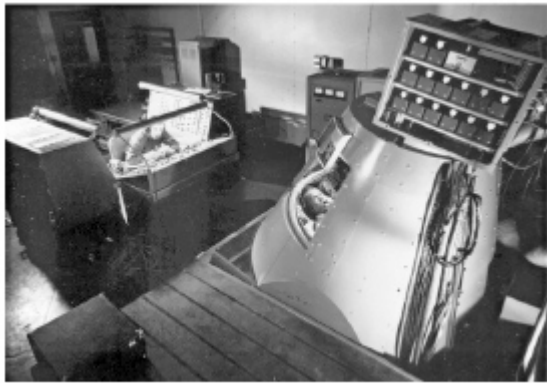
Dusk Scene



13.4 NASA



NASA's requirements for flight simulators far exceeded the state of the art when the first astronaut crews reported for duty in 1959. Feeling obligated to prepare the astronauts for every possible contingency, NASA required hundreds of training hours in high fidelity simulators. Each crewman in the Mercury, Gemini, and Apollo programs spent one third or more of his total training time in simulators.



John Glenn, one of the Mercury Seven Astronauts, runs through a training exercise in the Mercury Procedures (Link) Trainer at the Space Task Group, Langley Field, Virginia

Gemini Mission Simulators used between 1963 and 1966 in the space program operated on a mix of analog and digital data and thus were a transition between the nearly all-analog Mercury equipment and the nearly all-digital Apollo and later equipment. Three DDP-224 digital computers performed the data processing tasks in the Mission Simulator. Built by Computer Control Corporation, which was later absorbed by Honeywell Corporation in 1966, the three computers provided the simulator with

The primary simulator for the first manned spacecraft was the Mercury Procedures Simulator (MPS), of which two existed. One was at Langley Space Flight Center, and the other at the Mission Control Center at Cape Canaveral. Analog computers calculated the equations of motion for these simulators, providing signals for the cockpit displays.

The



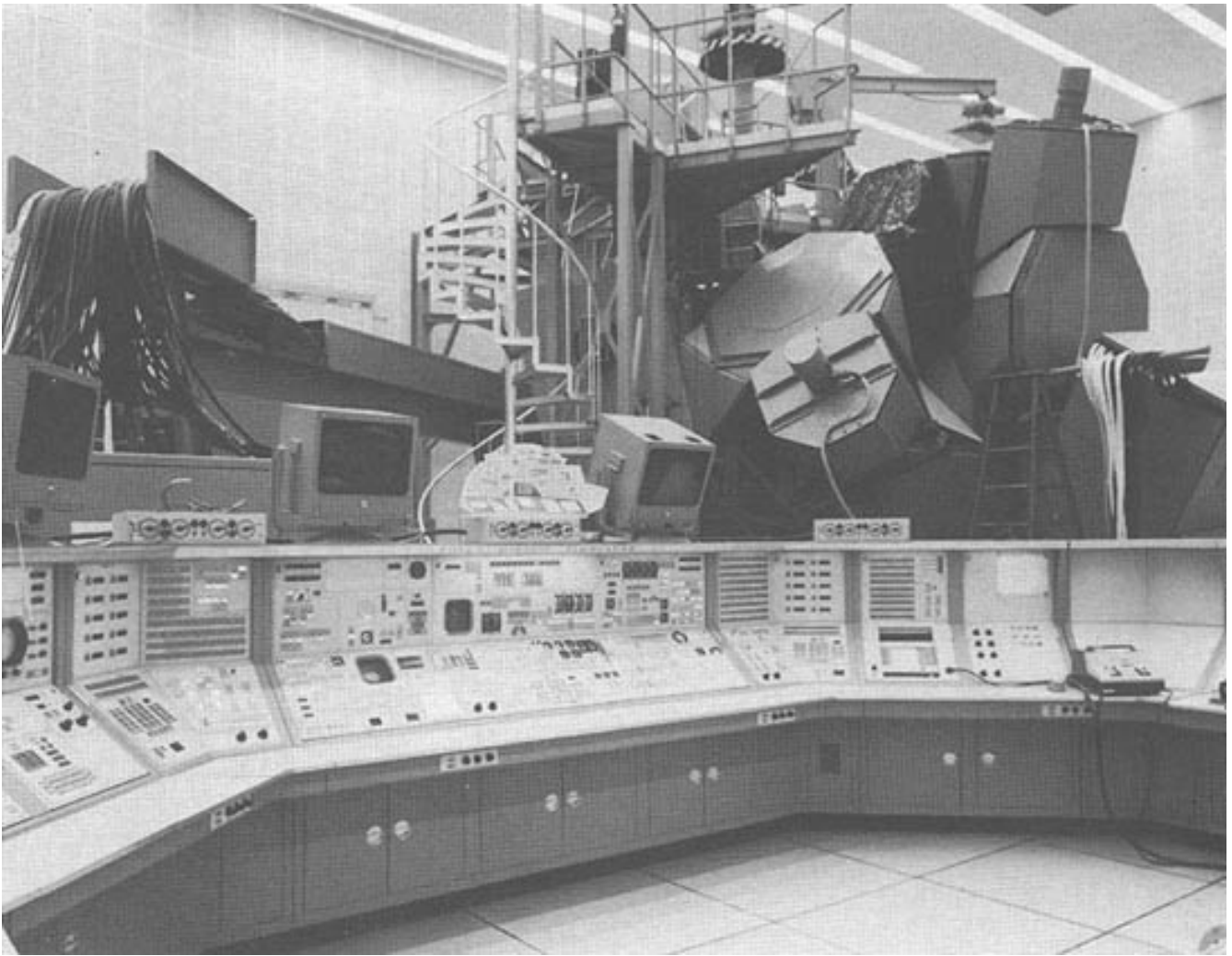
Gemini Mission Simulator

display signals, a functional simulation of the activities of the onboard computer, and signals to control the scene generators. Scene depiction in the Gemini era still depended on the use of television cameras and fake “spacescapes”, as in aircraft simulators. Models or large photographs of the earth from space provided scenes that were picked up by a television camera on a moving mount. Signals from the computers moved the camera, thus changing the scene visible from the spacecraft “windows,” actually CRTs. A planetarium type of projection was also used on one of the moving-base simulators at Johnson Space Center to project stars, horizon, and target vehicles.

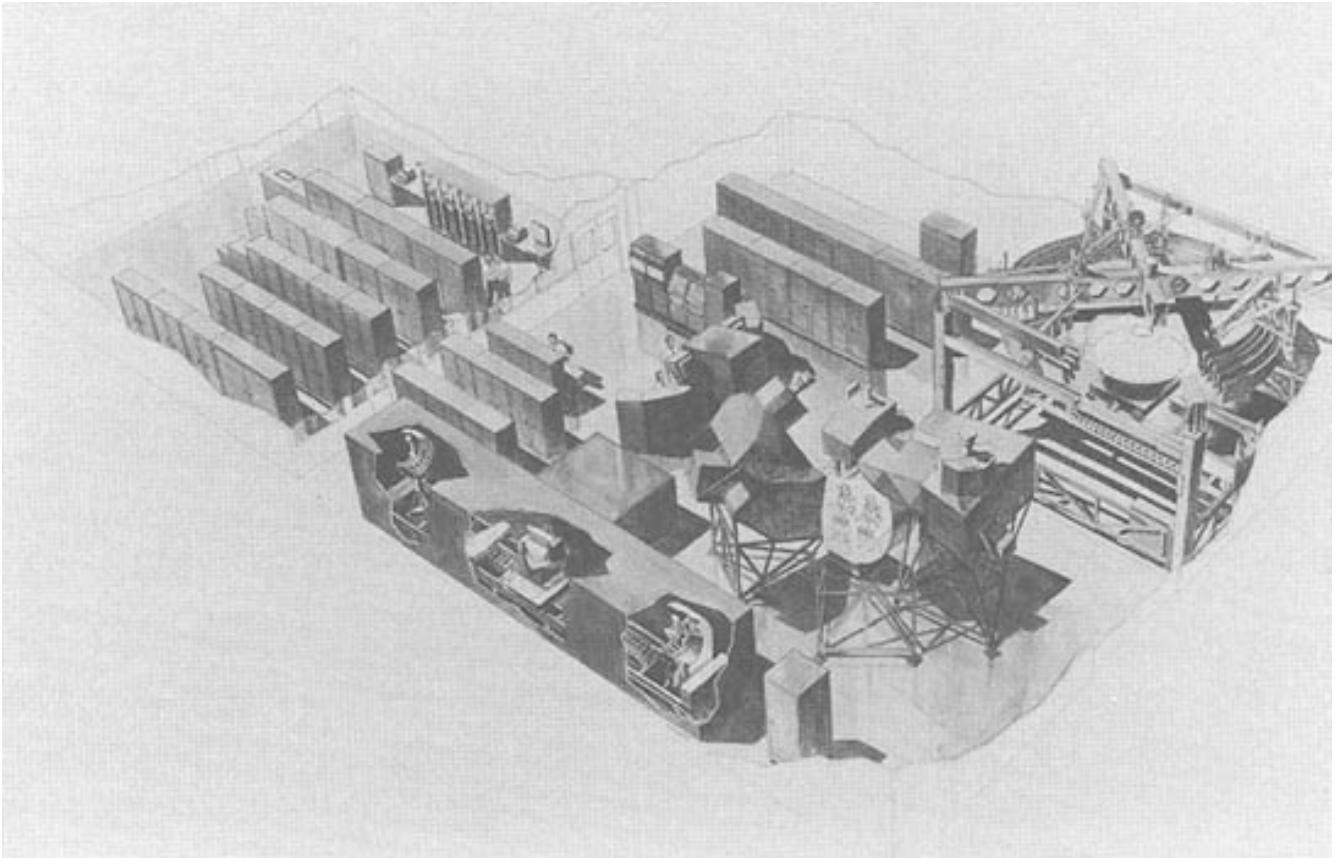


F-18 simulator at NASA Dryden Flight Research Center in Edwards California

The visual images for the Apollo trainers, and the later Shuttle and Skylab trainers, moved to an entirely digital control. Window scenes were entirely computer generated. Coupled with sophisticated **image processing** techniques, the simulations could not only represent the environment of Earth and near space, but also the surfaces and environments of the moon and Mars and other celestial bodies.



The Apollo Command Module Mission Simulator



An artist's conception of the Apollo Lunar Mission Simulator (Images in this section are used courtesy of NASA.)? <http://history.nasa.gov/computers/Ch9-2.html>

Movie 13.4 NASA Flight Simulation – 2004



Flight Simulators – A Safer Way to Test
<https://www.youtube.com/watch?v=QA1is2UtQnw>

13.5 Military



NTSC Head Mounted Display

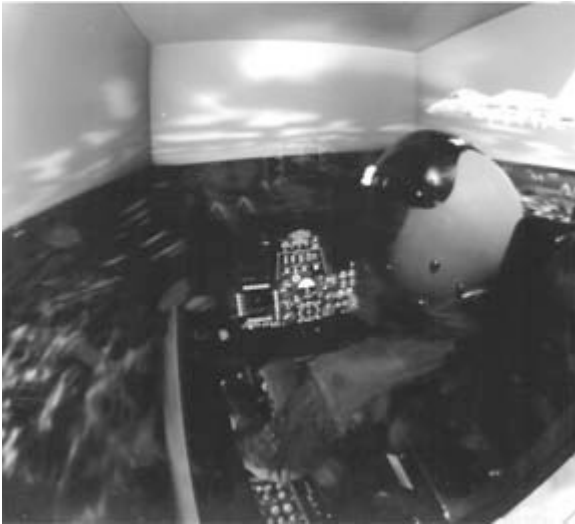
The U.S. Navy maintained an active simulation activity, particularly at their Naval Training Systems Center in Florida. Most notable was the early development on their VTRS, or Visual Technology Research Simulator. This simulator was an example of a “target tracked” system, which placed an image of the air-to-air combat target dynamically in a larger scene, in this case on a spherical screen surrounding the trainer cockpit. In the interest of computation speed, the area of most visual interest (the target and its nearby surroundings) was rendered in higher detail, and inset into a lower resolution background display representing the surrounding terrain outside of the interest field of view.

NTSC also developed a head mounted display for American Airlines that used the target tracking approach that was also developed by Singer-Link in their ESPRIT (Eye-Slaved Projected Raster Inset) system. The NTSC system used eye and head tracking technologies, and projected from a lens on

the helmet, so the higher resolution image was always coordinated with the pilot’s view.

The Air Force was also interested in low altitude simulation of high resolution, high detail terrain. Their ASPT (Advanced Simulator for Pilot Training) installed in 1974 at Williams AFB in Arizona was one of the first examples of a multiple display, multiple CGI channel “butted” display system, which was the model for most simulators built during the 1980s and 1990s. The field of view was divided between multiple CRTs surrounding the pilot, each fed with a signal from an independent but synchronized computer image generator. By aligning the boundary of one display with that of the adjacent, it gave the feel of a continuous image. The ASPT used seven

CRTs with complex optics to eliminate overlapped images, in what they called the “Pancake Window” (Farrand Optical Company). Each pentagonal window provided more than an 86° field of view.



Boeing Visual Integrated Display System

An alternate approach emerged from the Air Force Resource Laboratory. The Pancake Window mosaic display was becoming difficult to maintain. Seeking a low cost, full color replacement for the dim, monochrome Pancake Window led to experiments with rear projection screens and CRT projectors. A bright, clear real image was formed at approximately arm's length from the pilot's eye. An example of this technology was the Boeing VIDS (Visual Integrated Display System.)

The E&S CT5 and CT6 systems are configured like the ASPT system. The early CT5, coupled with the Rediffusion physical simulator, cost around \$20M. Other similar systems included the GE Compuscene IV made for Martin Marietta and the DIG from Singer-Link.

13.6 Other Approaches



GE Cell Texture

Researchers experimented with many different approaches to the generation of complex imagery for simulation. The Low-resolution environment coupled with the hi-resolution targets described in Section 5 gave only moderately acceptable results. Hardware, like that developed at E&S and elsewhere, made image generation faster, as did algorithms that were embedded in the software. General Electric used texture mapping to achieve reasonable results, as shown in the GE Cell Texture shown here.



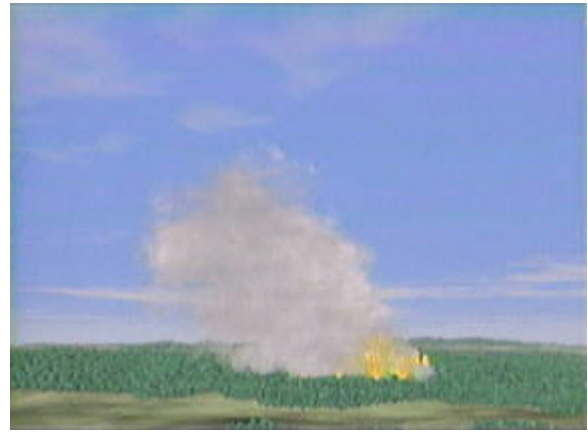
Honeywell Flight Simulation

Honeywell experimented with assembling real images stored on video discs, and retrieved, transformed and seamed them together based on the desired field of view and range in real time.

Vought researchers experimented with creating a mosaic of images obtained from aerial photographs into a terrain data base. A similar approach took advantage of the data bases of the Defense Mapping Agency, which can combine **height maps** representing elevations (for the geometry) with terrain and cultural artifacts.



Gardner's ellipsoid approach to representing trees, clouds, fire and smoke.



Gardner's ellipsoid approach to representing trees, clouds, fire and smoke.

Another interesting approach is attributed to Geoff Gardner at Grumman Data Systems, for the generation of terrain data and effects in simulations. Gardner presented a method to generate terrain, clouds and other objects in a SIGGRAPH 84 paper, realistic smoke and clouds in a 1985 paper, which he extended to smoke and fire in a 1992 paper. The models he presented used quadrics or **ellipsoids** (which are very computationally inexpensive for things like view intersection) that were covered using a texture derived as a function of the transmittance of transparency each ellipsoid should possess. The transmittance of transparency varied from the center of the object to the edges of the ellipsoid as a mathematical function. Gardner was able to use these ellipsoids and transparent textures to model the terrain, trees, clouds, smoke, fire and other elements.



Nighttime driving simulation

Evans and Sutherland, as well as other simulation manufacturers, and researchers in simulation as well as CGI in general extended the ideas of flight simulation to other vehicles, including maritime and automobile. For example, In the mid-80s, NTSC contracted with Ohio State to



Ohio State University submarine pilot training simulator

develop a submarine pilot simulation trainer for pilots who maneuver the ships into dock at the Norfolk base in Virginia.



Hiroshima University lighting simulation

Nakamae at Hiroshima University experimented with accurate lighting approaches to represent night time driving scenarios.

Movie 13.5 Beethoven's Sixth in CIG

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/beethoven-2.m4v>

Animation by Geoff Gardner, using his system of textured quadric surfaces for scene generation for flight simulation purposes (1984)

Microsoft Flight Simulator

Bruce Artwick was a student in Electrical Engineering at the University of Illinois in the mid 1970s when he became interested in the connection of emerging computer systems and airplane flight. His 1975 thesis, "A Versatile Computer Generated Dynamic Flight Display" showed how the computer display could effectively be used to demonstrate the flight of an aircraft. Artwick developed the code for the first consumer flight simulator that ran on the Apple II. Interest from the consumer market motivated him to start a company, SubLogic, that developed simulators that ran on the TRS-80 in 1980. In 1982, SubLogic released a version of the simulator for the IBM PC, called Microsoft Flight Simulator 1.0. He also developed for the Commodore 64, the Amiga and the Atari platform.

Several versions of Flight Simulator followed, and some say that it contributed to increased sales of computers because its graphics and CPU demands required more sophisticated computers. These later versions contained additional aircraft types, better landmarks, cities and scenery, multiple airports, and as of version 3.2, allowed the viewer to see the aircraft from outside of the cockpit. The software later included a Professional version with more capabilities, and a kiosk version to be run in public places.

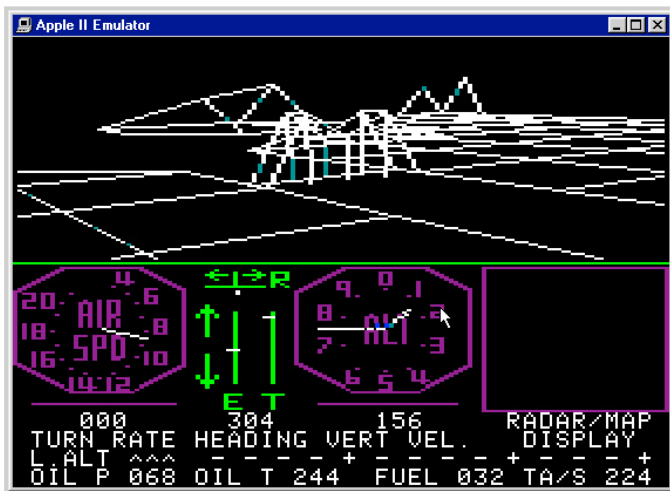
This very popular program (an estimated 21 million copies were sold by 1999) was one of the most successful software titles in history. Shortly before the version for Windows 95 was released, Artwick sold his company to Microsoft. They continued to expand the program until they closed the division in 1999.

Movie 13.6 Microsoft Flight Simulator



Video history of the Microsoft Flight Simulator on the PC <https://www.youtube.com/watch?v=ICb9ZXiD3q4>

Gallery 13.2 Screenshots from Microsoft Flight Simulator



Images: Screenshots from various versions of the Microsoft Flight

Simulator.



Chapter 14: CG in the Movies

CG in the Movies

After the movie *TRON* had such difficulty at the box office, there was hesitation to embrace the emerging technology in the motion picture industry. But special effects were desirable, and *The Last Starfighter* showed the value of using this approach to adding scenes to movies, and the usage escalated from there.



Flight of the Navigator – Viking Films (1986)

14.1 Introduction



As the image making capabilities advanced during the move from the lab to full scale production in the 1970s, Hollywood took notice. There were several movies that included one or more special effects scenes that were CGI.

For example, John Whitney Jr. produced some graphics effects for Michael Crichton's *Westworld* in 1973 – in particular, the “robot view” of the main character was the first example of digital image processing used in films;



Yul Brynner played the android in the Westworld western theme park, and his pixellated view is shown at the right.



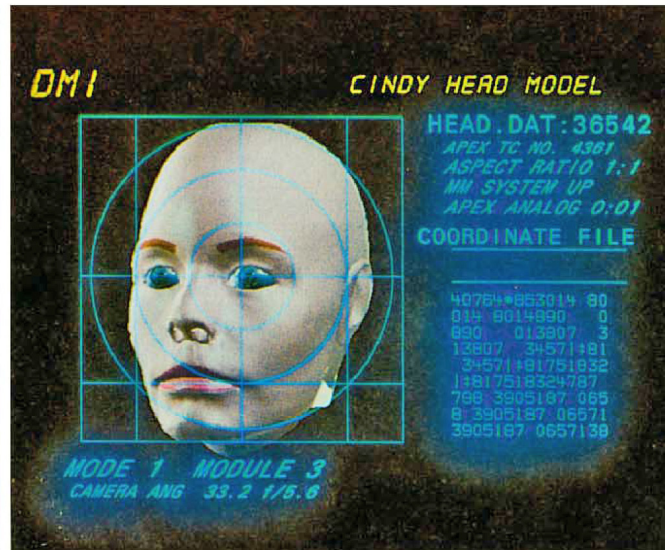
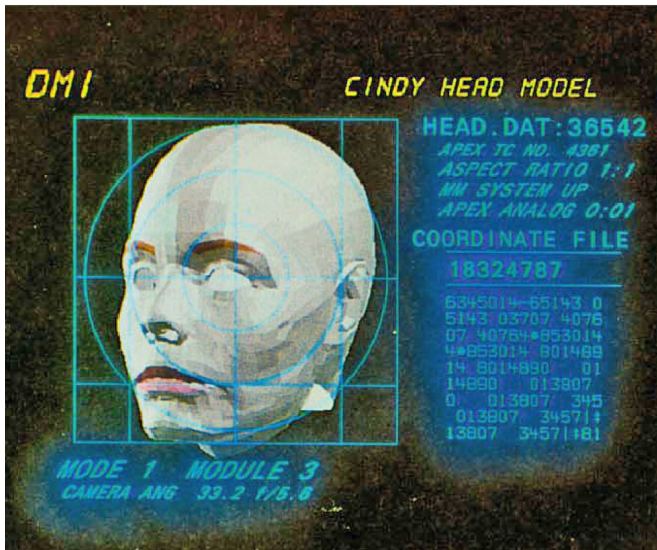
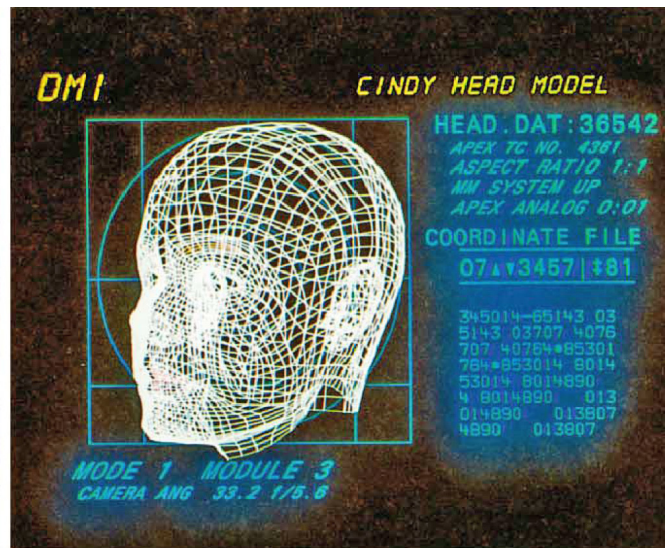
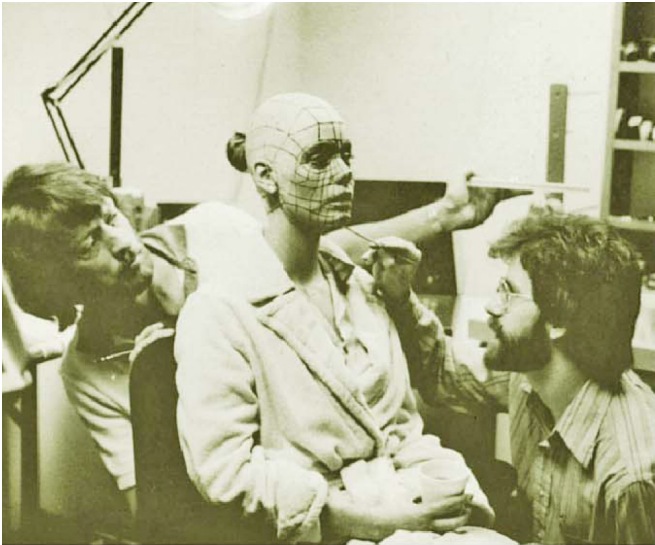
Information International Inc (III) produced a 3D representation of Peter Fonda's head for the movie *Futureworld* in 1976;



Peter Fonda digitized for 3D model

Susan Dey was digitized by III for several scenes in Michael Crichton's 1981 film *Looker*;





Cindy's head from the movie *Looker* (1980). Actress Susan Dey is digitized from reference lines by Art Durinski and Larry Malone.

Larry Cuba produced a scene for *Star Wars* using Tom DeFanti's software at the EVL at University of Illinois in Chicago, and another scene was done with SCANIMATE;

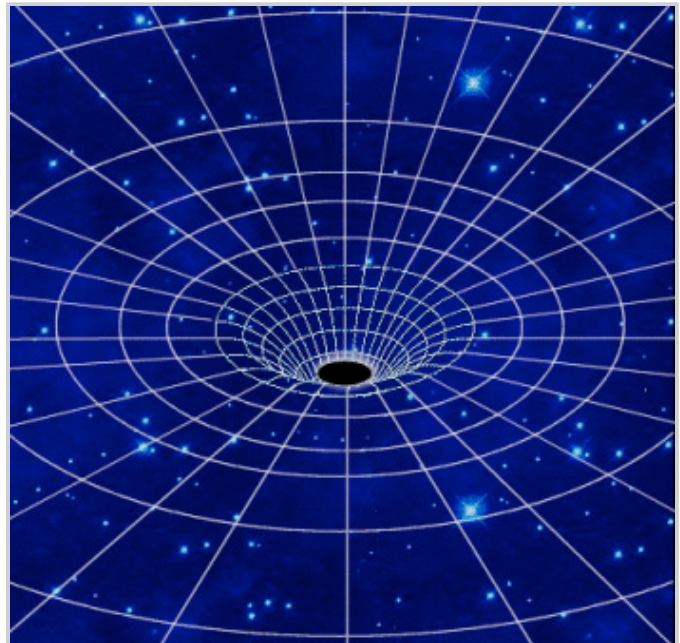


Larry Cuba graphics for Star Wars

John Whitney, Sr., R/Greenberg and others produced graphics for titles, including the famous *Superman* titles; Disney's *The Black Hole* used a 3D effect for the opening and for some trailers;



Superman opening title

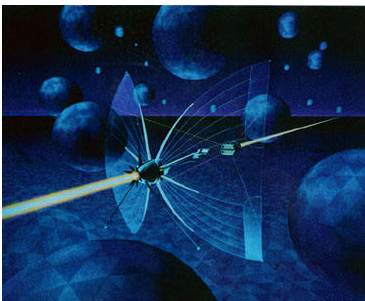


Black Hole graphics

the “Genesis Effect” was produced by Lucasfilm for *Star Trek: the Wrath of Khan* in 1982.



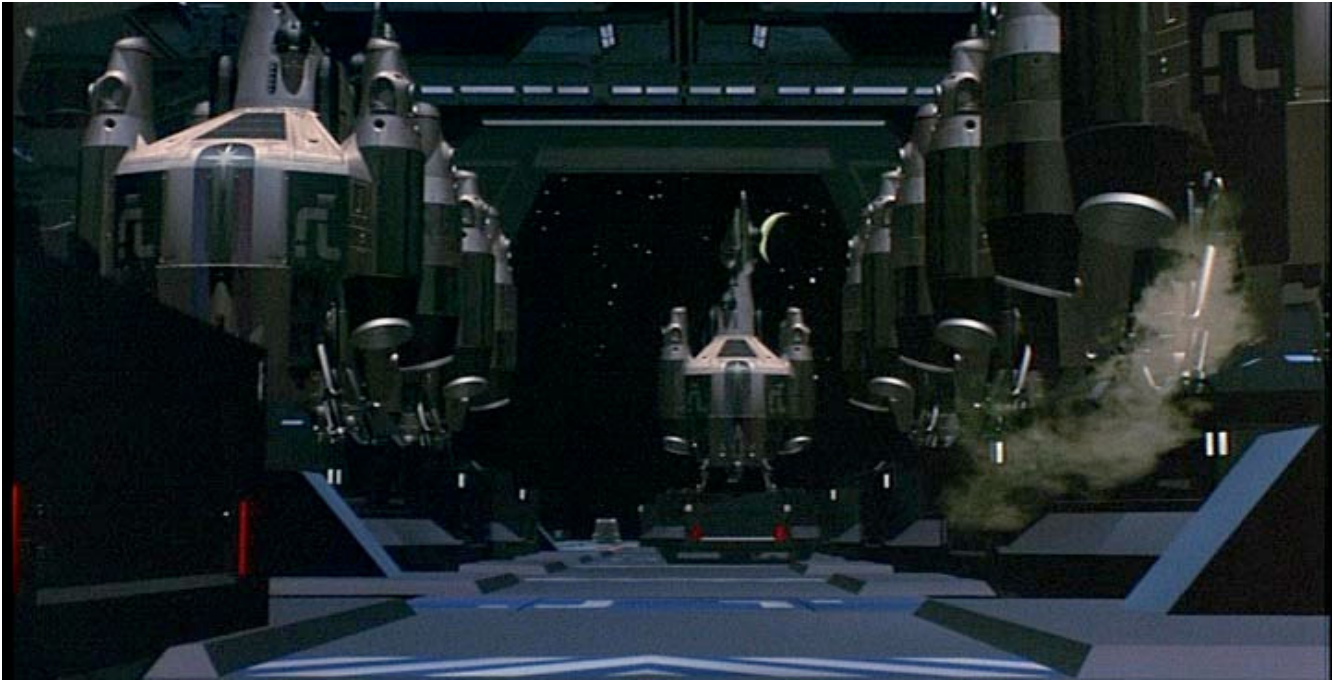
Genesis Effect (1982)



TRON Solar Sailor

But it was the 1982 sci-fi movie *TRON* that pushed the issue, using four major production companies to produce over 20 minutes of full 3D graphics. Whereas the movie was not a box-office success, it did prove that this new medium had tremendous potential for the industry. Read more details about this movie and the effects production in Section 3.

The cost of *TRON*, coupled with its poor performance at the box office, caused Hollywood to take a step back from CG film production. They became excited once more when Digital Productions produced the tremendous imagery for the movie *The Last Starfighter*.



The Last Starfighter – Universal Pictures (1984)

Read more about the production of *TRON* and *The Last Starfighter* in the article [Science and the Silver Screen](#) from the Time-Life series *Understanding Computers: Computer Images* (1986).

The CGSociety and 3D World presented [a rundown of the Top 100 3D Movies](#) as selected by the CG community in 1998.

[Greatest Visual and Special Effects \(F/X\) – Milestones in Film](#) from THE GREATEST FILMS – The “Greatest” and the “Best” in Cinematic History website

Movie 14.1 Animated Characters in the Movies



<https://vimeo.com/14437767>

14.2 CGI and Effects in Films and Music Videos



The following writeup, titled *The History of Computer Graphics and Effects*, was written by Matt Leonard of *Digital Dreams & Visions* in 1999. He included it on his website, which is inactive.

From the very early days of man's creation it seems he has been fascinated by the world around him. Early cave paintings show the very first artistic expression of man's desire to represent this world, showing not only the very form of creation but the living qualities of movement as well. This art form has been developed and diversified over the centuries until the establishment of the motion picture industry in the late 1800s. The first ever special effect or Illusion, as they were known then, was produced in 1895 by Alfred Clark in *The Execution of Mary Queen of Scots*.

1900s and 1910s



George Méliès: *A Trip to the Moon*

Around the turn of the century, the French magician George Méliès released his first film *Indian Rubber Head* (1901) bringing his own form of magic to the big screen. The following year he released *A Trip to the Moon* (1902) and *The Dancing Midget* (1902), using almost every type of special effects trick still used today.

Effects continued to become more elaborate throughout the next twenty years, through people such as Robert W. Paul and Edwin S. Porter. The technique of using mattes to composite several images onto one negative was employed in such films as *The Great Train Robbery* (1903) and *The Motorist* (1906).

1920s



The Lost World

By the mid 1920s things began to change. Willis O'Brien's stop motion hit theaters in 1925 in the form of *The Lost World*, while a year later Fritz Lang's *Metropolis* (1926) took the effects industry by storm. The Schüfftan Process artfully employed in *Metropolis* and other movies, utilized **forced perspective** techniques to create

an illusion of size and distance. Such techniques are still common today, being used in such films as *Mighty Joe Young* and *Armageddon* (1998).



Metropolis

Alongside this, MGM developed the Composite Reduction process, allowing previously photographed footage to be inserted into specific areas of another frame, as in *The Hunchback of Notre Dame* (1923), *The Ten Commandments* (1923) and *Ben-Hur* (1926).

1930s and 1940s



King Kong

The effects industry continued to grow through the 1930s with such films as *King Kong* (1933) and *Gone with the Wind* (1939). In 1934 Walt Disney's *Snow White* arrived, ushering in a new era of full-length animated films.

1950s



SAGE

The post-war years of the 1950s moved the focus of film to outer space, and with the development of the Motion Control Rig by Paramount, more sophisticated shots were developed. Meanwhile the SAGE Machine (Semi-Automatic Ground Environment) was created to follow enemy fighter planes during



Forbidden Planet

the Cold War. This provided the first interactive computer graphics. Some of the outstanding effects films of the 50s included *Destination Moon* (1950), *War of the Worlds* (1953) and *Forbidden Planet* (1956). The **Blue Screen** technique was also invented, enabling a person or object to be filmed against a blue, green, or sometimes red background, and then extracted and composited against a different background.

1960s



Jason and the Argonauts

There was little technical development during the early 1960s. Ray Harryhausen's *Jason and the Argonauts* (1963) came out, which included the famous **Stop-Motion** skeleton battle sequence which is still inspiring filmmakers today (e.g. *The Mummy* (1999)). 1963 saw the first Academy Award given for Best Visual

Effects, won by Alfred Hitchcock's *The Birds*. Then in 1968 Stanley Kubrick's *2001: A Space Odyssey* (Oscar winner), began to push the boundaries of special effects once again.



2001: A Space Odyssey



Sketchpad

Although the FX industry had not moved forward tremendously until the late 60s, the computer graphics industry had made headway. Ivan Sutherland had invented the Sketchpad interactive graphics software in 1962 and the University of Utah had opened the first CG department in 1966. 2D morphing techniques were first developed in 1967 at the University of Toronto, along with the development of Environmental Reflection Mapping (1976) and Bump Mapping (1978) by James Blinn.

Triple-I created the first feature Film appearance of 3D CG, while in 1968 Ivan Sutherland and David Evans joined forces to open the worlds first CG company, Evans & Sutherland, still going strong today. 1968 also saw the arrival of Ray Tracing developed by Bell Labs and Cornell University.



Jim Blinn

1970s

During the 1970s technology within computer graphics continued to grow, pushed forward by pioneers such as James Blinn and David Em. **Bezier curves** (1970) were invented along with both **Gouraud** (1971) and **Phong shading** (1975). 1975 saw the development of a CG teapot that has now become the computer graphics icon. Ed Catmull went on to develop texture mapping in 1974, refined later in 1976 by James Blinn. Bill Gates founded Microsoft while Steve Woznick and Steve Jobs built the first Apple Computer. Also Quantel created Paintbox, the first graphics product aimed specifically at the broadcast industry.

George Lucas formed Industrial Light and Magic (ILM) to cover the huge array of special effects for his new film *Star Wars* (1977) (Oscar winner). Among those who joined were Dennis Muren, John Dykstra and Richard Edlund. A host of films began to appear utilizing CG, including *The Black Hole* (Oscar nominated) and *Alien* (1979) (Oscar winner). Also in that year Ed Catmull left NYIT and joined ILM to head up their CG department.



Star Wars

1980s



TRON

In the 1980s, Triple-I continued their work, producing seven minutes of CG for *Looker* (1980), while ILM produced the first all-digital CG image for *Star Trek II: The Wrath of Khan* (1982).

Disney's *TRON* (1982) was the first extensive use of 3D CG.

Where the Wild Things Are (1982-83) was a pioneering 35mm film test, which digitally composited 3D CG backgrounds with traditionally animated (digitally inked and painted) characters. The work was led by Chris Wedge (now vice-president of Blue Sky/VIFX, *Joe's Apartment*, *Star Trek: Insurrection* and *Bunny*). John Lasseter (director of *Toy Story*, *A Bug's Life* and *Monsters Inc.*) left Disney and joined Lucasfilm Computer Graphics Division, working on the CG Endor moon sequence for "*Return of the Jedi*" (1983) (Oscar winner).

SGI (Silicon Graphics Inc.) was founded by Jim Clark in 1982 and by 1984 they had released their first product, the IRIS 1000. The early 80s also saw a surge in the opening of graphics software houses and the release of new products onto the market. These included 1983: Alias Research Inc. (Alias/1), 1984: Wavefront (PreView), 1985: Softimage (Creative Environment) and 1982: Autodesk (AutoCAD).

Between 1980 and 1985 the special effects and computer graphics industries began not only to settle down but also to merge slightly. Richard Edlund left ILM in 1983 and formed Boss Film Corp., powering onto the market with effects work for *Ghost Busters* (Oscar nominated) and *2010* (1984) (Oscar nominated). Lucasfilm Computer Graphics Division released *The Adventures of Andre and Wally B.*, directed by John Lasseter. Disney's *The Black Cauldron* (1985) became the first animated feature film to contain a 3D element. Lucasfilm Computer Graphics Division produced the 3D animation required to bring to life a knight made of stained glass for the film *Young Sherlock Holmes* (1985) (Oscar nominated). The project was also the first to composite CG with a live-action background. Dennis Muren was the Visual Effects Supervisor.



Young Sherlock Holmes

In 1986 Pixar was formed when the Lucasfilm Computer Graphics Division was purchased from George Lucas by Steven Jobs for \$10 million. The pioneers included John Lasseter, Ed Catmull and Ralph Guggenheim. The company went on to produce the famous Renderman software and animated features including *Luxo Jr.* (1986) (Oscar nominated), *Reds Dream* (1987), *Tin Toy* (1988) (Oscar winner), *Knick Knack* (1989), *Toy Story* (1995) (Oscar winner), *A Bug's Life* (1998), *Toy Story II* (1999), *For The Birds* (2000). (More about Pixar can be found in Chapter 11.)



Pixar Movies

Howard the Duck (1986) was the first film to use digital wire removal and the first work carried out by the new ILM computer graphics department. Later that year they also worked on *Star Trek IV: The Voyage Home* (1986) which contained the first use of 3D scanning by Cyberware on a film. During the following year Arcca Animation produced *Captain Power and the Soldiers of the Future* (1987). It was the first TV series to include characters modeled in 3D entirely within the computer.



The Abyss

By the end of the 80s things were beginning to steam ahead. ILM won another Academy Award for *Who Framed Roger Rabbit*, and completed the first digital morph for *Willow* (1988) (Oscar nominated). The following year ILM produced the Donovans destruction sequence for the end of *Indiana Jones and the Last Crusade* (1989). The shot involved scanning multiple film elements into the computer, digitally compositing them together and then scanning back out to film. Also in that year, ILM produced the water pseudopod creature for “*The Abyss*” (1989) (Oscar winner). The software used included Alias/2 and Photoshop. Dennis Muren, Mark A.Z. Dippe and

John Knoll were some of the brains behind the success of the project.

1990s

As we move through the final decade towards the next millennium, the Computer Graphics and Special Effects Industries continue to break new boundaries and bring us the most spectacular array of visual imagery to date.

One of the newer CG companies to appear towards the end of the 80s was Rhythm & Hues. They produced over 30 shots of photorealistic airplanes, bombs and smoke all in daylight for a film *Flight of the Intruder* (1990). Another new company, deGraf/Wahrman, produced the first CG simulator ride that same year called *The Funtastic World of Hanna-Barbera*. They also produced the CG head of the robot villain for *Robocop 2* (1990).



Shutterbug

Disney produced the first completely digital film in the shape of *The Rescuers Down Under* (1990) and ILM painted the first digital Matte Painting for the film *Die Hard 2: Die Harder* (1990). The film also contained extensive Blue Screen Compositing for a sequence in which Bruce Willis is ejected out of a plane's cockpit. Pixar used their new Photorealistic Render software, Renderman, to produce the famous "Shutterbug" image. Autodesk released 3D Studio v1, their own 3D modeling and animation software.



Terminator



Dennis Muren, Steve Williams, Mark Dippe & Eric Armstong – ILM

1991 marked the beginning of the ground breaking years. James Cameron's *Terminator 2: Judgment Day* (Oscar winner) brought to life by the artists at ILM began to change the way Hollywood perceived computer graphics. It was the first major digital character to be used in a film since the stained glass knight in *Young Sherlock Holmes*. Alias/2 and Photoshop were used along with a host of in-house tools designed especially for the project. Dennis Muren, Mark Dippe, Stefen Fangmeier, Tom Williams and Steve Williams were some of the people involved. Another major contribution that year came from Disney's *Beauty and the Beast*; the ballroom sequence contained a complete 3D rendered background. Stop Motion was superseded by Go Motion created by Phil Tippett for *Dragonslayer* (1991).

During 1992 ILM continued to push the boundaries in *Death Becomes Her* (Oscar winner), creating photorealistic skin. Walt Disney also continued to push their techniques in both *Aladdin* and their short in-house project *Off His Rocker*. Also Virtual Reality hit Hollywood in the form of the *Lawnmower Man* (Angel Studios).



Jurassic Park

Various things happened the following year, but all were overshadowed by the release of Steven Spielberg's *Jurassic Park* (1993) (Oscar winner). ILM employed a huge range of tools to create CG dinosaurs and various other special effects needed for the film. These included Alias PowerAnimator, Softimage 3D, Matador and Lightwave (for simple animatics). 1993 also saw the rise of Digital Domain formed by James Cameron, Stan Winston and Scott Ross.

1994 saw a significant rise in films containing CG. This included *Forest Gump* (ILM) (Oscar winner), *The Flintstones* (ILM), *The Mask* (ILM) (Oscar nominated), *The Lion King* (Disney), *Timecop* (VIFX), *The Shadow* (R/Greenberg Associates) and *True Lies* (Digital Domain) (Oscar nominated). Also Mainframe Entertainments *Reboot* came out as the first 100% CG television show. Microsoft bought Softimage, and the computer game *Doom* was released.

During 1995 SGI acquired both Alias and Wavefront combining the two companies into Alias/Wavefront. In the film industry, *Toy Story* (Pixar) became the first full-length 3D animated film. *Judge Dredd* (Kleiser-Walzack

Construction Company) became one of the first films to incorporate CG stunt doubles along with *Batman Forever* (Warner Bros.). ILM released *Jumanji*, further developing their ability to produce photorealistic hair, and *Casper*, the first CG characters to take a leading role. Rhythm and Hues *Babe* won an Academy award for its special effects. Steven Spielberg, Jeffrey Katzenberg and David Geffen joined together to form Dreamworks SKG, and the Sony Playstation was released, and *Apollo 13* was released.

By 1996 *Dragonheart* (Oscar nominated) was finished. Rob Coleman of ILM oversaw hundreds of shots of the talking dragon, Draco, achieving not only a full range of emotional expressions but also the ability to talk. The breakthrough Caricature software or Cari for short, had been developed by Cary Philips and has now become one of ILMs main in-house tools. ILM also relied heavily on Alias/Wavefronts Dynamation particle system software for the movie *Twister* (Oscar nominated).



Hunchback of Notre Dame

Disney's remake of *The Hunchback of Notre Dame* used CG to produce crowds, props and other effects. Among the other big films to contain computer animation were *Space Jam* (Warner Bros.) combining traditional animation with live action, and *Independence Day* (Oscar winner). The computer game Doom was superseded by Quake, and Autodesk released 3D Studio MAX.



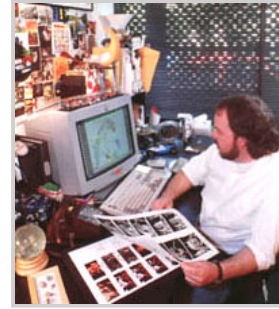
Titanic

Alias/Wavefronts Dynamation particle system was again used in 1997 by ILM in the creation of a CG cape for *Spawn* together with realistic goo, drool and saliva. George Lucas restored Episodes 4, 5 and 6 of the *Star Wars* saga; over 350 shots were modified or added to the existing footage. James Cameron's company Digital Domain created a huge number of shots for *Titanic* (Oscar winner) which included

extensive use of Motion Capture.

Other CG movies in 1997 were *Dante's Peak*, *Starship Troopers*, *The Lost World: Jurassic Park*, and *The Fifth Element*.





Pixar won an Academy Award (in March 1999) for *Geri's Game* (1998) which utilized Subdivision surfaces. Radiosity Rendering was used in the creation of *Bunny* (1998) (Blue Sky/VIFX) which also won an Academy Award the same year. 1998 seemed to be a year of animation involving animals with *A Bug's Life* (Pixar) and *Antz* (PDI). Chris Landreth received a Genie Award for his contribution to *Bingo*, the test project used on the newly released Maya character animation and special effects package from Alias/Wavefront.



aaa

1999 was an excellent year for both computer animation and special effects. In May George Lucas released the long awaited *Star Wars Episode 1: The Phantom Menace*, containing almost 2,000 digital effects created by Industrial Light & Magic under the supervision of Dennis Muren, John Knoll, Scott Squires and Rob Coleman. This was without question the biggest computer animation and special effects film thus far in history. Among the digital tools used to create this ground breaking achievement were PowerAnimator, Maya, Softimage 3D, Commotion, FormZ, Electric Image, Photoshop, After Effects, Mojo, Matador, and RenderMan.

Various proprietary in-house software packages were also used including Caricature, Isculpt, ViewPaint, Irender, Ishade, CompTime and Fred.

Among ILM's other contributions this year are *The Mummy*, *The Haunting* and *Wild Wild West*. Other major effects movies this year include *The Matrix*, whose special effects were created by Manex Visual Effects, *Toy Story 2* (Pixar), *Supernova* (Digital Domain), *Deep Blue Sea* (Hammerhead) and *Lake Placid* (Digital Domain).



Jar Jar Binks

As we move into the next millennium, one of the big questions which is often asked within the computer animation and effects community is "what is the next big thing?" Jar Jar Binks from *Star Wars Episode 1: The Phantom Menace* (ILM) (1999) was the first photorealistic all digital main character in a feature film. People are still fascinated by the concept of entirely digital photorealistic humans. With the improvement in both hardware and software our ability to create more and better digital characters improves by the year.

Some people argue that various questions need to be asked before a huge amount of effort is put into one relatively small area of the industry. Elvis was Elvis not because of how he looked but because of how he moved and acted. There are hundreds of Elvis impersonators in the world, some of which are very good, but none of them are good enough to fool us into thinking Elvis has returned. The closer we get to creating a completely digital character the more our senses seem to alert us to the fact that something is not completely right and therefore we dismiss it as a cheap trick or imitation.



The Matrix

There are no doubt many reasons for using digital humans, such as for stunt stand-ins or simply for those impossible situations conjured up by Hollywood, but as Dennis Muren of ILM once said, “Why bother! Why not focus on what doesn’t exist as opposed to recreating something that is readily available.” Over the last few years we have begun to see animation and special effects creating more impossible situations such as the Flow-Mo and Bullet Time effects shots of *The Matrix* (1999) and the beautiful artistic style of *What Dreams May Come* (1998).



What Dreams May Come

Hollywood has found there to be a huge shortage of dinosaurs, dragons, Gungans and various other creatures and characters needed for lead roles in today's motion pictures. A lot of people are very keen to see the progression of digital creatures taken to its logical conclusion of human beings, while others say the focus should be on more artistic effects. Whatever your opinion is, you can be sure of one thing: the magic of computer animation and special effects will continue to advance even faster into the next millennium as a tool to bring to life the dreams of storytellers.

THE HISTORY OF 3D IN COMPUTERS
From gigantic wonders of the world to handheld supercomputers—**MOVIES** and **GAMES** feature better and better graphics, while **DEVICES** become smaller and smaller.

MOVIES

- Recognized by the Oscar statuette, 3D is the foundation of the science and engineering and entertainment.
- Designed on Ivan Sutherland's Sketchpad graphics computer.
- Refracted glass polygons were the first 3D model.
- In the mid-1970s, interactive computing and animation, with the Z-buffer, enabled the growth of 3D.
- In the early '70s, a flurry of development of CG algorithms began, establishing the mathematical foundations for the modern 3D computer and display.
- By the mid-1970s, interactive computing and animation, with the Z-buffer, enabled the growth of 3D.
- In 1984, the first desktop computer for use in movie production was the first for interactive 3D computer graphics, with an SGI 4D in 1989.
- While the SGI 4D was the first for interactive 3D computer graphics, it was an SGI 4D in 1989.
- In 1988, the SGI 4D was the first to offer real-time shaded graphics—\$55,000 then, about \$90,000 today.
- In 1988, SGI introduced the first 3D workstation, the IRIX 4400, with a cost of \$120,000 to build (about \$230,000 today).
- In 1990, the first 3D movie game, "The Sims" from Atari, appeared in Japan. In 1990, it could only produce 100,000 images per frame. Today, it could only produce 100,000 images per frame. Today, it could only produce 100,000 images per frame.
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GAMES

- As technology shrinks and becomes more affordable, the uses of 3D grow exponentially.
- Microsoft's Xbox was the first game console to support multiple players (CPU and GPU) and DirectX 9.0 (for 3D acceleration).
- NVIDIA introduced the GeForce 400 in 2008, the first programmable GPU, and the world's first GPU to use real-time ray tracing.
- Microsoft's Xbox 360, the first game console with unified memory and 1080p resolution.
- The PS2 was considered the first game console with 100% DirectX Shader operations and 1080p resolution.
- Microsoft's Xbox 360, the first game console with unified memory and 1080p resolution.
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DEVICES

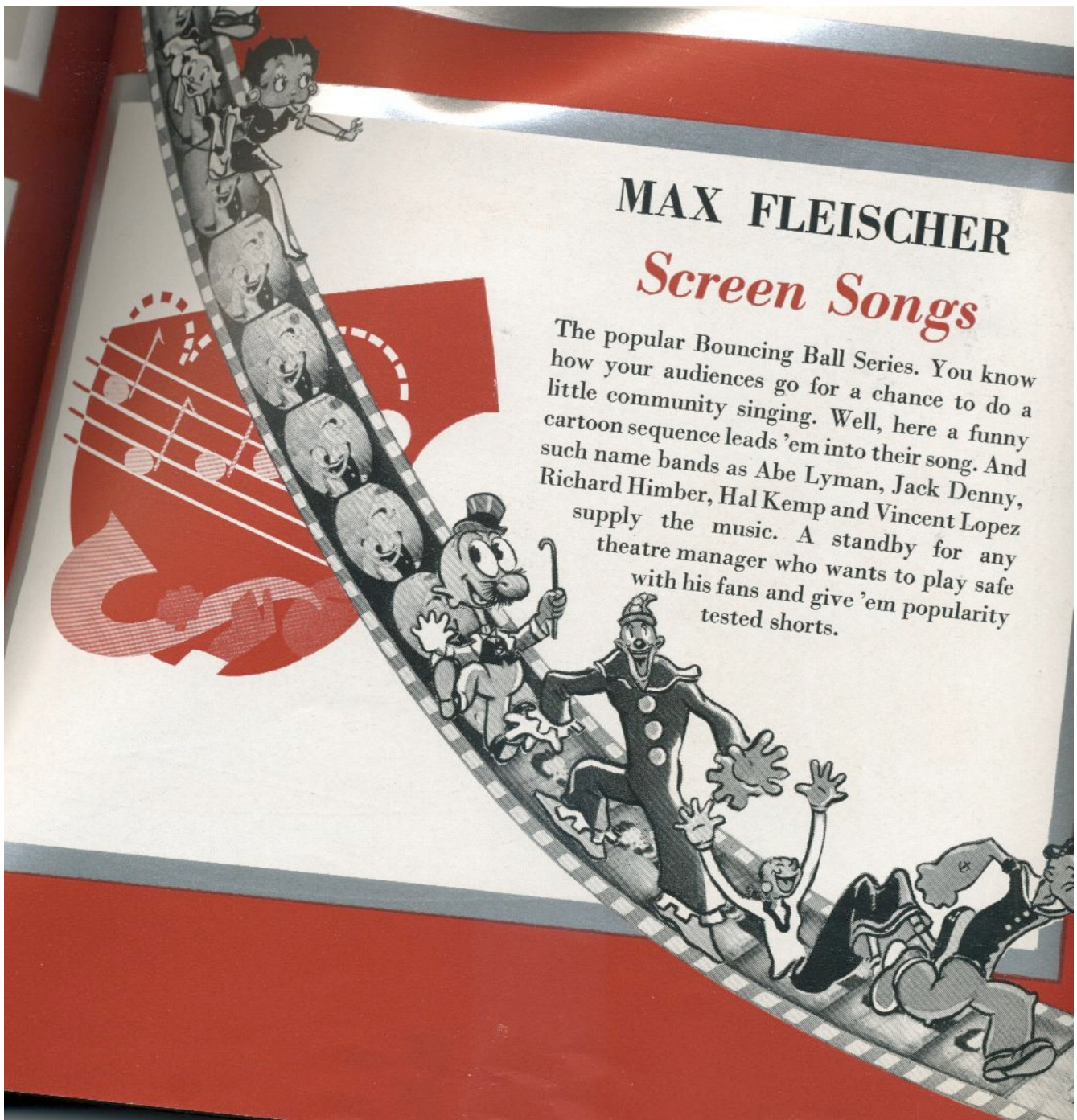
- Modern GPUs reach 100% performance in 2004. NVIDIA introduced the first dual-programmable GPU using a programmable GPU.
- Microsoft's Xbox 360, the first game console with unified memory and 1080p resolution.
- The PS2 was considered the first game console with 100% DirectX Shader operations and 1080p resolution.
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Timeline: 1950s, 1960s, 1970s, 1980, 1982-1984, 1985-1989, 1990-1994, 1995-1999, 2000, 2001, 2002-2003, 2004, 2005, 2006, 2007

Poster attributed to Jon Peddie Research (<http://jonpeddie.com>)

Music Videos

Another film-making effort (closely aligned with movies) that utilizes CG special effects is the creation of music videos. The intent of music videos has always been to promote a song or album, or as an artistic expression of a band or artist. They date back to the early commercial music era of the late 1920s and early 1930s. For example, Max Fleischer's patented *Screen Songs*, much like “Sing Along with Mitch” of the early 1960s, were produced as sing alongs for the audience, using the bouncing ball as a way to keep the viewer connected to the music.



Early 1930s cartoons, such as the Disney *Silly Symphonies* or *Fantasia*, featured musicians performing in live action or recorded shorts in conjunction with the cartoons. Warner Brothers often featured short musical numbers to promote their upcoming films.

Movie 14.2 Disney Silly Symphony Farmyard Symphony (1938)



<https://www.youtube.com/watch?v=ni4iZJ2NU-I>

Rock groups of the 1960s and 1970s used the genre to promote their music, often filming at live concerts or lip-synching in different environments. Some people point to the Beatles *Hard Days Night* as the real launching pad for music videos, but many acknowledge that it was Queen's *Bohemian Rhapsody* that really was the video that convinced the industry of the potential for this art form.

Movie 14.3 Queen – *Bohemian Rhapsody* – 1975



<https://www.youtube.com/watch?v=irp8CNj9qBI>

Michael Nesmith of the Monkees developed a TV show to feature music videos, called *PopClips*, in the late 1970s. It was tested on Warner's QUBE cable network in Columbus, Ohio. Nesmith later produced an award winning compilation called *Elephant Parts*, and a show that aired in 1985 called *Television Parts*. But the music video industry really didn't take off in a big way until 1981 with the first broadcast of MTV.



MTV Logo

Most of the music video productions during this early time used video effects, such as green screen, slit scan or other motion effects, as the special effects component of the pieces. Although there were some early music videos that used basic CG effects, the first real documented production was done by Alex Weil, Jeff Klein and Charles Levi of Charlex in 1983 for the video for the Cars song *You Might Think*.

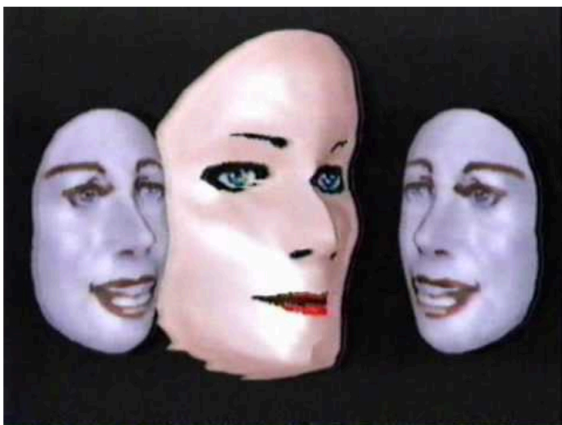
Movie 14.4 You Might Think



<https://www.youtube.com/watch?v=3dOx510kyOs>

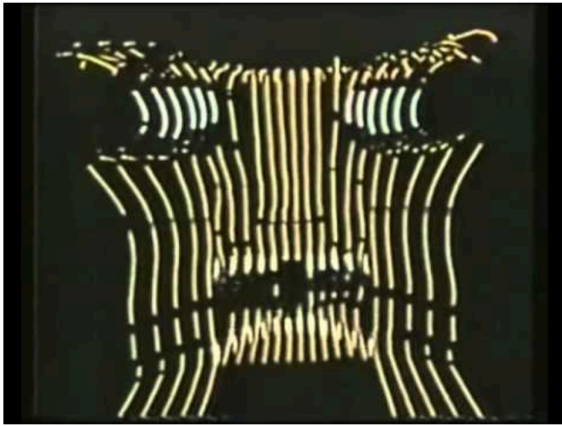
That same year Rebecca Allen at New York Institute of Technology produced talking faces (à la Fred Parke) for the Will Powers song *Adventures in Success* and CG bodies for *Smile*. (Will Powers was actually the stage name used by celebrity photographer Lynn Goldsmith when she created a self-help comedy music album entitled *Dancing for Mental Health*).

Movie 14.5 Adventures in Success



<https://www.youtube.com/watch?v=j5BLHeOdvYI>

Movie 14.6 Smile



<https://www.youtube.com/watch?v=g43lzoRamWE>

The next music video that featured CG generated characters was the video for Dire Straits' *Money For Nothing* in 1985. It has often been designated as the first music video that featured computer graphics, but that is obviously incorrect, although it was very instrumental in shaping the acceptance of the technology for use in the creation of this art-form. It was produced by Gavin Blair and Ian Pearson at Rushes Post Production using the Bosch FGS-4000 animation system and Quantel. Blair and Pearson later produced the popular *ReBoot* computer-animated series at their new company Mainframe Entertainment.

Movie 14.7 Money for Nothing



<https://www.youtube.com/watch?v=lAD6Obi7Cag>

Also in 1985, Digital Productions produced the graphics for *Hard Woman* from Mick Jagger's *She's the Boss* album (although the song on the video was not the same recording from the album, as it was re-recorded by Jagger and the Hooters for this made-for-MTV video.) The video can be seen via the link in Section 4 of Chapter 6.



Reboot

Many think that the 1986 video for Peter Gabriel's song *Sledgehammer* was CGI, but in fact was produced by Aardman Animation using stop motion and claymation, much like the other Aardman production *Wallace and Gromit*. Gabriel did use computer generated animation extensively in his video for *Steam* in 1992.

Movie 14.8 Steam



https://www.youtube.com/watch?v=Qt87bLX7m_o

In 1983 Rebecca Allen at NYIT also produced wireframe graphics in the widely acclaimed video for Kraftwerk's *Musique Non Stop* from the album *Electric Cafe*. Allen used the digitized faces of the band to generate the images on the proprietary NYIT animation system, but the animation wasn't used immediately. It sat for three years until the album was completed and Allen reworked the imagery. The video has enjoyed frequent airing on MTV and highlight shows, and also has been regarded as a true artistic statement, having been featured in exhibitions as well.

Movie 14.9 Musique Non Stop



http://www.dailymotion.com/video/x175jh_kraftwerk-music-non-stop_music

In 1991 Pacific Data Images produced a portion of the video for Michael Jackson's *Black or White*, using their

successful **morphing** technique to cleanly transition from one face to another. The concept had previously been used in videos for The Reels (*Shout and Deliver*)¹ in 1981, and Godley and Creme (*Cry*) in 1985, although the technique used in these two videos was actually analog video dissolves.

Movie 14.10 Black or White (excerpt)



<https://www.youtube.com/watch?v=R4kLKv5gtxc>

Movie 14.11 Cry

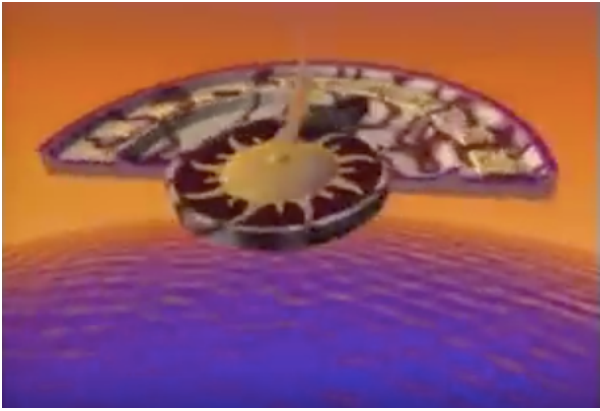


<https://www.youtube.com/watch?v=KxtPRF6NG7I>

Also in 1991 Todd Rundgren used the Amiga and the Newtek Video Toaster to produce graphics for the video for *Change Myself*. Rundgren produced the graphics in part to show the capabilities of the Toaster.

Movie 14.12 Change Myself

1. Keyboardist Karen Ansel of the Reels left the band and became an animator at ILM, where she worked on the effects for the movie *What Dreams May Come* and other well known movies.



<https://www.youtube.com/watch?v=7mH8PaWbi1E>

Rundgren talks about how he made the video in a speech at a LA SIGGRAPH 91 meeting at

<https://www.youtube.com/watch?v=Jhs24mL8Lx0>

Rundgren was active in early music video days, and his video for the song *Time Heals* was one of the first on MTV. He produced a piece for RCA, accompanied by Gustav Holst's *The Planets*, that was used as a demo for their videodisc players.

In the 1990s, Rundgren was a big proponent of the capabilities of the Toaster, and he made several videos with it after *Change Myself*. He also used the system for videos for *Fascist Christ* and *Property* from his album *No World Order*. Later, he set up a company to produce 3D animation using the Toaster, and produced the company's first demo, *Theology*.

Another influential production from Ian Pearson was the 1992 video for Def Leppard for their anthem *Let's Get Rocked* from their album *Adrenalize*. Pearson produced CG effects for a stage in the shape of the British flag, as well as a CG character named Flynn.

Movie 14.13 Def Leppard – Let's Get Rocked



https://www.youtube.com/watch?v=BO1Nae_EBvQ

The German band Rammstein used a combination of CGI and stop-motion to portray an army of ants, mobilized underground by the hero in the video, attacking some foraging beetles in their song *Links 2-3-4* (Left 2-3-4). The

video was created in 2001. The video clip referenced here is the “how it was made” video, and is in German with English subtitles.

Movie 14.14 Links 2-3-4



<https://www.youtube.com/watch?v=Ddizibd1Et4>

The video for Creed’s song *Bullets* is interesting because of its use of video game technology to create the imagery. It was created in 2002 by the team at Vision Scape Interactive. The band was digitized and the imagery created by the game developers included accurate representations of each member, down to their tattoos. An [article from MTV.com](#) described the goals:

“It was important that Mark [Tremonti] do battle with an axe because he’s a guitar player,” added Matt McDonald. “And then Scott Phillips is a drummer, so we gave him two swords. And the designs on the swords came from his tattoos. It was really important to the guys that we matched all their tattoos perfectly. The only thing we did different is we made them a little buffer than they are now.”

Movie 14.15 *Bullets* – excerpt



<https://www.youtube.com/watch?v=oPzhUp8mWgs>

There have been many more music videos that utilize computer graphics for the visual effects since these early contributions, including videos for Bjork, Coldplay, Shania Twain, Radiohead, Michael Jackson, Gorillaz and others. Wayne Lytle’s *Animusic* effort, founded in 1995, is an example of a company fully devoted to videos that

accompany music. In the case of Animusic, the videos are “compilations of computer-generated animations, based on MIDI events processed to simultaneously drive the music and on-screen action, leading to and corresponding to every sound.”

The skeleton from Robbie Williams *Rock D.J.* video is particularly noteworthy. The 2000 video showed Williams dancing in a roller rink, trying in vain to get the attention of the D.J. He takes extra steps, stripping off his clothes, then his skin, and finally his muscles so that what remains is a dancing skeleton, controlled with motion capture data. The video was banned in several countries because of the shock value, but won the MTV award for effects that year.

Movie 14.16 Rock D.J.



http://www.dailymotion.com/video/x2rmj_robbie-williams-rock-dj-uncensored_music

A list of the MTV Video Music Award for Best Special Effects ?can be found here.

Todd Rundgren had previously released a software paint package for the Apple II, called the Utopia Graphics System, and with David Levine, the screensaver *Flowfazer – Music for the Eyes*.

Note about some music video ?playback on mobile devices: Some of the music videos referenced in the previous section are not available for playback in their entirety on mobile devices. This could be due to licensing restrictions, advertising on the videos, or the encoding format. If problems arise, try watching on a desktop. Also, many movie and music videos will be deleted from YouTube or other providers if proper clearance hasn't been obtained.

14.3 Tron



The 1982 movie *Tron* was produced by Walt Disney Productions, with CGI by MAGI, Digital Effects, Robert Abel and Associates, and Information International Inc. (III)

The following text is from a 1982 press release:

“Walt Disney Productions has combined computer-generated imagery with special techniques in live-action photography that have marked a milestone in optical and light effects. *Tron* brings to life a world where energy lives and breathes, where laws of logic are defied, where an electronic civilization thrives. Starring in *Tron* are Jeff Bridges, David Warner, Bruce Boxleitner, Cindy Morgan and Barnard Hughes. Steven Lisberger makes his feature directorial debut on the film, which he scripted and developed with producer Donald Kushner.

Futuristic industrial designer Syd Mead, comic artist Jean “Moebius” Giraud – whose work is a prime inspiration for the magazine *Heavy Metal* – and high-tech commercial artist Peter Lloyd served as special visual consultants. Harrison Ellenshaw was associate producer. Special effects were supervised by Ellenshaw and Richard Taylor. Bruce Logan was director of photography.

Characters in *Tron* are set in landscapes that could not physically exist in the real world, a world where terrains and vehicles are created by computers. Although CGI was used sparingly in movies before (eg, *Westworld*, *Star Trek*, *Looker*) *Tron* was the first motion picture to make such extensive use of computer imagery.

Tron completed principal photography in July, 1981. Post-production continued through the spring of 1982 for a summer 1982 release by Buena Vista, in color by Technicolor. Filmed in Super Panavision 70.”

Tron is set in two worlds: the real world, where a vast computer system in a communications conglomerate is controlled by a single program; and the electronic world, whose electric-and-light beings want to overthrow the program which controls their lives. The electronic world was shot on sound stages at Walt Disney Studio in Burbank. Photography for the real world took place at locations around Los Angeles, and at the U.S. Government’s Lawrence Livermore Laboratory outside Oakland, California.



Steven Lisberger

Computer graphics were first applied to aerospace and scientific research in the mid-1960s, when methods of simulating objects digitally in their dimensions proved as effective as building models. The technology was then diverted into the entertainment field. Information International Inc. (Triple-I) and Robert Abel & Associates of Los Angeles, and the Mathematic Applications Group Inc. (MAGI) and Digital Effects of New York – four of the nation’s foremost computer graphics houses – produced the computer imagery for *Tron*.

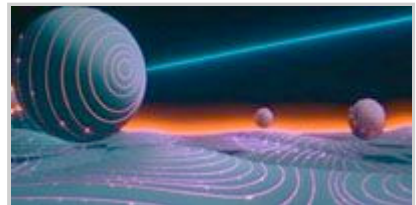
Computer-generated landscapes, buildings and vehicles provided settings for live-action characters in the film’s electronic world. MAGI, the single largest contributor of computer imagery, speeded the process of supplying its work to Disney Studios in Burbank by a trans-continental computer hook-up. Before each scene was finalized in MAGI’s lab in Elmsford, N.Y., it was previewed on a computer monitor at Disney. Corrections could then be made in the scene immediately. Previously, the only way of previewing the scene was to film it, ship it to Burbank, get corrections made, ship it back to Elmsford... and continue this ping-ponging until the scene was correct. The computer link cut between two-and-a-half to five days from the creation of each scene.



Vistas



Canyons



Balls

Tron was not a box office success, for several reasons. One big reason is that its release, originally scheduled for Spring of 1982, was delayed until summer. It therefore competed with several other major films, including *ET: The Extraterrestrial*, *Blade Runner*, *Fast Times at Ridgemont High*, *Poltergeist*, *Friday the 13th (Part 3)*, and *Star Trek II The Wrath of Khan* (and, of course, *Porky's*). Also, the 15 minutes of CGI and the over 50 minutes of backlit animation drove the cost of the movie to over \$20M.



Ellenshaw

Harrison Ellenshaw was associate producer and co-supervisor of special effects. After earning a degree in psychology from Whittier College in 1964, Ellenshaw turned to art and apprenticed in the matte department at Disney Studios. Within 10 years he was considered one of the top matte artists in the film business. Ellenshaw has painted mattes for *The Man who Fell to Earth*, *Star Wars*, *The Black Hole*, and was part of the team which won the optical effects Oscar for *The Empire Strikes Back*.

Richard Taylor, who headed the Entertainment Technology Group at Information International Inc., was co-supervising the special effects on *Tron*. He oversaw the design and programming of the film's computer animation. After stints in the Naval Academy, the Merchant Marines and as a Wyoming ranch hand, Taylor earned a graduate degree in art and film from the University of Utah in 1969. He then co-founded Rainbow Jam, a company which designed computerized light shows for rock concerts. In 1973 Taylor joined Robert Abel and Associates in Los Angeles, where he designed graphics for television commercials. In 1979 he moved to Information International. He was assisted at MAGI by Larry Elin, head of MAGI's computer graphics division, and by optical effects artist John Scheele.



Richard Taylor

The production of *Tron* marked the first time that computer-generated imagery (CGI) had been extensively used in a feature film. A full fifteen minutes of the film consists of moving images generated entirely by computer. Additionally, there are over two hundred scenes that utilize computer-generated backgrounds. Much of the remaining effects in the film were backlit optical effects. Because of the amount of the computer-generated imagery necessary for *Tron*, the filmmakers decided to divide the work among four different companies that specialized in computer graphics: Digital Effects, Robert Abel & Associates, Mathematical Applications Group Incorporated (MAGI), and Information International Incorporated (Triple-I).

In the paragraphs below, Computer Effects Supervisor Richard Taylor and Computer Image Choreographer Bill Kroyer discuss the challenges of using computer generated imagery for the film:

Taylor: “I think the most difficult thing in doing *Tron* was to marry the computer simulation moments with the live-action photography, and have them feel like they were all in the same place. The fact that we were shooting people in black and white costumes on sets that were black, and matting those people into computer simulated worlds, and that many of those backgrounds were computer simulated scenes putting people in them or computer simulated images into graphically created scenes and matting people into that; to have that all homogenize and feel like it is the same place so you don't say ‘that was done that way and this was done this way.’ And also that all the work done by MAGI, Triple-I, Abel all married and felt like one thing, so you wouldn't say, ‘Oh, that was done by MAGI, that was done by Triple-I,’ so that it just became a homogenized world where it all melted together. As a design problem and as a film-making problem, I think that was the most difficult thing to do. It was what I was most pleased with that it did work so well. I noticed very early on in my work with computer simulation that all the different companies who did it basically had their own technique for doing it. It's like they each had their own kind of hot rod, and their own kind of crew, and they were all hybrid systems. The most difficult thing was getting them to have the same vocabulary, same understanding, same description of three space motion, same description of a color.

After looking at it for a while, I realized that there were similarities that everybody understood. Basically, it's everybody's understanding of three space, of dimensional choreography, how surfaces are rendered, whether one company could make things shiny or smoother or more like chrome; that's basically when you get down to making a picture a matter of art direction.”

Kroyer: “When we started dealing with the computer companies on *Tron*, you have to remember that a lot

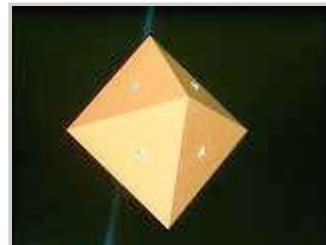
of the people developing software for computers are not really film-makers. They didn't begin their career as film-makers. So they won't approach the creation of visual imagery the same way that a film-maker will. We went in not knowing anything about computer technology. We only knew what we wanted to achieve on the film. With discussions with the development groups of each company, we were convinced that we could actually develop the technology as we went along and marry it with the creative needs, and end up with a film that would look good. As an example, we wanted a feeling of vast scale in *Tron*. We wanted that cycle arena to feel like it was miles wide. When a computer creates a picture, it will create everything crystal clear. So something that's a mile away will actually appear as clear and distinct and as well lit as something that's a foot away. That just doesn't look real. So we said that we need a feeling of atmosphere in these shots. We have to make it look as though things that are far away are far away. In real life you do that by softening the focus, and kind of dimming the colors.

We came up with something that is very simple and I think is standard technique now in computer graphics which is called depth glowing. You assign a mathematical progression to the light of the points, depending how far away they are from the camera source. The farther away they are the less distinct they are, and that makes them look farther away. It's something you automatically get in live-action photography. It's something you have to mathematically apply to a computer image. Again, it was this constant give and take with our visual requirements with their technical possibilities that created *Tron*. When we finished *Tron*, we had pushed the technology of these companies I think many, many years ahead of where they would have been if they hadn't worked with us during the feature."

Digital Effects, Incorporated, animated the Bit character and the creation of the *Tron* character in the opening title sequence.

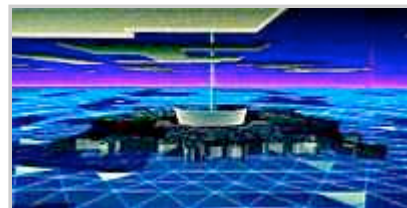
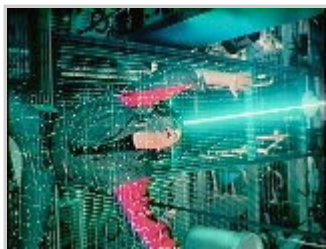


The Bit character from TRON – ?No state

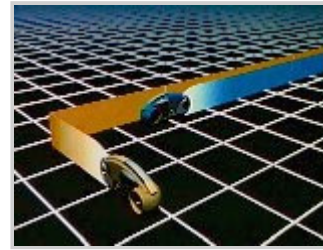


The Bit character from TRON – ?Yes state

Robert Abel & Associates provided the remaining animation for the opening sequence and for Flynn's transition into the Electronic World.



Because of their abilities to create complex motion and 3-D shaded graphics, the bulk of the computer animation was handled by MAGI and Triple-I. MAGI's computer imagery occurs mostly in the first half of *Tron* in the Game Grid area, where they created such vehicles as the Lightcycles, Recognizers and Tanks.



MAGI employed a unique process of computer simulation call SynthaVision. This process utilized basic geometric shapes that the computer recognized as solid objects with density. By varying the size and quantity of these shapes, MAGI could construct a limited variety of three-dimensional designs and animate them easily. The SynthaVision process was limited in its ability to create complex objects. It was, however, very easy to create fluid motion (choreography) for these objects. Based on its strengths in motion animation, MAGI was assigned the computer imagery for the first half of the film, which consists mostly of dynamic action sequences.

The following are transcribed interviews from excerpts of a TV special entitled “*Beyond Tron*,” which explores MAGI’s involvement in *Tron*.

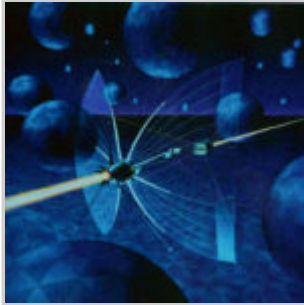
Dr. Phillip Mittelman, Founder of MAGI: “When MAGI was first started in 1966, we were working primarily with the government doing what’s called nuclear radiation transport. Worrying about, if you had a nuclear reactor, how much radiation would come out and what kind of radiation dose would people get. The way we did that was to describe three dimensional objects, and then follow around the nuclear radiation, follow it through its path through the material. One day we realized that if we followed light rays instead of nuclear radiation, we could simulate photography. We could simulate following the light rays from the sun to the object, from the object in through the camera lens to the film. If we could just calculate how much light hit each point on the film, we could make a photograph of things.”

General MAGI information From The Special: In 1967, the Mathematics Application Group, Incorporated turned their efforts to developing a program to create movies in the computer. They added color and other refinements to the software, and in 1972, MAGI SynthaVision introduced the process to the advertising world. The program has been refined over the years, but is still unique in the industry. Rather than use just polygons as the beginning point for the animation, MAGI SynthaVision uses combinations of other kinds of shapes to describe objects and to bring texture and contours to the surface. In 1975, a young animator from Boston was present at a screening conducted by Phillip Mittelman of the computer graphics his company had been creating for advertisers and other clients. The future writer/director of *Tron*, Steven Lisberger, was fascinated with the computer’s ability to conquer perspective and lend a 3D feeling to images.

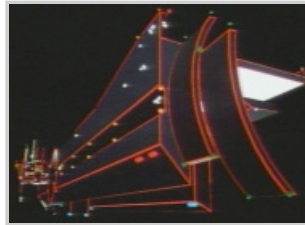
Steven Lisberger: “I think on that original reel from MAGI, the thing that stuck with me the most, that I couldn’t get out of my head for years, was the image of moving through a computer generated environment.

When a year or two after that, the video games started becoming popular, and I started talking to the computer people, it seemed that I now had the characters I could put into that computer environment.”

The computer imagery seen in the second half of the film, such as the MCP and the Solar Sailer, is the work of Triple-I.



Solar Sailer



Sark's Carrier



MCP



These images are among the most complex designs in the film. Unlike MAGI's SynthaVision process, most computer graphics companies today employ a method similar to that used by Triple-I. Using a schematic drawing or blueprint, Triple-I engineers recorded the visual images by tracing the lines of a drawing onto a digitizing tablet. This information was translated to the computer as an image whose surface is composed of a multitude of polygons (i.e., triangles). At a 1981 convention for computer graphics (SIGGRAPH), Triple-I presented a demonstration reel that illustrated the company's achievements in computer imagery. This reel was instrumental in convincing the Disney Studios' executives that computer animation could be successfully integrated into a motion picture.

Richard Taylor discusses the role that the Triple-I demo reel played in Disney's decision to make *Tron*:

“The conference saw a big 35mm representation of what really had a beginning, middle, and an end. It tried to really demonstrate to the world the potential of this medium. It had a great effect. It helped other people develop their things. It gave them an insight into what you could really do. And it had everything to do with why Disney believed that *Tron* could be done. Because it was a piece of film that they could see that worked overall and had a wide range of things that had been choreographed and created specifically.”

Tron began as the inspiration of Writer-Director Steven Lisberger. In the mid-seventies, Steven Lisberger was operating a studio in Boston that was producing animation for commercials and for the title sequences of television programs. At that time, he began exploring the possibilities of using computer-generated imagery for a story about characters that lived inside a video game. Using conventional animation, Lisberger produced this animated logo for his studio, which was licensed as advertising to several radio stations around the country. This was the first appearance of a character that he called *Tron*. As originally conceived, *Tron* was to be predominantly a traditional animated film. The story would begin with live action to portray the Real World. Later, the Electronic

World inside the computer would be represented by a combination of computer-generated imagery and hand-drawn, backlit animation.

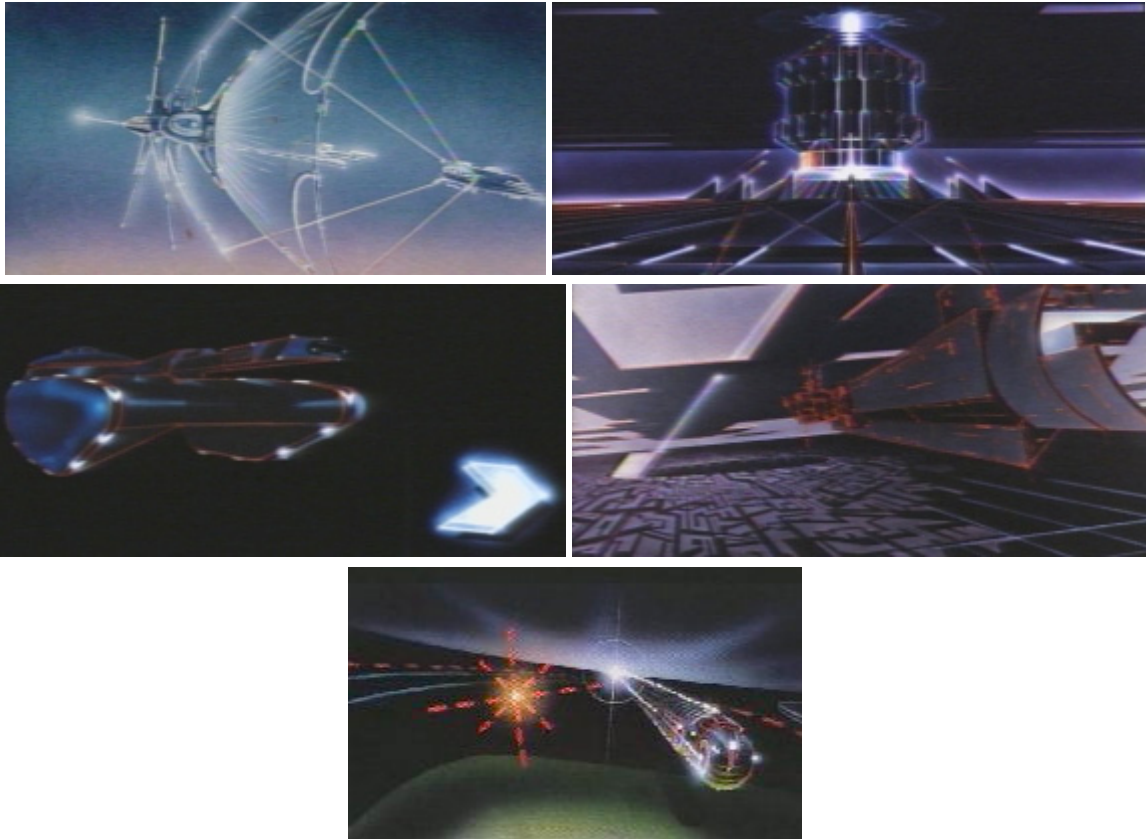
In 1977, Lisberger partnered with attorney and theatrical producer Donald Kushner to produce an animated spoof of the Olympic Games entitled “*Animalympics*.” Lisberger and Kushner moved their studio (along with eighteen artists) to Venice, California, in 1978. Their hope was to finance *Tron* independently with the revenues from this film. Unfortunately, the U.S. boycotted the 1980 summer Olympics, and “*Animalympics*” was not as lucrative as it otherwise might have been. Lisberger and Kushner were forced to seek studio backing for *Tron*. In June, 1980, they approached The Walt Disney Studios with a detailed proposal for the project. Their ideas were enthusiastically received, and pre-production began shortly thereafter. Steven Lisberger and Donald Kushner discuss the early stages of development and inspirations for *Tron*:

Lisberger: “When I wrote the script for *Tron*, it was my intention that the film would be done by computer generated imagery, because you could only tell the story with computer generated imagery. It wasn’t a question of a choice where one would say, ‘well, we can do it this way, we can do it that way.’ I was inspired by the film *Star Wars*, not just in a specific sense of effects. I was inspired by that film, I guess it came out in the late 70’s. I was inspired by that. I was inspired by *Jaws*. Just because it seemed up to that point in time that films were becoming very formula oriented. When those two films in particular came out, it seemed that they had so much energy and so much excitement, and that they were willing to try new techniques in ways that would aid their stories and cinematically make certain things possible. Those films definitely had some bearing on making me feel that a film like *Tron* would be possible or could get made.”

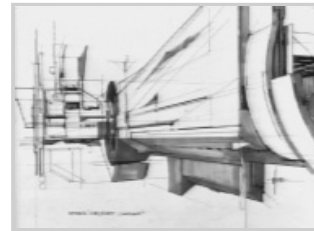
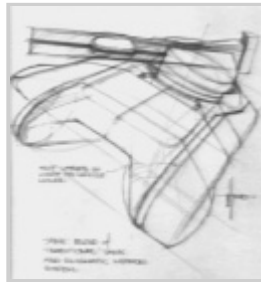
Kushner: “One of the difficult areas on *Tron* was to create a unified look for both the real world and the electronic world. Like in *The Wizard Of Oz*, there are two worlds. The difficult part was integrating both of the worlds. We used computer simulation, we used backlit techniques, and we used conventional live action. The difficult part was to make them all part of a cohesive look in this film. In that respect, I think we achieved our goal, of creating an overall unified look. When we started marketing the picture to studios, Disney was one of the last on the list. The reason is that since they were the vanguard of traditional animation, that they probably would not be interested in computer simulation. Or if they were interested in computer simulation, they would probably want to develop something in house. As it turned out, when we presented the project to them, they were very susceptible from the very beginning. So it turned out that it was very easy to persuade them since this was an area that they had been looking for and were exploring how to get involved in. We presented them with a project that was ready to go.”

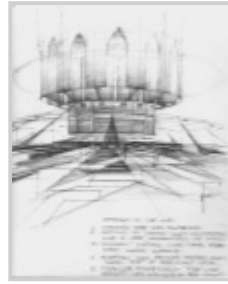
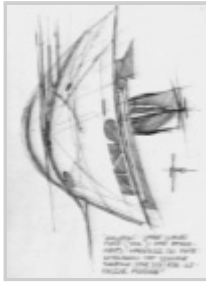
Soon after Disney committed to the project, conceptual artist Andy Probert (who later would go on to create designs for the television series “*Star Trek: The Next Generation*”) was brought on to create designs of vehicles, sets and costumes. However, none of his designs were used in the final film. In early 1981, Steven Lisberger assembled an illustrious team of artists to finalize the designs for *Tron*. This team included Jean “Moebius” Giraud, Syd Mead and Peter Lloyd. Moebius, a French comic book artist known for his work in the magazine “*Heavy Metal*,” contributed costume designs and storyboard art. The designs of the vehicles and computer environments fell to futuristic industrial and film designer Syd Mead. Commercial airbrush artist Peter Lloyd designed environments and backgrounds, in addition to serving as a color stylist.

Gallery 14.1 Peter Lloyd Designs

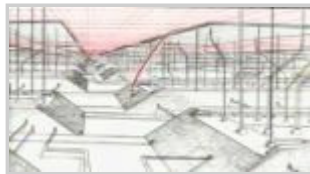
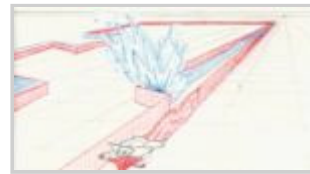
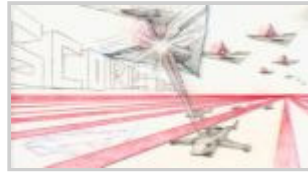


Gallery 14.2 Syd Mead Designs





Gallery 14.3 Moebius storyboard art



See also <http://www.tron-sector.com/>

Movie 14.17 Tron Trailer



Original trailer for the movie Tron from 1982.
<https://www.youtube.com/watch?v=3efV2wqEjEY>

14.4 Miscellaneous



The July 2002 issue of *Computer Graphics World* featured Part 7 of their retrospective series, devoted to coverage of CG in the movies, written by Barbara Robertson. A copy of this feature is included on their web site at

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/05/CGWRetrospective-Part7.pdf>

The first Academy of Motion Pictures Arts and Sciences award for science and engineering or technical achievement was given in 1984 to John Whitney Jr. and Gary Demos of Digital Productions. After a lull in these awards, they began recognizing the contributions of the CG industry again in 1991, and since then many of the individuals and companies that have contributed to the motion picture industry have received their just recognitions.



Gary Demos, right, winner of the Gordon E. Sawyer Award, an Oscar statuette, is pictured here with actress Rachel McAdams, host of the Academy of Motion Picture Arts and Sciences' Scientific and Technical Awards Ceremony on February 18, 2006, at The Beverly Hilton in Beverly Hills, CA.

Issac Kerlow has a timeline of animation and visual effects in his book *The Art of 3D Computer Animation Effects*. A digital capture can be found at [Google book's site](#)

AMC Filmsite has a listing of visual effects in the movies at

<http://www.filmsite.org/visualeffects.html>

A list of the Academy Awards for Best Visual Effects can be found at

https://en.wikipedia.org/wiki/Academy_Award_for_Best_Visual_Effects

Note: The reference for the table below is unknown at this time.

It's hard to believe that the first real use of what we now know as CGI in a feature film was in 1973, when we were treated to the computerized point of view of Yul Brynner's robot gunslinger as he ran amok in *Westworld*. But it would be another 20 years before Hollywood experienced a real revolution in special effects, when, in a nice coincidence, photorealistic dinosaurs rampaged through *Jurassic Park*, another Michael Crichton-inspired theme-park-gone-wrong movie. Here are some landmarks in the history of CGI in films.

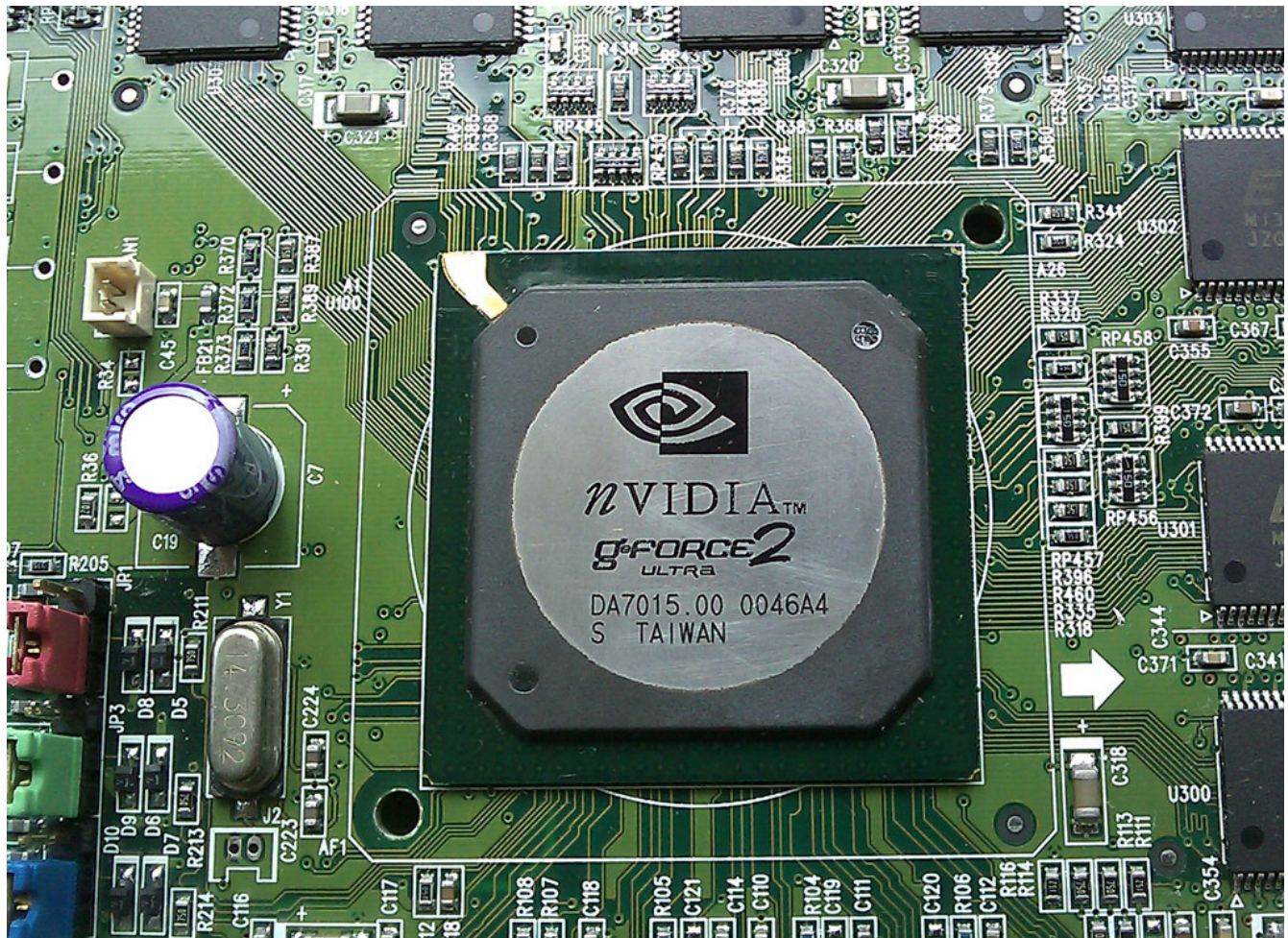
FIRST...	FILM
Use of 2-D computerized images	<i>Westworld</i> (1973)
Use of 3-D computer graphics	<i>Futureworld</i> (1976)
Use of animated 3-D wire-frame graphics	<i>Star Wars</i> (1977)
Use of shaded 3-D CGI	<i>Looker</i> (1981)
Film to feature extensive CGI (over 20 minutes)*	<i>Tron</i> (1982)
Use of 'integrated CGI' to represent real-world objects	<i>The Last Starfighter</i> (1984)
Disney animated film to contain CG objects	<i>The Black Cauldron</i> (1985)
Photorealistic CG character	<i>Young Sherlock Holmes</i> (1985)
Use of photorealistic morphing effects in a feature film	<i>Willow</i> (1988)
3-D CG water effect	<i>The Abyss</i> (1989)
CG character with realistic human movements	<i>Terminator 2: Judgement Day</i> (1991)
Photorealistic CG creatures	<i>Jurassic Park</i> (1993)
CG characters to interact realistically with live actors	<i>Casper</i> (1995)
Full-length CG animated film	<i>Toy Story</i> (1995)
Full-length CG film based on photorealistic and live-action principles	<i>Final Fantasy: The Spirits Within</i> (2001)*



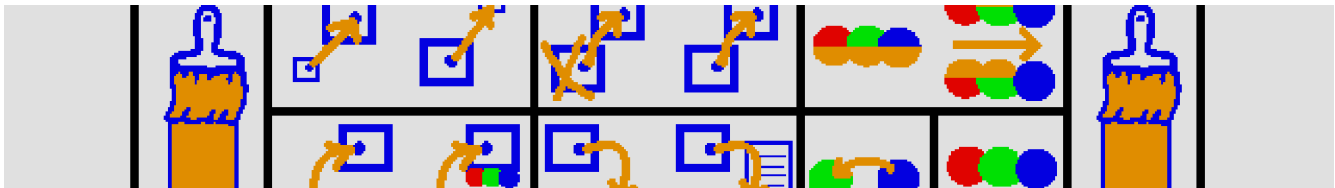
Chapter 15: Graphics Hardware Advancements

Graphics Hardware Advancements

As the computer workstation was developed, graphics algorithms were accelerated by embedding the logic in the display hardware, and the Graphics Processing Unit, or GPU, made real time graphics a possibility.



15.1 Early Hardware



For a little more than a decade in the beginning of computer graphics history, images were created and displayed as vectors – straight lines connecting points on the screen of a CRT. These displays were “refreshed” from a display list, which was a portion of memory that the display controller accessed to determine what to draw. A change in the image was accomplished by a change in the contents of the display list, which could be done fairly rapidly.

The “democratization of computer graphics”, as one author put it, was made possible by the introduction of raster graphics. This technology used a standard television CRT that utilized a video controller to scan the image from top to bottom, turning on or off the individual addressable points on the screen, and providing information as to the color of the points. The video controller obtained its information from a memory array whose contents represented in a one-to-one match the points on the screen. This memory was called a frame buffer, and was significantly larger than the display list memory of vector devices. Each point on a line in a raster system had to be stored, not just the endpoints of the line required by the vector displays. An early standard TV had approximately 250,000 addressable points (called pixels) on the screen, so the memory was rather large, particularly when color was included (which increased the size by a factor of three.)

As was mentioned earlier, core memory was the technology until the 1960s. There were some early implementations of a frame buffer comprised of core arrays, but they were bulky and expensive. The first breakthrough in affordable memory technology came with the introduction of integrated circuits. At this point, some experimental “shift-register” frame buffers were introduced. Each location on the screen was represented in the shift register as a bit. A refresh cycle for a scan line on the raster device was accomplished by shifting all the bits in the register and reading the one on the end, placing it at the beginning and shifting the bits again. The intensity of a screen element could only be changed when its bit came up at the end of the register. This resulted in a delay for screen updates.

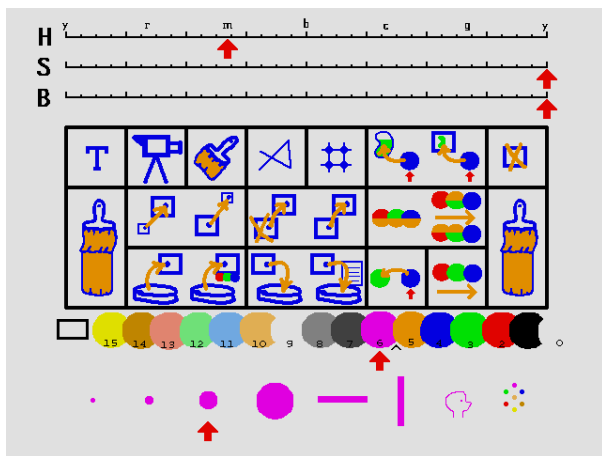
The real contribution came with the introduction of the **Random Access Memory** (RAM) chip a few years later. Instead of the sequential storage required in the shift register, the RAM allowed the computer or display processor to access any bit at any time – randomly. A 1K (1024) bit RAM chip was available in 1970, allowing for the

affordable construction of a frame buffer that could hold all of the screen data for a TV image, and it could be updated rapidly because of the access capabilities for each bit. In order to increase the complexity and realism of the image on the screen, even larger frame buffers allowed displays as large as 1024×1024. The depth (the number of bits used to represent the intensity and color of each pixel) increased from 1 to 8 to accommodate color, and then to 24 (8 bits for each RGB value) and upwards.

Because of the cost of the frame buffer at this time, a user who needed the image complexity of the 24 bit version had to look for other approaches. (24-bit color is sometimes referred to as “true” color. With 256 levels of red, green and blue a total palette of 16.7 million colors is possible.) One approach was to use an 8 bit frame buffer and the “look-up table”.

In an 8 bit buffer, 8 bits of data represented all the information for a pixel. A normal configuration would allow 3 bits each for the Red and Green color channels, and 2 for Blue. Thus Red and Green could achieve 8 levels each ($2 \times 2 \times 2$), and Blue had 4 levels (2×2). Hence one could represent a total palette of 256 colors, which is barely capable of representing realistic color. Better realism was achieved through the use of an “adaptive” palette of colors. In this case the image is analyzed and the best fit of 256 colors is directed to a look-up-table (LUT) where each color is associated with an 8-bit address in the table. So rather than representing the intensity/color directly with the 8-bit element of the frame buffer, the location of the intensity/color stored in the table was recorded as an 8-bit address in the frame buffer. To refresh the screen, the address was read from the frame buffer, the processor then pulled the intensity value from the table at that address, and refreshed the image accordingly.

Still, early frame buffer designs were constrained by the high bandwidth required to refresh the entire screen. Software and hardware modifications made this less of an issue, with implementations like the **Bit BLT** (block transfer of bits) operator that allowed larger portions of the image to be updated as a unit, and word organizations in which the buffer was organized into words that contained multiple pixels. Later, the frame buffers were enhanced with hardware; the z-buffer was introduced by Catmull in 1974, hardware implementations of which included RAM to represent not only the RGB colors for each pixel, but also the z depth from the 3D geometry to be used for update comparisons. Hardware, such as the enhanced frame buffer described by Whitted, was added to the memory to perform operations such as the z-comparison separate from the CPU.



Superpaint Menu Screen

The frame buffer was developed and expanded in both commercial and proprietary environments from the late 1960s through the early 1980s. Bell Labs developed a 3-bit system in 1969; Dick Shoup developed an 8 bit frame buffer at Xerox PARC for the *SuperPaint* system (Shoup later founded Aurora Systems); NYIT developed the first 24 bit RGB buffers; a flexible system was designed at North Carolina State University, and later modified at Ohio State; companies like Evans and Sutherland, Genisco and Raster Tech developed commercial versions; the NCSU buffer evolved into a commercial programmable display developed by Nick England called the *Ikonas* system, which later became the

Adage system. In 1984, Loren Carpenter introduced the **alpha channel** to the frame buffer, allowing images to be efficiently composited with **antialiasing**.

Most installations used the same workflow configuration during this time: a mainframe computer or minicomputer was accessed by multiple users, each with a terminal but sharing a frame buffer, which was connected to the computer with a Bus interface. The concept of the single user workstation, configured with its own internal frame buffer was still on the horizon.



“This is the very first picture captured in the SuperPaint frame buffer when it first came to life in April, 1973. The system took a standard video signal as input, digitized it to 8 bits, and could capture or combine it with other data. To take this picture, I pulled a clip lead off of the back panel using my knees. The card says ‘It works! (sort of)’. At this moment the interface to the Nova 800 CPU had not been debugged or even plugged in to the system yet. In order to preserve this picture, I had to plug the interface card in and get it working with the power on. Later, I was able to clean up some of the missing bits with a heuristic program and some fiddling.” ??(Dick Shoup, quoted in Alvy Ray Smith: RGBA, the birth of compositing & the founding of Pixar, by Mike Seymour at fxguide.com)

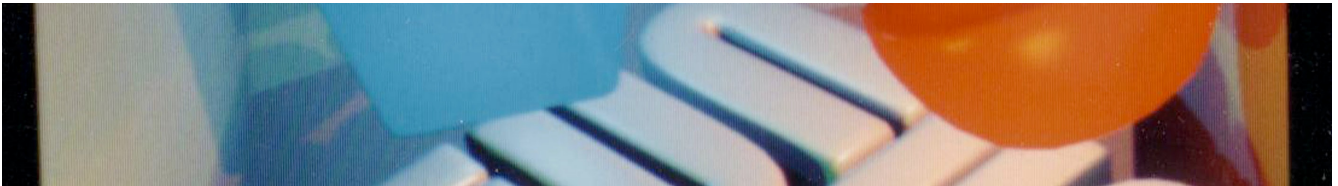
Catmull, Ed. *A Subdivision Algorithm for Computer Display of Curved Surfaces*, Ph.D. Thesis, Report UTEC-CSc-74-133, Computer Science Department, University of Utah, Salt Lake City, UT, 1974

Whitted, Turner, "Hardware Enhanced 3-D Raster Display System," Proceedings of the 7th Man-Computer Communications Conference, 1981.

Fuchs, Henry. Distributing A Visible Surface Algorithm Over Multiple Processors. Proceedings of the ACM National Conference 1977

For a discussion of paint systems and the development of hardware support, see Alvy Ray Smith's article [*Digital Paint Systems: An Anecdotal and Historical Overview*](#), from the April 2001 issue of the IEEE Annals of the History of Computing

15.2 Apollo / SGI / Sun

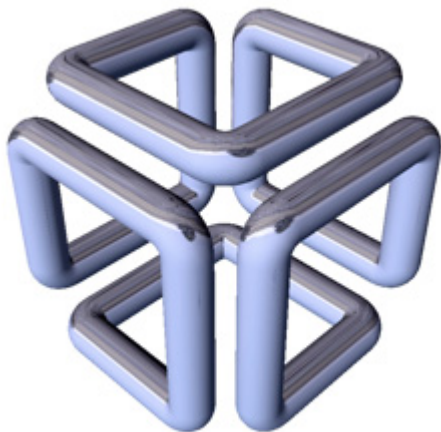


In the early 1980s some computer companies concentrated their efforts on the development of specialized workstations, the “**graphics workstation**”. Customers used graphics workstations for electronic and mechanical design because basic workstations were too slow and lacked sophisticated graphics.

Apollo

Several early graphics workstations were sold by Apollo and Sun. Early on the Sun 1, the Sun 2 and Sun 3 workstations came on the market. Apollo, one of the real workstation pioneers, started their workstation development in 1981 with the DN100 and later the DN550. Their workstations were widely used through the mid 80s, and Apollo, Sun, and HP each had about 20% of the workstation market when Apollo (after a short try at a joint project with Intel), produced the DN3000, the DN4000 and four-CPU DN10000 workstations (DN meant “DOMAIN Node”.) They introduced the PRISM CPU to the market. It was the first real two-instruction microprocessor and the fastest available workstation until the IBM RS/6000 series. Apollo was acquired by HP in 1989, and they merged their own Series 9000 workstation line with that of the Apollo systems.

SGI



3D representation of the SGI mark

One of the most important contributions in the area of display hardware is attributed to Jim Clark of Stanford in 1982. His idea, called the Geometry Engine, was to create a collection of

components in a **VLSI** processor that would accomplish the main operations that were required in the image synthesis pipeline: matrix transforms, clipping, and the scaling operations that provided the transformation to view space. Clark attempted to shop his design around to computer companies, and finding no takers, he and colleagues at Stanford started their own company, Silicon Graphics Inc.



© Apollo Computer

Silicon Graphics Inc. (later known simply as SGI) was one of the leading manufacturers of graphics computer systems, workstations, and supercomputers. Its history may be described as an exemplary Silicon Valley success story, until lower-priced competitors and inept production methods resulted in heavy losses in the late 1990s. Silicon Graphics capitalized on pioneering technology in 3-D computer graphics to create products used in a wide variety of professions, including engineering, chemistry, and film production.

In 1983 the company released its first products: the IRIS (Integrated Raster Imaging System) 1000 graphics terminal and an accompanying software interface known as the IRIS Graphics Library. It used the 8MHz M68000 processor with up to 2 MB memory, a custom 1024×1024 frame buffer, and the Geometry Engine gave the workstation its impressive image generation power. The next year Silicon Graphics released its first workstation, the IRIS 1400, and followed it in 1985 with the IRIS 2400, a workstation with a window manager. These early

entries in the IRIS series targeted the middle range of the graphics workstations market – those selling for \$45,000 to \$100,000 – and accounted for over 50 percent of all 3-D graphics workstations sold by 1988.

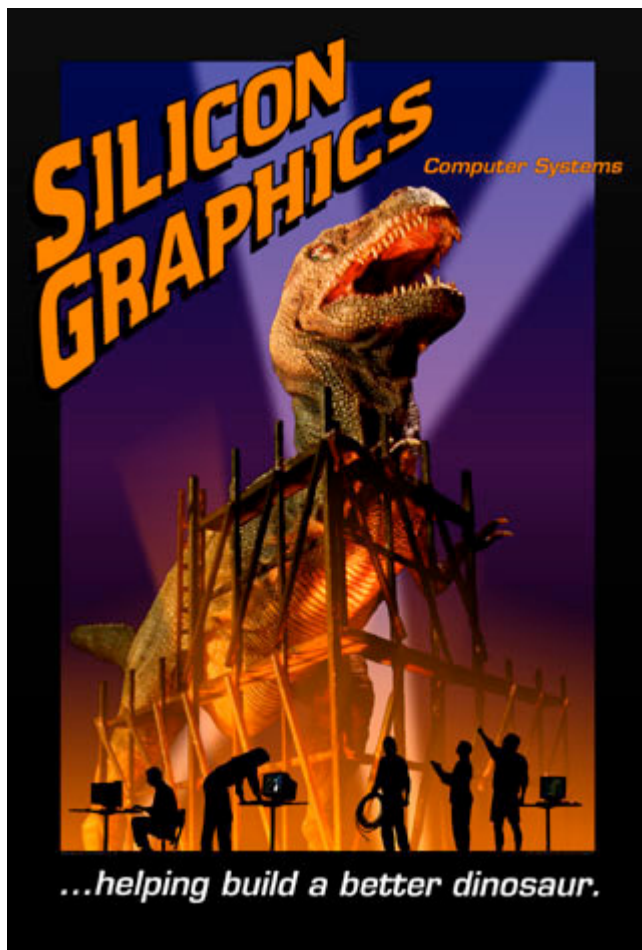
Silicon Graphics succeeded because it introduced a product that served cross-markets, from 3-D graphics simulations useful to mechanical engineers who wanted to assess their designs without having to build prototypes, to chemists who used 3-D modeling to study molecules. Such workstations as the IRIS series provided power at a relatively affordable price and major workstation manufacturers, including Hewlett-Packard, Apollo Computer, and Sun Microsystems, were slow to focus their energies on 3-D graphics, leaving Silicon Graphics without much direct competition.

In 1987 it became the first computer company to make use of MIPS Computer Systems' innovative reduced instruction-set chip, or **RISC**, when it incorporated RISC architecture into its new IRIS 4D/60 workstation. Within several years, most workstations would use RISCs. The company received a boost the next year when IBM agreed to buy Silicon Graphics' IRIS graphics card for use in its own RS/6000 graphics workstations and to take out a license for the IRIS Graphics Library, helping to make the IRIS Graphics Library the industry standard.

Also in 1988, Silicon Graphics introduced a new line of entry level graphics workstations, which it called Eclipse. The Eclipse was designed to bring 3-D graphics to people who had previously regarded IRIS workstations as unaffordable. Eclipse lacked the speed and processing power of more expensive machines, but initial versions sold for less than \$20,000 – as little as one-fifth of the cost of higher-end machines.

In 1991 the company released an even less expensive product line – the IRIS Indigo, a 3-D graphics workstation so compact that the company called it the first personal computer to use RISC architecture. The Indigo offered many features found on more expensive models, as well as digital audio and video processing capability, and the base model sold for less than \$10,000.

In 1991 the company granted a license to Microsoft for the IRIS Graphics Library. Microsoft intended to use the IRIS Graphics Library in its NT operating system for personal computers.



SGI Jurassic Park Poster

DreamWorks SKG – the entertainment entity formed by Steven Spielberg, Jeffrey Katzenberg, and David Geffen, and DreamWorks Digital Studio for the creation of animation, feature films, and other products. Silicon Graphics also acquired Alias Research and Wavefront Technologies for \$500 million in 1995, which positioned Silicon Graphics in the software business. Alias specialized in 3-D animation software that was widely used in the entertainment industry and in industrial design. It had developed new ways to simulate wind, fire, skin, and other special effects, and it also had an animation tool used by Nintendo in its video games. WaveFront Technologies developed industrial visualization software.

In April 1999 Silicon Graphics Inc. changed its name to SGI as part of a new worldwide corporate identity strategy that reflected the breadth and depth of the company’s products and services. The strategy included three sub-brands: SGI servers and workstations, Silicon Graphics visual workstations, and Cray supercomputers.

In 1993 Silicon Graphics and Industrial Light and Magic joined forces to create a high-tech entertainment special effects laboratory. The joint venture was called Joint Environment for Digital Imaging (JEDI) and grew out of the fact that Industrial Light and Magic had been using Silicon Graphics workstations since 1987. The cyborg featured in the film *Terminator 2*, the dinosaurs in *Jurassic Park*, special effects in *The Hunt for Red October* and *The Abyss*, and animation in *Beauty and the Beast* were all created on Silicon Graphics computers. For Industrial Light and Magic, the benefits were that digital manipulation of images cost about one-tenth as much as models and drawings, and, according to Lucas, would “change motion pictures from a photographic process to more of a painterly process,” enabling greater authorial control over a film’s appearance. For its part, Silicon Graphics hoped that alliance with an entertainment industry partner would help push the leading edge of its technological development forward.

In 1995 Silicon Graphics teamed up with



SGI “Impact” Poster

(Note: In 2005, SGI was delisted from the NYSE and filed Chapter 11 in 2006. They reemerged from bankruptcy later that year, but were delisted from NASDAQ in 2008. They again declared bankruptcy, and sold their assets to Rackable Systems in 2009 for \$42.5M. Their downfall was documented in an interesting series of web articles at <http://www.vizworld.com/tag/sgi-bts/>)

Sun

At about the same time in 1982, Sun Microcomputers was founded. They also introduced a workstation that had an embedded frame buffer. The CG1, CG2 and CG3 boards were the boards used in the Sun 1, Sun 2 and Sun 3 workstations. (The Apollo workstation also provided the single user-dedicated frame buffer technology.) Sun later used an add-on accelerator board made by *Trancept Systems* for the Sun 3 and Sun 4 workstations.

According to Nick England, one of the designers of the TAAC board:

In the Spring of 1987 we introduced the TAAC-1 product for Sun Microsystems workstations. The TAAC-1 consisted of two large PC boards, one full of video RAM, the other full of a micro-programmed wide-instruction-word (200 bits) processor optimized for graphics and imaging operations. The TAAC-1 was plugged into and memory mapped onto the Sun's VME bus.



Trancept Systems Poster

of Facebook in 2011.

Movie 15.1 SGI Iris 2400

The Trancept board was intended to be replaced by the VX/VMX boards in 1990. The VX included one Intel i860 processor with a VRAM frame buffer, and the MVX added a board with 4 more i860's (potentially up to 4 boards with 16 processors).

Both SGI and Sun were facing fierce competition in the 3-D graphics and imaging markets from Apple Computer Inc., which was introducing QuickDraw 3D, and Microsoft Corporation, which had recently acquired SoftImage and its line of simulation software. In addition Steve Jobs, founder of Apple and NeXT, had recently purchased animation producer Pixar and teamed with Walt Disney Studios on Toy Story, a full-length animation film created entirely with computers. In 2006 SGI filed for Chapter 11 bankruptcy, and although they emerged from the reorganization that same year, they filed again in 2009. The once powerful workstation company sold all of its assets to Rackable Systems for just over \$40M. Also in 2009, Sun and Oracle entered into an acquisition agreement, and in 2010 it was acquired by Oracle; their sprawling Menlo Park headquarters became the new home



<https://www.youtube.com/watch?v=9EEY87HAHzk>

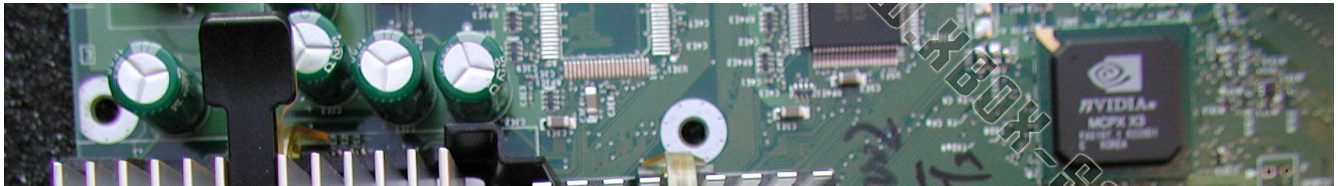
Clark, James H. *The Geometry Engine: A VLSI Geometry System for Graphics*. Computer Graphics (SIGGRAPH 82 Proceedings) 16(3) July 1982

Simons, John, “*Ghosts in the Machine: SGI Tries to Regain Its Former Luster—But Challenges Abound*,” U.S. News & World Report, November 11, 1996, p. 60 (referenced at <http://www.fundinguniverse.com/company-histories/sgi-history/>)

For a little Sun frame buffer and graphics processor history, ?click [here](#).

VizWorld.com published a blog series on the downfall of SGI titled [What Led to the Fall of SGI?](#)

15.3 Graphics Accelerators



Graphics accelerator boards that were developing at this time included hardware acceleration for many of the image synthesis operations, hardware pan and zoom, antialiasing, alpha channels for compositing, scan conversion, etc. The concept of adding a coprocessor to take the graphics operations away from the CPU was instrumental in bringing complex graphics images to the masses. The early frame buffers and the later accelerator boards associated with them are now embodied in the graphics cards in today's computers, such as those manufactured by NVIDIA, 3Dlabs and ATI.

HowStuffWorks.com has a reasonable explanation of the emerging role of these graphics coprocessors:

How Graphics Boards Help

Since the early days of personal computers, most graphics boards have been translators, taking the fully developed image created by the computer's CPU and translating it into the electrical impulses required to drive the computer's monitor. This approach works, but all of the processing for the image is done by the CPU — along with all the processing for the sound, player input (for games) and the interrupts for the system. Because of everything the computer must do to make modern 3-D games and multi-media presentations happen, it's easy for even the fastest modern processors to become overworked and unable to serve the various requirements of the software in real time. It's here that the graphics co-processor helps: it splits the work with the CPU so that the total multi-media experience can move at an acceptable speed.

As we've seen, the first step in building a 3-D digital image is creating a **wireframe** world of triangles and polygons. The wireframe world is then transformed from the three-dimensional mathematical world into a set of patterns that will display on a 2-D screen. The transformed image is then covered with surfaces, or rendered, lit from some number of sources, and finally translated into the patterns that display on a monitor's screen. The most common graphics co-processors in the current generation of graphics display boards, however, take the task of rendering away from the CPU after the wireframe has been created and transformed into a 2-D set of polygons. The graphics co-processor found in boards like the VooDoo3 and

TNT2 Ultra takes over from the CPU at this stage. This is an important step, but graphics processors on the cutting edge of technology are designed to relieve the CPU at even earlier points in the process.

One approach to taking more responsibility from the CPU was done by the GeForce 256 from NVIDIA (the first **graphics processing unit**, or GPU). In addition to the rendering done by earlier-generation boards, the GeForce 256 added transformation of the wireframe models from 3-D space to 2-D display space as well as the work needed to compute lighting. Since both transformations and rendering involve significant floating point mathematics (called “**floating point**” because the decimal point can move as needed to provide high precision), these tasks require a large processing burden by the CPU. Because the graphics processor doesn’t have to cope with many of the tasks expected of the CPU, it can be designed to do those mathematical tasks very quickly.

3dfx introduced their GPU, the Voodoo in 1996. The Voodoo5 took over another set of tasks from the CPU. 3dfx called the technology the T-buffer. This technology focused on improving the rendering process rather than adding additional tasks to the processor. The T-buffer was designed to improve anti-aliasing by rendering up to four copies of the same image, each slightly offset from the others, then combining them to slightly blur the edges of objects to minimize the “**jaggies**” that can plague computer-generated images. The same technique was used to generate motion-blur, blurred shadows and depth-of-field focus blurring. All of these produced smoother-looking, more realistic images that animators and graphic designers wanted. The object of the Voodoo5 design was to do full-screen anti-aliasing while still maintaining fast frame rates.

The technical definition of a GPU is “a single chip processor with integrated transform, lighting, triangle setup/clipping, and rendering engines that are capable of processing a minimum of 10 million polygons per second.” (NVIDIA)

The proliferation of highly complex graphics processors added a significant amount of work to the image making process. Programming to take advantage of the hardware required knowledge of the specific commands in each card. Standardization became paramount in the introduction of these technologies. One of the most important contributions in this area was the graphics API.

The Application Programming Interface (**API**) is an older computer science technology that facilitated exchanging messages or data between two or more different software applications. In other words, the API was the virtual interface between two interworking software functions, for example between a word processor and a spreadsheet. This technology was expanded from simple subroutine calls to include features that provided for interoperability and system modifiability in support of the requirement for data sharing between multiple applications.

The API is a set of rules for writing function or subroutine calls that access functions in a library. Programs that use these rules or functions in their API calls can communicate with any others that use the API, regardless of the others’ specifics. In the case of graphics APIs, they essentially provided access to the rendering hardware embedded in the graphics card. Early APIs included X, Phigs, Phigs+ and GL. In 1992, SGI introduced OpenGL, which became the most widely used API in the industry. Other approaches were Direct3D and vendor specific approaches, like Quartz for the Macintosh and the Windows API.

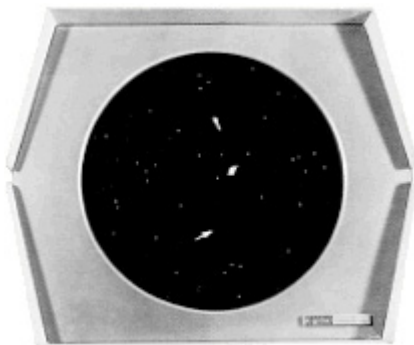
Movie 15.2 Dawn



<https://www.youtube.com/watch?v=4D2meIv08rQ>

Demo was released in 2002 to showcase the release of the NVIDIA GeForce FX series of graphics acceleration cards.

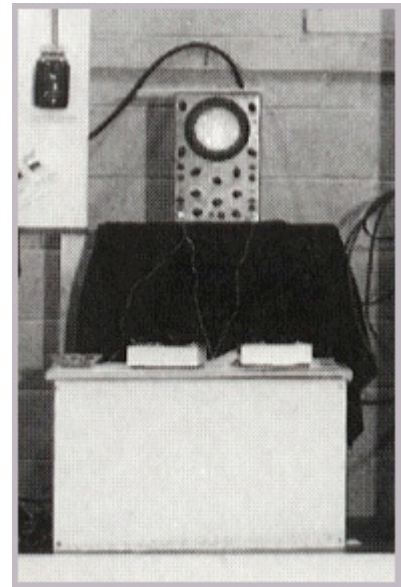
15.4 Influence of Games



Spacewar! Display

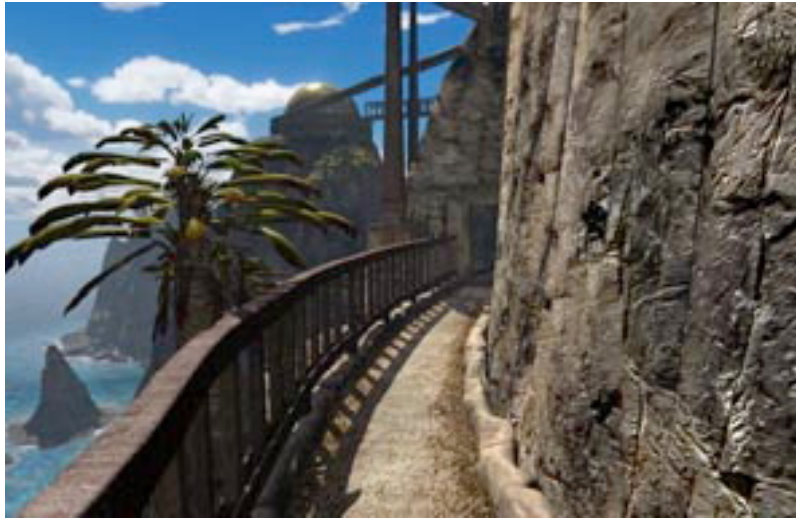
like the Xbox.

Certainly some of the big push toward better and faster graphics image generation came from the video and arcade game industry¹ Graphics moved from the primitive images of Higenbotham's 1958 oscilloscope-based *Tennis for Two* and Steve Russell's 1961 *Spacewar* on the PDP-1, to the more realistic environments found in later popular games like *Myst* and *Riven*, EA sports games, and games for systems



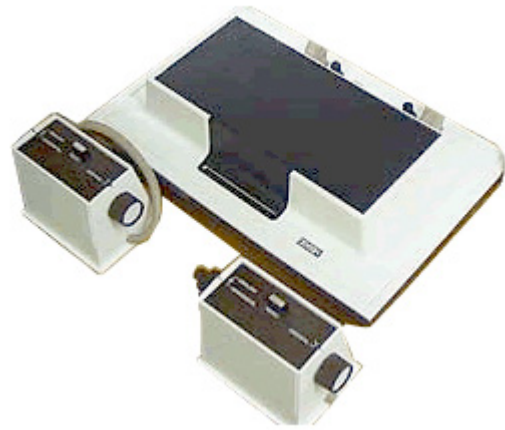
Tennis for Two

1. This section is not intended to be an in-depth treatment of the gaming history, but rather to give some flavor of innovations which influenced the evolving graphics industry. More detailed games history can be found in the link at the end of the section.



Screenshot from Cyan's Riven

The first commercial home video game was the Magnavox Odyssey, designed in 1968 and released in 1972. The game was *Table Tennis*, which was created by Ralph Baer, who worked for the defense-electronics company Sanders Associates. It was licensed to Magnavox and for a time was Sanders' most profitable line, even though many in the company looked down on game development. The Odyssey used discrete logic, a type of removable circuit card that inserted into a slot similar to a cartridge slot. The system also came with plastic overlays that gamers could put on their TV screen to simulate the playing of different "games," but only two TV sizes were supported. It also came with plastic game tokens and score sheets to help keep score, much like more traditional board games.



Odyssey Console



Nolan Bushnell

The next technology to hit the market was dedicated (nonprogrammable) video game consoles, which were often inaccurately called “analog” but actually used discrete logic. Examples of this kind of console was the Atari *Pong* game, sold by Nolan Bushnell’s Atari company (Note: Bushnell was a University of Utah graduate). The Atari unit also connected to a separate television set.

Following the success of *Pong*, Atari in 1977 introduced the 2600 VCS, which is considered one of the first generation of “8-bit” programmable systems. It was the home unit modeled after the very popular arcade game *Pac Man*. Other similar systems were the Odyssey2 (1978) (known in Europe as the Philips G7000), the Channel F (1976) and the Astrocade (1977). The 2600 used the MOS Technologies 6507 CPU with 128 bytes of RAM and a TIA video processor. Memory was so expensive that there was simply no way to have a frame buffer included with sufficient resolution.

Instead Atari allocated enough memory for only one line of the display at a time. When the TV completed drawing a line, the next line was transferred to the TIA (television interface adapter) while the TV was resetting for the next line. (This became known to 2600 programmers as “*racin*g the beam“.)

The 2600 proved to be one of the most complex machines in the world to program. Nevertheless it was that same complexity that actually made the system incredibly flexible, and when authors discovered the “tricks” the games soon started to gain in power far beyond what the original designers had ever imagined.

Work proceeded on more sophisticated systems, which can be categorized as the second “8-bit” generation. Games in this category included Intellivision (1980), Colecovision (1982), Philips G7400 (1983) (This was to be released in the USA as the Odyssey3; changing market conditions prevented its release), Arcadia 2001 (1982), Vectrex (1982) and the Atari 5200 (1982). The Intellivision used a General Instruments CP1610 16-bit CPU and 371 bytes of RAM, and 16 colors was available with 160 pixels wide by 196 pixels high (5×4 TV pixels make one Intellivision pixel). The Colecovision graphics was supplied by a Texas Instruments TMS9928A, 256×192 resolution, 32 *sprites*, and 16 colors. It used the Z80A CPU.

This generation was followed by a collapse in the video game market in North America (1984).



Famicom Console with attached disk system

color), with 256×240 pixels. *Donkey Kong* was one of the first games used on this system. The Sega used an 8-bit 3.6 MHz Zilog Z80 CPU and a Texas Instruments TMS9918 derived VDP (Video Display Processor).

The fourth generation machines really started the rebirth of the industry. The most significant early entry in 1989 was the 16 bit Sega Genesis. The Genesis initially competed against the 8-bit Nintendo Entertainment System, but although it had superior graphics and sound, had a hard time overcoming Nintendo's ubiquitous presence in the consumer's home. The Genesis used the 16-Bit Motorola M68000 processor running at 7.61Mhz and a VPD (Video Display Processor) dedicated for playfield and sprite control, giving 512 colors, 80 sprites and 320 x 224 resolution. Other fourth generation machines were the Super Nintendo Entertainment System and the Philips CD-i .



Sega Genesis console and controller

Fifth generation games included the Apple Pippin (1996) (which was never marketed), Atari Jaguar (1993) (marketed as "64-bit"), Playdia (1994), 3DO (1993), the Sega Saturn (1994-1998), and the cream of the crop, the Sony PlayStation (1994) and the Nintendo 64 (1996-2002) (also marketed as "64-bit").



Nintendo 64 console and controller

The N64 specifications included a 93.75 MHz MIPS 64-bit RISC CPU (customized R4000 series) with a RCP (Reality Control Processor) which mapped hardware registers to memory addresses and an RDP (pixel drawing processor) with Z-buffer, anti-aliasing, and realistic texture mapping (tri-linear filtered MIP-map interpolation, perspective correction, and environment mapping). In comparison, the Playstation CPU was the R3000A 32bit RISC chip running at 33.8688MHz manufactured by LSI Logic Corp with technology licensed from SGI. It also contained in the same chip the Geometry Transfer Engine and the Data Decompression Engine. It could render 1.5 million flat-shaded polygons per second, 500,000 texture mapped and light-sourced polygons per second with 16.7 million colors, Gouraud shading, and texture mapping.

The Playstation console angered Nintendo who subsequently filed a lawsuit claiming breach of contract. They attempted to, in federal court, obtain an injunction against the release of the PlayStation but the federal Judge presiding over the case denied the injunction.



Nintendo Gamecube

The next models were the Sixth generation systems (starting around 1999.) They include the Sega Dreamcast, Sony PlayStation 2, Nuon, Microsoft Xbox and Nintendo GameCube. These systems had more of a PC-like architecture, as well as DVDs for game media.

The Seventh generation systems were introduced beginning in 2005. The Blu-ray Disc was used by the PlayStation 3, and HD DVD by the Xbox 360 (at least until the format went away.) The Nintendo Wii used motion as input, and IR tracking. All seventh generation consoles used wireless controllers. This generation also introduced the Nintendo DS, and the Nintendo DSi, which added touch screens and cameras.

The Nintendo Wii U is considered the first of the eighth generation consoles. The portable consoles include the Nintendo 3DS, and Sony's PlayStation Vita.

For more information on these video games, with listings of the titles associated with each, go to https://en.wikipedia.org/wiki/History_of_video_games

For a detailed history of video and computer games, go to <http://www.emuunlim.com/doteaters/>

Movie 15.3 Spacewar!



Designed on a PDP-1 at MIT by Steve Russell, this is the first fully interactive video game.

<https://www.youtube.com/watch?v=RmVb4Hktv7U>

Movie 15.4 Interview with Nolan Bushnell



Interview with Nolan Bushnell, founder of Atari, from the documentary Silicon Valley: A 100 Year Renaissance https://www.youtube.com/watch?v=WW_rCV254yg

Movie 15.5 Interview with Ralph Baer



Interview with the inventor of the Magnavox Odyssey, inventor Ralph Baer

<https://vimeo.com/37870722>

In 1975 Ralph Baer and Magnavox, creators of the first home console system – the Magnavox Odyssey – sued Atari (and many other companies, including Bally Midway, Allied Leisure and Chicago Dynamics) for their clones of the Magnavox Odyssey’s ‘Table Tennis’ game. The Atari game in question was ‘Pong.’

Due to the patents held by Baer and Magnavox parent company Sanders Associates, and coupled with the fact that there was ample evidence of Atari founder Nolan Bushnell having played ‘Tennis’ at a product exhibition (he actually signed a guest book indicating that he had played the game on the day in question), Atari decided to settle the case outside of the courts, for about \$700,000. Other companies were also forced to pay royalties for similar ‘Pong’ clones.

As part of the June 1976 settlement, Magnavox would obtain rights to any Atari products released for the next year. Atari therefore decided not to release any new titles for the next year. This was the first strike from Magnavox, Sanders and Baer in what was to become a lucrative business of defending their intellectual property and receiving license fees.

In 1985 Nintendo was fast becoming a video game titan themselves, leading the invasion of the third generation of consoles, but even they could not stand up to the watertight patent laws, and after attempting to invalidate Baer’s patents, they were forced to continue paying royalties to Sanders.

The following website is *The History of Video Game Lawsuits*:

<http://mygaming.co.za/news/>

Nintendo was known in the 1980s for its draconian licensing conditions and rabid prosecution of all “unlicensed” game producers. One of the sore points among developers of the period was the fee that they had to pay to Nintendo to get their games licensed, which meant that Nintendo tested them and produced them at its own facilities (either part of the fee or for an additional cost). Another sore point was that Nintendo actually decided how many cartridges of each game it would manufacture. The company’s virtual monopoly in the console market at the time allowed it to basically impose any rules that it chose, and the rules were always meant to increase profit, quality, or both. Several companies began producing games, refusing to pay the licensing fee (or being refused by Nintendo), and all were eventually forced out of business or out of production by legal fees and court costs for extended lawsuits brought by the giant

against the transgressors. The one exception was Color Dreams whose religious themed games under the subsidiary name Wisdom Tree prevented Nintendo from suing due to a fear of public backlash.

Companies that made unlicensed games include (Nintendo did not sue every one of these companies):

- Active Enterprises – only two games
- American Game Cartridges – several games
- American Video Entertainment – several small companies rolled into one
- Camerica
- Color Dreams
- S.E.I. – one game: Impossible Mission 2
- Tengen – most popular of unlicensed companies; many games
- Wisdom Tree – was not sued due to religious themes in games

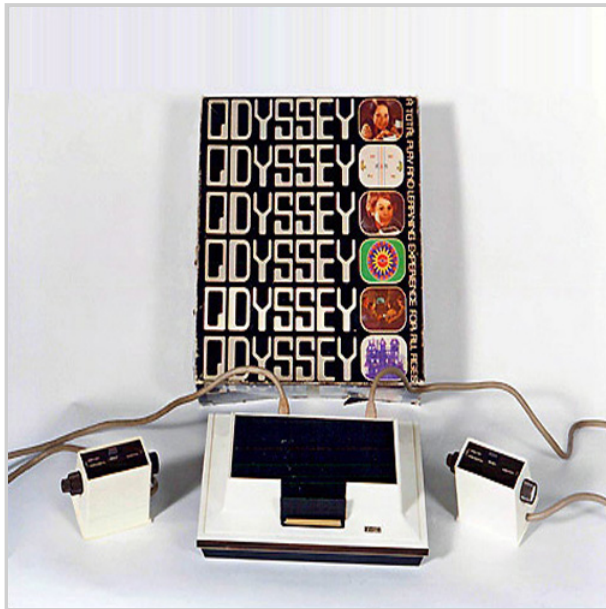
Gallery 15.1 Magnavox Odyssey



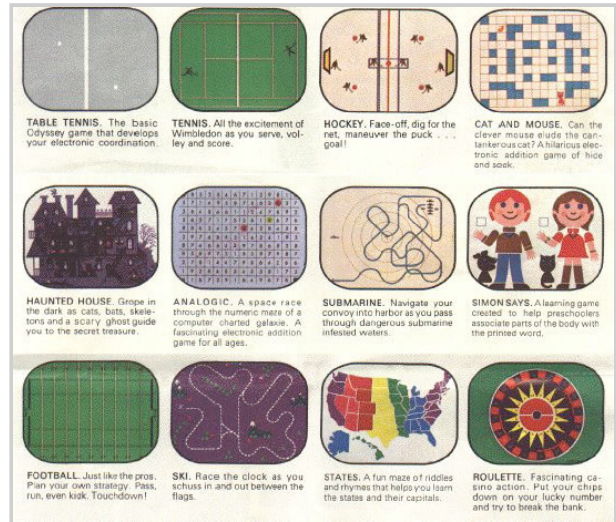
The Odyssey console and two plug-in controllers



The system had three moving components, two players and a ball, and used transparent overlays that taped to the screen for different game configurations.



Game system and packaging.



Twelve games shipped with the original Odyssey game box in 1972.



The Odyssey system shipped with plastic overlays that were attached to the TV screen to “create” different games for the user.



The Odyssey was a multi-player game.



Ralph Baer was the inventor of the Odyssey



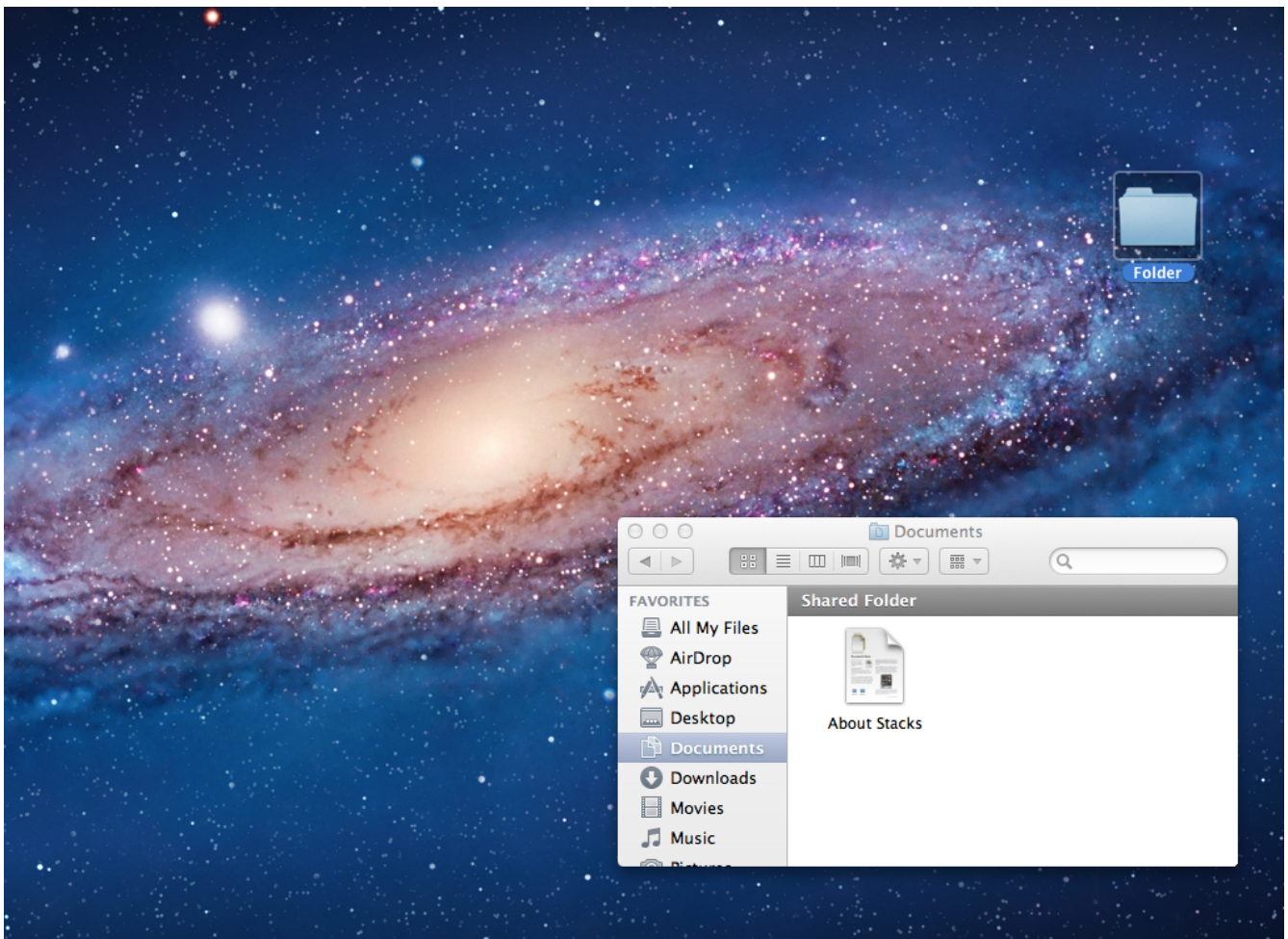
Ralph Baer, foreground, with the Table Tennis game on the screen

Chapter 16: The GUI and the personal computer

The GUI and the personal computer

As far as the customer is concerned, the interface is the product. An interface is humane if it is responsive to human needs and considerate of human frailties.

Jef Raskin



16.1 Xerox PARC



In 1975 the researchers at Xerox PARC (Palo Alto Research Center) moved into their permanent headquarters at 3333 Coyote Hill Road near Stanford University in Palo Alto, California. Jacob Goldman had founded PARC just five years previous, and already at this early date the research team had developed many of the ideas that shaped the future of computing.¹

The Palo Alto Research Center's mission as directed by Xerox management was to create the office of the future. To that end they created many of the technologies we take for granted in the modern office, such as networked personal computers, with email, word processing, and laser printing, but the most significant innovation at PARC was the **graphical user interface** (GUI), the desktop metaphor that is so prevalent in modern personal computing today.

The GUI would make computer graphics an everyday part of the working environment. No longer would the display be simply lines of code and commands, it would be graphical with a true representation of typefaces and images. The bitmapped GUI display would help promote the concept of WYSIWYG (what you see is what you get) allowing people to laser print exactly what they saw on the screen.

1. Thanks to graduate students John Buck and Jon Gladden for their contributions to this chapter.

In workstations of the past, graphics and commands were split between three different screens, a vector device for line graphics, a text display for entering commands, and a video / raster graphics screen coupled with a frame buffer to display the final rendered result. Xerox PARC combined these separate technologies into one raster graphics screen along with an easier way of issuing commands: the pop up menus, icons, and desktop metaphor of the graphical user interface. While mainline computer engineers scoffed at the idea of one computer for each person, the Xerox team built the Alto personal computer. Traditional computer applications centered on number and data manipulation; the Xerox team focused on words, design and communications.



Alto computer



Alan Kay

The researcher roster at PARC reads like a who's who of the CGI world. As with many other areas of computer graphics, researchers from the University of Utah would play a key role in the development of the GUI and other products developed at PARC. The idea for GUI was actually first developed by [Alan Kay](#) from the University of Utah who went to work at PARC on the Alto project in 1970. Kay and Ed Cheadle built a computer called FLEX at the University of Utah between 1967 and 1969 that included the rudimentary elements of a GUI, including multiple tiled windows and square icons representing data and programs.

The first GUIs tried at Xerox PARC were very difficult to work with and depended too much on the processor to re-draw each bit when moving overlapping windows around. In 1974 a PARC researcher named [Dan Ingalls](#), who was one of the principle architects of the [Smalltalk](#) object oriented language, invented a procedure for the movement of whole blocks of bits on the screen called "Bit Blit", or [BitBLT](#). This display algorithm allowed overlapping windows to be quickly shuffled around the screen without overtaxing the processor.



Xerox Star Computer

The Xerox Star was the first commercial personal computer to use the now common desktop metaphor. David Smith, developer of the Star interface, said in a 1982 article:

“Every user’s initial view of the Star is the Desktop, which resembles the top of an office desk, together with surrounding furniture and equipment. It represents a working environment, where projects and accessible resources reside. On the screen are displayed pictures of familiar office objects, such as documents, folders, file drawers, in-baskets, and out-baskets. These objects are displayed as small pictures, or icons.”

PARC was initially divided into three units: the Computer Science Lab (CSL), the Systems Science Lab (SSL), and the General Science Lab (GSL). The CSL, run by Bob Taylor, was most responsible for the development of the graphical user interface. Taylor had worked on the ARPAnet, (a distributed network of computers, the predecessor to the Internet) and brought the idea of networked computers to PARC.

By 1979 there were hundreds of Altos networked together with more traffic and ‘nodes’ than the entire ARPAnet. Xerox PARC even had the world’s first computer virus called a ‘tapeworm’ because it would eat it’s way through the Ethernet and consume all available resources. Like many of PARC’s innovations networking was ahead of it’s time, and would not be widely available in personal computers for another decade.

that invented the first version of the personal computing future found itself struggling to recapture the advantages of its copier past.



Computer Magazine Cover (Sept. 1989)

bibliography box below)

John Warnock (University of Utah) helped develop Interpress and other printing and page description systems at PARC which allowed the Alto to become the first WYSIWYG computer when coupled with Xerox's laser printer. Later Warnock founded Adobe Systems which along with Apple computer helped bring about the desktop publishing revolution of the late 1980s. The combination of the Macintosh, the LaserWriter, and Adobe's page description software would forever change the world of publishing, typesetting, and graphic design.

Larry Tesler at PARC, who would later be part of the Apple LISA development team, began work on Gypsy, the world's first user friendly word processing application using pop-up menus and icons in 1974. Gypsy was later to become the basis for Microsoft Word when it's co-creator Tim Mott and others at PARC went to work at Microsoft. Gypsy was essentially the world's first desktop publishing software with advanced features such as drawing and editing graphics within the same application as the word processor. These features began to emerge in software packages such as Adobe InDesign and QuarkXpress.

It is widely believed that the Xerox corporate management never realized what they had at PARC — it seems that they never shared the same vision as the researchers. The innovations developed there were never marketed successfully under the Xerox name. It took outside companies to market PARC innovations in GUI and **WYSIWYG** to make them the standards they are today.

Alto had the ability to show other computers on the network as icons on it's graphical desktop. Much later Macintosh acquired this ability. With the birth of the Internet and the World Wide Web, computers could network to others across the world, but this was done with a separate application that was at first nongraphical (telnet, text-based FTP software). Later applications for accessing the internet became more GUI-like but were not part of the operating system (TurboGopher, Fetch, Anarchie). With the introduction of the first graphical web browser, Mosaic, in 1993 accessing the internet began to look more like an environment one would see with a GUI.

With the release of Windows 95 and NT, Microsoft attempted to blur the distinction of the web browser application and operating system by bundling Windows 95 with Internet Explorer. The windows and interface of Windows 95 could be set so that browsing the local computer looked almost the same as browsing the Internet. Microsoft got into legal trouble because the bundling strategy was seen as an attempt to block competition from Netscape and other browsers. (See Landgrave article listed in

“Office automation has emerged as a full-blown systems approach that will revolutionize how offices work.”? (Business Week, June 1975)

“The basic purpose of Xerox Corporation is to find the best means to bring greater order and discipline to information. Thus, our fundamental thrust, our common denominator, has evolved towards establishing leadership in what we call ‘the architecture of information’. What we seek is to think of information itself as a natural and undeveloped environment which can be enclosed and made more habitable for the people who live and work within it.”? (C. Peter McCulough, CEO Xerox Corporation)

“None of the main body of the company was prepared to accept the answers. So there was a tremendous mismatch between the management and what the researchers were doing and these guys had never fantasized about what the future of the office was going to be. When it was presented to them they had no mechanisms for turning those ideas into real live products and that was really the frustrating part of it. You were talking to people who didn’t understand the vision and yet the vision was getting created everyday within the Palo Alto Research Centre and there was no one to receive that vision.”? (John Wamock)

“People came there specifically to work on five year programs that were their dreams.”?(Adele Goldberg, Former Xerox PARC Researcher??)

“Everybody wanted to make a real difference, we really thought that we were changing the world and that at the end of this project or this set of projects personal computing would burst on the scene exactly the way we had envisioned it and take everybody by total surprise.” (?Larry Tesler)

Here is a sampling of PARC contributions. To view a timeline of GUI contributions, see Section 5 in this chapter.

- The Alto – The first personal computer, the Alto embodied such innovations as the world’s first WYSIWYG editor, commercial mouse, graphical user interface (GUI) and bit-mapped display.
- Client/Server Architecture – This approach was a paradigm shift that moved the computer industry away from the hierarchical world of centralized mainframes downloading to dumb terminals and toward more distributed access to information resources.
- Ethernet – Ethernet became the global standard for interconnecting computers on local area networks. The Ethernet standard spawned a series of increasingly sophisticated networking protocols that not only enabled distributed computing, but led to a re-architecting of the internal computer-to-computer communication within Xerox copiers and duplicators. The 10 Series copiers were the first to use numerous built-in microcomputers with a low-bandwidth Ethernet as the communications interface.
- Network Architecture – The development of Ethernet, Alto and research prototypes of networking protocols for distributed computing led to the development of XNS, Xerox’ robust, leading-edge networking protocol. This led to the Corporate Internet, an internal wide area enterprise network that was well ahead of its time in enabling employees to exchange formatted documents worldwide with speed and ease. In fact, with Xerox’ STAR system, 1981, users were able to access file servers and printers around the world through simple point-and-click actions, a functionality that has yet to be matched by today’s computing systems.
- Internet Standards – PARC scientists are playing a leading role in designing the protocols that will

govern and define how the Internet will work in the future. The “M-Bone” multicast backbone, a collaboration between PARC and several universities from around the world, was first implemented at PARC and has been delivering realtime video over the Internet since 1992. Currently, a PARC research team has been chosen by the World Wide Web Consortium to lead the design for the next generation of HTTP.

- **Glyphs** – PARC is a world leader developing embedded data schemes that transform paper into a user interface. Glyphs are used in many applications, including data verification and finishing applications.
- **Information Visualization** – PARC’s unique approach to the visualization of information uses people’s perceptual and cognitive capacities to help them deal with large amounts of information. The approach was originally used in 3-D Rooms and was an integral technique used in the Xerox product Visual Recall. The hyperbolic browser, which could revolutionize the way people access information on the Internet, and other focus-plus-context visualization techniques are part of the foundation for Inxight, a Xerox New Enterprise Company.
- **Collaborative Tools** – Work on collaborative tools, beginning with Colab, resulted in the development of a product for document-based group collaboration called LiveBoard. This technology, which spawned a business unit called LiveWorks, enabled colleagues – both locally and in remote sites – to work together using real-time, multi-media documents. More recently, research on how a sense of place can create more meaningful interaction on the Internet has turned into a spin-out company called Placeware, in which Xerox holds a partial interest
- **Flat Panel Display** – Work in amorphous silicon led to the development of thin film transistors. Arrays of these devices now provide for a new generation of flat, print-quality displays. This technology, resulted in the formation of dpiX, a Xerox New Enterprise Company. The panels that are used to make electronic documents as easy to read as paper documents have also found application in document scanning and digital X-ray imaging.
- **Laser Printing** – Electronic printing provided a means of seamlessly transferring digital documents into the paper domain. The original idea of modulating a laser to create an electronic image on a copier’s drum migrated from Rochester to the newly-formed PARC where it became the basis for Xerox’ multi-billion dollar printing business. The early Raster Output Scanner optical designs for Xerox laser printers were also developed at PARC. This invention changed the entire notion of documents and document processing.
- **Page Description Languages** – Page Description Languages enable the construction of documents from higher-level sources. They are the intermediaries between tools for creating documents and devices for displaying them. Press, the first PDL, was developed by PARC scientists and greatly influenced the design of Interpress and PostScript.
- **Device Independent Imaging** – A software document architecture that enables device dependent aspects of imaging to be cleanly separated from generic imaging operations, Device Independent Imaging has been a research thrust at PARC for a number of years. This work is enabling Xerox printing products such as DocuPrint to drive different Xerox printers from a common software base.
- **Laser Diodes** – PARC’s laser research has made Xerox a world leader in semiconductor laser diodes, resulted in hundreds of patents and spawned Spectra Diode Laboratories. Laser diodes are used in all new Xerox printing products. Multi-beam Lasers – PARC was the first organization in the world to create a multi-beam laser diode and Xerox is, to date, the only printing company to have this capability. The dual-beam laser emits two beams rather than the a standard single beam, making it

possible to print twice as fast. The dual-beam laser is in use in Xerox' flagship product, the DocuTech 180, and is being incorporated in Xerox' new DocuCenter color products.

- Blue Lasers – In October of 1997, Xerox PARC was the first printing company to create a blue laser. The reduced wavelength of a blue laser allowed much higher resolution printing than was possible with standard red and infrared lasers.
- DocuPrint – The system that drives Xerox high-end, network based printers brought together two decades of knowledge and a number of technologies including higher level languages, integrated software for page description and device independent imaging.
- Integrated AI Environments – Interlisp is an ACM award-winning integrated environment that supports artificial intelligence applications. It combines ideas for rapid prototyping with explicit knowledge representation. With the Loops object-oriented extensions, it was used to develop a number of valuable knowledge-based systems for Xerox.
- BITbIt – This small but important invention enables programmers, without special hardware, to manipulate images very rapidly. The “bit blasting” computer command enables the quick manipulation of the pixels of an image and was built into the instruction code of the Alto.
- Mesa/Cedar – Mesa is a system programming language developed at PARC that incorporated mechanisms for making software more reliable, while supporting rapid development. Many of the ideas from this language were used in the development of ADA, the standard DOD language. Mesa was used to implement much of DocuTech software. Cedar, a successor to Mesa also developed at PARC, enabled the rapid development of the DocuPrint system.
- Object-Oriented Programming – The notion of objects that are described and addressed individually and that can be linked together with other objects without having to rewrite a entire program has revolutionized the software industry. PARC's early and continuing work in this area makes it a world leader. SmallTalk, developed at PARC, was one of the first successful object-oriented languages and led to the spinoff of PARCPlace Systems. All current software development at Xerox uses an object-oriented methodology.
- Expert Systems – PARC researchers developed the Interlisp-D environment for AI programming as well as a variety of applications utilized within Xerox. For example, Trillium enables the quick simulation of new user interface designs and Pride captures engineers' experience and rules of thumb for designing paper paths using pinch rollers.
- VLSI Design Methodology – A new representation of VLSI (very large scale integration) integrated circuit designs led to a new generation of computer-aided design (CAD) tools, reduced design time and spawned the silicon foundry industry. Linguistic Compression Technology – Based on an understanding of the deep structure and mathematical properties of language, this technology is used for visual recall, intelligent retrieval and linguistic compression. This work has had a major impact on the automatic processing of language structures and is one of the key research areas underpinning Xerox' Multilingual Suite of products.
- Constraint-Based Scheduling – This technology uses intelligent modeling to create real time machine control, providing the planning software that enables the DocuCenter “plug and play” family of copiers. It gives Xerox a competitive hardware advantage by enabling very effective and efficient machine control at the customer site. Reusable models also improve time to market and performance quality.
- Smart Service – Smart Service provides workers with the tools for generating information systems

that enable productivity and learning through lateral communication. One implementation is the Eureka knowledge-sharing system which has helped field service technicians in France, Canada and the U.S. dramatically improve their productivity and the quality of service delivered to Xerox customers.

- Work Practice Studies – Ethnographic studies conducted by PARC social scientists have revealed how people really work and what they need from technology. By observing the practices of customers using copiers, field service technicians doing repairs and people doing office work, PARC researchers have evolved a community based approach to the design and use of technology.

Movie 16.1 XEROX STAR demo (1982)



<http://www.youtube.com/watch?v=Cn4vC80Pv6Q>

Marcin Wichary's excellent collection of GUI material – *GUIDebook: Graphical User Interface Gallery*
<http://www.guidebookgallery.org/>

The Graphical User Interface
<http://www.sitepoint.com/article/real-history-gui>

Xerox PARC history
<http://www.parc.com/about/>

1972: Xerox PARC and the Alto
<http://www.cnn.com/TECH/computing/9907/08/1972.idg/>

Microsoft's Settlement: the End of an Era, Tim Landgrave
<http://www.techrepublic.com/article/microsofts-settlement-the-end-of-an-era/5035167>

16.2 Apple Computer



A few miles down the road from Palo Alto was a man ready to share the vision of the PARC researchers.¹ At the height of Apple Computer's early success in December 1979, Steve Jobs, then 24, had a privileged invitation to visit Xerox PARC. Jobs and engineers from Apple visited Xerox PARC and were given demonstrations of the Alto and its graphical user interface. They would later incorporate much of what they saw into the design of the Lisa and Macintosh. **Bill Atkinson** and the architects of Lisa had begun working on a GUI before the demonstration at PARC, but it was far more static than what showed on the Alto.

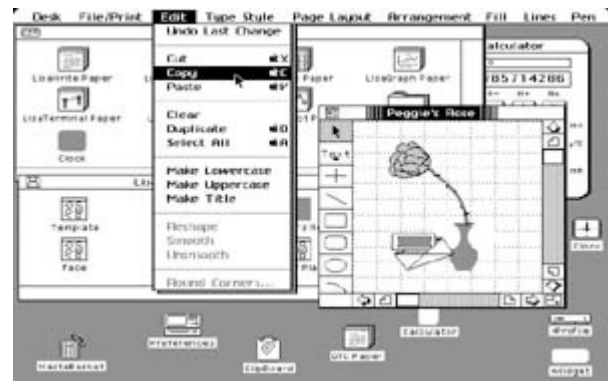


Apple Lisa

In January 1983, Apple Computer officially unveiled the Lisa. It featured a 5-MHz 68000 microprocessor, 1MB RAM, 2MB ROM, a 12-inch B/W monitor, 720×364 graphics, dual 5.25-inch 860KB floppy drives, and a 5MB Profile hard drive. It was slow, but innovative. Its initial price was \$10,000. (“Lisa” stands for Local Integrated Software Architecture.)

1. *Triumph of the Nerds* (PBS Transcripts, Part III - <http://www.pbs.org/nerds/part3.html>)

The original Lisa interface was less reliant on the mouse; it used a “softkey” as it’s primary pointing device, which was essentially arrow keys on the keyboard. The demo gave those at Apple that were devoted to a more dynamic GUI for the Lisa the proof they needed that the graphical desktop was the direction to head. Atkinson recalls that “mostly what we got was inspiration from the demo, and a bolstering of our convictions that a more graphical way to do things would make a business computer more accessible.” Jobs liked what PARC had done with the GUI so much that he convinced Larry Tesler to switch from PARC to Apple and help him develop the interface for the Lisa.



Lisa Desktop image

“They showed me three things. One of the things they showed me was **object-oriented programming**. Another one they showed me was a networked computer system ... they had over a hundred Alto computers all networked using email etc. I didn’t even see that. I was so blinded by the first thing they showed me which was the graphical user interface. I thought it was the best thing I’d ever seen in my life. Now remember it was very flawed, what we saw was incomplete, they’d done a bunch of things wrong. But we didn’t know that at the time, but still though, the germ of the idea was there and they’d done it very well. Within you know, ten minutes, it was obvious to me that all computers would work like this some day.”? Steve Jobs, *Apple Computer?*, commenting on his visit to Xerox PARC.

The Apple Lisa did not sell well because, like the Xerox STAR, it was too expensive (\$10,000) as compared to IBM PCs of the day. 1984’s Macintosh was the first personal computer with a GUI to be marketed successfully because of it’s more reasonable price and well planned advertising strategy. At first the Mac did not sell as well as expected, because of it’s lack of software; MacPaint and MacWrite were not enough for businesses who needed spread sheets and accounting software.

The following segment is from an [article](#) in PCworld online in honor of the 20th anniversary of the Mac.

Remembering 1984

But the Macintosh marketing memories²

"It was the autumn of 1983. Business Week magazine had an IBM personal computer on its cover, with the ominous words, And the winner is...IBM. Apple Computer was in a world of hurt. The Apple II had lost its competitive edge. The Apple III was a sales disappointment and the Lisa, introduced in January 1983, was a financial failure. Great expectations were being placed on the Macintosh, scheduled to launch on January 24, 1984. Yet there was skepticism both in and outside the company. There was no hard disk support. The screen was too small and it wasn't in color. There was limited software. Yet many believed that the Macintosh was indeed The computer for the rest of us. The engineers knew it. The software guys knew it. And most of all Steve Jobs knew it. The challenge for the Mac Marketing Team was simple: They had to establish and hold a beachhead. Or else they and the product would die. The introduction of the Macintosh computer launched a comprehensive and integrated approach to high-tech marketing. Much of what was highly innovative in 1984

2. The Computer History Museum hosted a panel session in 2004, telling the true story of the early Macintosh marketing. The following text describes the panel session introduction. The entire 2 hour session can be viewed at <https://www.youtube.com/watch?v=JTVDWGtf9m4>

is now standard fare for all product introductions." begin for most of the pioneers with the "1984" ad that played during the Super Bowl the week of the Macintosh's launch. Crafted by Hollywood director Ridley Scott, it was dramatic and artsy — and, as several of the principals recall, it almost didn't run.

A preview of the ad was greeted with foot-stomping, whistling applause from the sales force at a fall meeting, several members of the original Macintosh marketing team say. But the Apple board of directors was much less impressed, and in fact ordered ad agency Chiat/Day to try to sell the Super Bowl advertising time spots. When the agency reported it couldn't unload the 60-second spot by the deadline, Apple's board suggested swapping in an Apple II advertisement—but none was suitable. So the board acquiesced, the spot ran—and the Mac made its mark on the advertising field as well as on the technology world. Today, the Super Bowl is often the showcase for innovative advertisements.

"At the next board meeting two weeks later, they summoned the senior members of the Macintosh team," [Mike] Murray says. "We went into the board room, and they all stood up and applauded."? Although broadcast just once, the ad is still a marketing message for Apple. It was eventually preloaded on some Apple systems and is available for download.

Movie 16.2 Apple's famous "1984" Macintosh ad



The "1984" commercial introduced the Apple Macintosh. It was conceived by Chiat/Day, and directed by Ridley Scott.

<https://www.youtube.com/watch?v=2zfqw8nhUwA>



From '1984' Ad, with iPod added.

*At the 2004 MacWorld, **Steve Jobs** presented the 1984 ad again as part of his keynote speech. In this version, the hammer-wielding female was outfitted with an Apple t-shirt and an iPod. The remade ad can be seen by [clicking here](#).*



The hammer throwing athlete/actress is Anya Major, who also appeared as the Russian border guard in Elton John's music video [Nikita](#).

Movie 16.3 *Nikita* – excerpt

<https://osu.pb.unizin.org/graphicshistory/wp-content/uploads/sites/45/2017/04/nikita-excerpt.m4v>

The following description of the Apple/PC developments is from the introductory chapter of a 1994 Masters thesis written by Lionel A. Smith (<http://lionels.orpheusweb.co.uk>):

Hewlett-Packard minicomputer electronics engineer and programmer, **Steve Wozniak**, had developed an interest in microcomputers through the Homebrew Computer Club. Wozniak, whose real forte was simplifying circuits by making components fulfill more than one function, proceeded to design a small computer with video-terminal capability around the Mostek 6502 microprocessor (because at \$25 it was the only one he could afford).

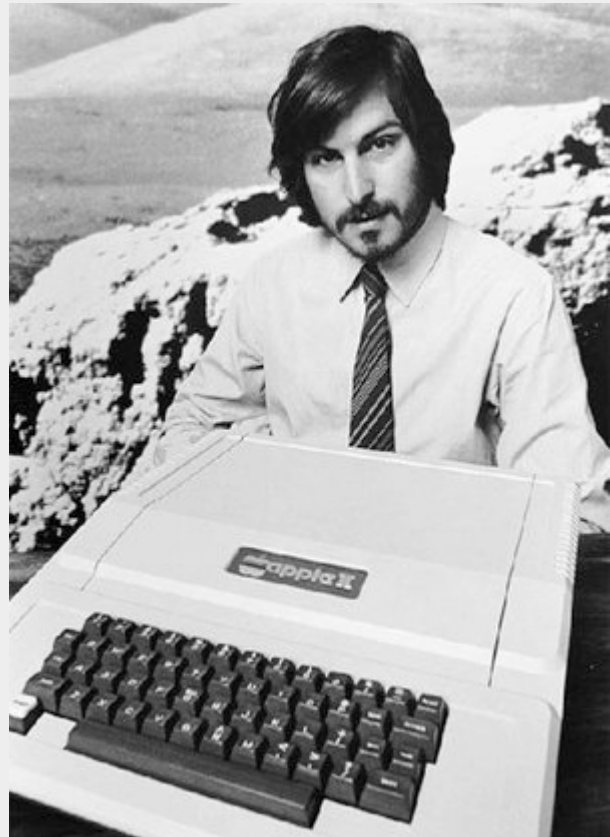
Electronics engineer, and entrepreneur Steve Jobs, the son of a salesman, had, while working for Atari, engaged the talents of Wozniak in hardwiring the video game Breakout. Wozniak reduced the chip count to 44 (when normal chip counts for this type of game were 150-170). The design was too complex for Atari engineers to understand and a pre-production redesign was required. Wozniak's talent for minimalist design was a vital factor in product commercial viability by keeping construction costs down.

Demonstrations of Wozniak's microcomputer at the Homebrew Club quickly led to firm orders for production machines. Hewlett-Packard, having declined an interest in the microcomputer designed by their employee, gave Wozniak a legal release, opening the way for the formation of Apple Computer and sales of the Apple I.

Soon Jobs and Wozniak realized that what the world wanted was a personal computer that only required connecting to a domestic TV to be made ready for use, so Wozniak designed a successor.

The Apple II, also based on the Mostek 6502 microprocessor, scored immediate success with its color graphics and use of discs for data and program storage. The operating system, also supplied on disc, required loading into RAM during startup. Sales of this machine accelerated fast enough for third parties to become interested in developing hardware expansions and software.

The spreadsheet, as an aid to financial planning and what-if analysis was the concept of Dan Bricklin who first produced a demonstration version written in BASIC on an Apple II. It was with this demonstration that the use of the slash character to initiate a command first appeared, which became such a familiar feature of spreadsheet software including Lotus 1.2.3. Bricklin teamed up with Bob Frankston and created the Software Arts company to produce the full assembly language version, VisiCalc. The combination of VisiCalc and a disc system was so successful that many Apple IIs were sold into the business community, enhancing Apple's credibility. Indeed, IBM held up the announcement of the IBM PC until a VisiCalc conversion was ready.



Jobs holding Apple II

Thus, in the early nineteen-eighties, there were two de-facto standards for personal computers; the S-100 bus–CP/M camp and the Apple following. There were many other proprietary machine architectures, each with a unique combination of microprocessor, bus, memory architecture and file system formats, and transfer of data between formats was all but impossible.

When the IBM Personal Computer (PC) was introduced in August 1981, little did the world suspect that a standard was being set, a standard which would continue to make its existence strongly felt as far into the future as 1994, and possibly beyond.

IBM brought their first PC to market in a little over thirteen months from inception. This was remarkable for a company whose project gestation period was usually measured in years. A major factor in the short development time was that IBM had taken the unprecedented step, for an industry giant noted for developing products which were proprietary through and through, of using existing hardware components from external vendors. The use of many design elements of IBM's earlier System/23 DataMaster was also a major factor in the speed of development and expansion cards for this system could be used in the new machine.

More remarkable was the adoption of an operating system from the relatively small Microsoft company, who also supplied a BASIC language interpreter. IBM also offered CP/M-86, a 16-bit version of the 8-bit CP/M from Gary Kildall's Digital Research. The first DOS was 86-DOS for S-100 computers upgraded with the Intel 8086 CPU. DOS-86 was produced by Seattle Computer Products, the rights of which were bought by Microsoft.

The well thought out synthesis of the best features from existing microcomputers and the close compatibility with CP/M systems ensured marketing success beyond even IBM's expectation. The non-proprietary nature of the PC system architecture encouraged many other manufactures to begin building compatibles. This development had far-reaching consequences for the way in which the personal computer industry developed.

Although the 8088 microprocessor operates at 16-bits internally, it communicates with other components of the PC over an 8-bit bus. The advantage of this design strategy was that DataMaster features and 8-bit logic chips, which were plentiful and cheap, could be used.

Accessing memory over an 8-bit bus caused a bottleneck. In 1983 IBM introduced the PC/XT which was also built around the 8-bit Intel 8088 microprocessor. The PC/XT used version 2.0 of PCDOS, which for the first time used a hierarchical filing system capable of dealing with the much larger capacity hard discs with which the XT could be equipped.

Meanwhile Apple had embarked on a new project, code named Lisa, to develop a new office computer. In search of funds, Apple's Steve Jobs approached Xerox, whereupon he and other members of the Lisa team visited Xerox's Palo Alto Research Center (PARC), where they were shown the Alto. The Apple team was so impressed with the Alto's sharp graphics, displaying a virtual desktop complete with usable documents and small on screen pictures called icons, they decided that the Lisa would be the Alto for the masses. The Apple team's enthusiasm and ideas so impressed Larry Tesler, a member of the Alto's design team that he joined Apple.

High resolution graphics demand fast microprocessors and ample RAM, both very expensive commodities in 1983, the resultant high unit price was the major factor in the Lisa's commercial failure. Undeterred, the Apple team carried on with development and launched a scaled down version in 1984 under the name Macintosh, based on the Motorola 68000 microprocessor.

The Macintosh with its **WIMP** based GUI and its lack of program modality was a revelation to a world used to a command line, or at best menu driven interface. The Macintosh was to have a profound effect on the future development of personal computers. The Mac, as it became known, with

its GUI-fronted operating system was presumably what Byte's Editor in Chief had in mind when he wrote:

"I'd buy an operating system any day that takes a long time to run a given program but which makes me more productive by communicating with me in useful ways." ?(Morgan, 1981).

In 1984 IBM introduced the IBM PC/AT built around the new Intel 80286 16-bit microprocessor. The 80286 apart from being capable of faster throughput than previous models offered some advanced features. Amongst these were processing parallelism and hardware implemented task switching with program protection.

Unfortunately in maintaining backward compatibility with version 2, the new 3.0 version of PCDOS did not support either **multitasking** or multiuser environments. Thus, the AT was primarily used as a more efficient PC/XT and could still only make use of a maximum of 640k of user memory in 'real address mode'. Users wishing to take advantage of the possible 16 megabytes of memory, as well as the multitasking and multiuser capability were expected to wait for the forthcoming XENIX operating system.

A major architectural feature of the original PC was the use of an expansion bus equipped with connectors, or slots, to take adaptor cards for interfacing with peripherals in particular visual display units (VDUs) and hard drives. The expansion slot data width is one factor which determines how quickly data flows between the microprocessor and the peripheral. The original PC slots had an 8-bits wide data path increased to 16-bits on the AT to match the data width of the 80286. Both the 8-bit and the 16-bit bus specifications are known as the ISA.

Compatible makers continued to build enhanced versions of the PC for sale at competitive prices, introducing all manner of compatibility issues as a result. IBM when developing a 32-bit bus to suite the new 32-bit Intel 80386, and realizing that they had lost control of their architecture, produced MCA. MCA used many proprietary methods and components with which IBM hoped to defeat the compatible makers. The first systems with MCA were the PS/2 range, launched in 1987, this included models built around the 80386, 80286 and 8086. PC compatible manufacturers were allowed to use MCA architecture providing they paid IBM substantial royalties.

To avoid paying such royalties, a consortium of compatible makers, led by Compaq, responded by developing the 32-bit EISA bus which, apart from being faster and cheaper to implement, had the added advantage of maintaining compatibility with existing 8MHz ISA bus adaptors.

The launch of the Macintosh had focused the computer world's attention on the user interface and where Apple led many were soon to follow. Digital Research produced GEM which could run under CP/M-86 or TOS on the Atari ST, and Microsoft produced Windows for the PC, both of which incurred Apple's wrath for being too close to the look and feel of the Mac interface, Commodore having bought out a small company Amiga, launched a computer of that name using Intuition, as a GUI.

IBM with Microsoft produced a new 16-bit operating system OS/2 for the PS/2 range. OS/2 was designed to give a GUI, Presentation Manager, a head start by clearing away the 640k memory limitations of MS-Dos. Meanwhile the Unix camp were evolving their own many flavors of GUI such as Motif, DEC-windows, Open Look, Open Desktop and NextStep. Nextstep is the user interface developed to run under Unix on the Next Computer, the product Steve Jobs nurtured sometime after leaving Apple.

The move towards GUIs was generally welcomed by the computing fraternity, but there was one big drawback, especially for users of PC systems running MS-Dos. GUIs such as Windows, with their

resolutions of 640 x 480 pixels or larger as opposed to the typical 24 lines of 80 characters, increased dramatically the amount of video traffic.

Furthermore, if ram is limited, large volumes of data need to be swapped out to disc frequently. When this is achieved over the 8Mhz ISA bus then systems can become sluggish and unresponsive, no matter how fast and capable the microprocessor.

With the introduction of the fast 80486 CPU, overcoming the ISA bus bottleneck became a high priority, especially where graphics adaptors and Windows, SCSI interfaces often used by CD-ROMS and scanners and hard drives were concerned. One answer appeared in the concept of the local bus, with which peripherals are connected directly to the CPU and/or ram. A number of manufacturers, including Compaq, Dell and Hewlett-Packard developed their own proprietary local bus systems which, although technically adequate, restricted adaptor choice to specifically designed cards.

The first widely adopted local bus standard was the 32-bit VESA local bus, (VLB or VL bus). This bus could be driven as fast as the clock of a 33Mhz processor, higher speeds requiring the implementation of wait states. The VLB has a maximum rated throughput of 128-132 Mbs compared to the ISA bus maximum of 8Mbs. VESA is a voluntary standard which some manufacturers have only partially implemented and it is in the process of being updated to cope with the 64-bit wide data path of the Pentium CPU.

PCI is an Intel initiated local bus standard which has been slow to gain wide acceptance because of its late introduction. With the increasing numbers of Pentium based systems PCI is becoming more widely accepted.

Many of these more recent bus technologies overcome the DMA and IRQ configuration troubles which continue to dog the majority of systems which still use the ISA bus. Many of these problems will not disappear until Windows dispenses with the services of the archaic DOS operating system:

“The 640KB of RAM that once seemed so luxurious is now choked with contentious device drivers and TSR programs. IRQs (interrupt requests), DMA channels, I/O memory ports, and other system resources are now being fought over like the last pebbles of ore in a played-out gold mine”. (Halfhill, 1994)³

Adaptor card timing problems can also cause much slot swapping and a rapidly growing collection of mutually exclusive cards. The Apple Macintosh and the Acorn 32-bit RISC computers do not suffer from any such problems: the systems were designed from the ground-up with a more efficient and extensible combined operating system and GUI.

The Computer History Museum has an excellent tribute to Steve Jobs and Apple, including this rare 1980 footage in which he describes the early days of the company.

<http://www.computerhistory.org/highlights/stevejobs/video/>

Steve Jobs talks about NeXT (1987)

<http://www.youtube.com/watch?v=WHsHKzYOV2E>

In 1984, Steve Jobs contributed an essay that originally appeared on page 135 of the first issue of Macworld.

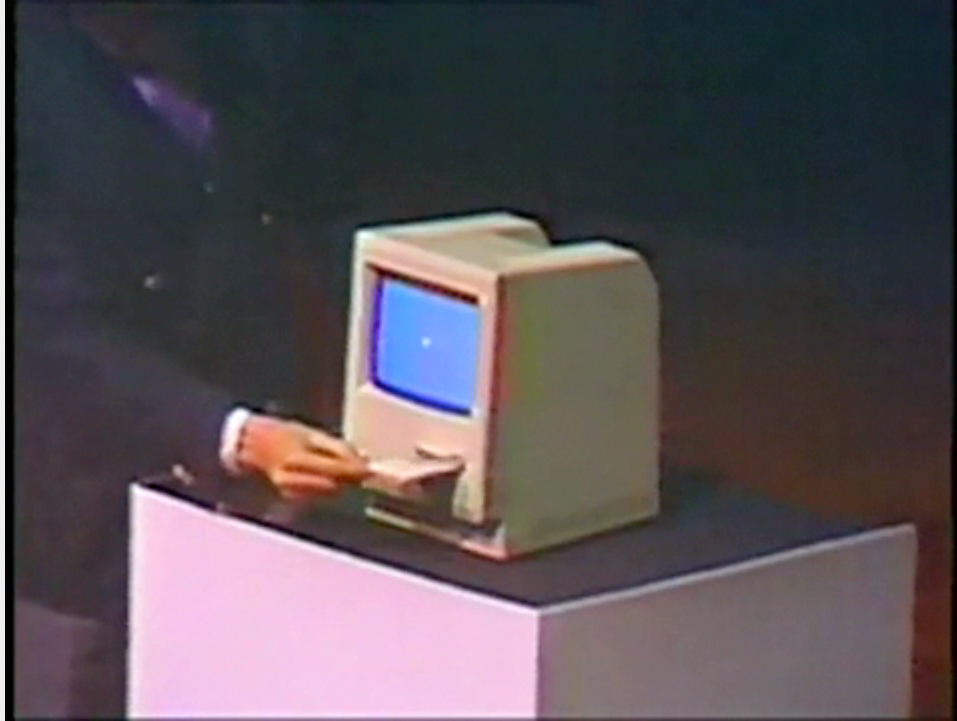
The people who are doing the work are the moving force behind the Macintosh. My job is to create a space for them, to clear out the rest of the organization and keep it at bay. I can't spend enough time here, unfortunately, because I have other responsibilities. But every spare moment I have, I dash back because this is the most fun place in the world.

This is the neatest group of people I've ever worked with. They're all exceptionally bright, but more importantly they share a quality about the way they look at life, which is that the journey is the reward. They really want to see this product out in the world. It's more important than their personal lives right now.

The Apple II had a magical feel about it. You couldn't quantify it, but you could tell. The Macintosh is the second thing in my life that's ever felt that way. Opportunities like this don't come along very often. You know somehow that it's the start of something great. So everyone wants it to be perfect and works really hard on it. Everyone feels a personal responsibility for the product.

The Macintosh is the future of Apple Computer. And it's being done by a bunch of people who are incredibly talented but who in most organizations would be working three levels below the impact of the decisions they're making in the organization. It's one of those things that you know won't last forever. The group might stay together maybe for one more iteration of the product, and then they'll go their separate ways. For a very special moment, all of us have come together to make this new product. We feel this may be the best thing we'll ever do with our lives.

Movie 16.4 Steve Jobs Introduces Macintosh



The Original 1984 Macintosh Introduction: the magic moment, when Steve Jobs unveils the Macintosh and releases it from its bag. <http://www.youtube.com/watch?v=2B-XwPjn9YY>

Movie 16.5 Gates and Jobs together



Bill Gates and Steve Jobs appeared on stage together at the D5 All Things Digital event in 2007. https://www.youtube.com/watch?v=P_5xhcpoeoM

This sequence is the opening video of the discussion, which can be seen in its full (1 hour and 30 minutes) entirety at http://www.youtube.com/watch?v=ZWaX1g_2SSQ

Movie 16.6 Gates/Jobs Rivalry



Steve Jobs Biographer Walter Isaacson chronicles the tumultuous relationship between the two tech giants dating back to the 1970s.

<https://www.youtube.com/watch?v=1Bk-qTzN7vE>

The first Macintosh had no network capabilities, and when asked about it, Steve Jobs reportedly threw a floppy disc at a journalist, saying “Here’s my network”.

16.3 The IBM PC and Unix



The IBM PC was introduced in 1981, impacting the business world in ways that were dramatic. First, it caused other companies, including Apple, to take a new look at how the computer and the GUI could have an impact even beyond the personal computing arena. The PC ultimately impacted many of the decisions that resulted in the introduction of the Macintosh.



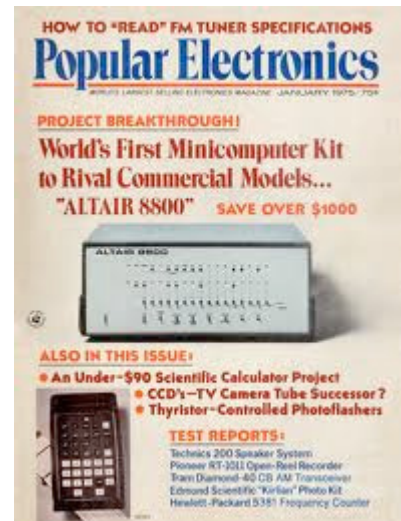
The IBM 5100 weighed over 50 pounds. It was marketed from 1975-1982

In the mid 1970s the IBM company was split into independent business units, including one called the Entry Level Systems (ELS) group. They were responsible for the design of new machines that would advance the IBM brand, within the “affordable” market. The group introduced the IBM 5100 Desktop Portable in 1975 and the 5120 in 1980. These platforms were used as data collection and analysis systems for small labs, and the 5100 had an integrated CRT, keyboard, and tape drive. It was capable of emulating IBM mainframe software. The 5120 was a larger, more expandable version of the 5100.

Intel introduced the first commercial microprocessor in 1971, the Intel 4004, and a few years later introduced the 8008. Altair used the microprocessor in its hobbyist-focused Altair 8800, released in 1975. At the same time, software markets started to open up, thanks to programmers at companies like Digital Research, which sold the CP/M operating system and several programming languages.

The success of the Altair got IBM executives and other computer companies thinking about how they could play in this evolving market. IBM in particular started plans for introducing an IBM microcomputer aimed towards small businesses and consumers. They designed a prototype, based on the Intel 8088 16-bit processor. The software development team for the prototype wanted to make certain that appropriate and necessary operating systems, compilers and software could be available in a timely fashion, so they looked to outsourcing the development. Enter the independent company Microsoft, the market leader in programming languages. Using emulation software running on a DEC minicomputer, Microsoft ported its version of BASIC to the 8088. The project, codenamed Project Chess, presented the prototype, internally called Acorn, to IBM management, showing it running CP/M and using the newly created MBASIC.

Because of disagreements between IBM and the CP/M team, IBM chose to develop a different OS, so they again contacted Microsoft to develop an OS and programming language for Acorn.



January 1975 Cover



IBM PC/XT

The new PC computer, which the marketing staff wanted to price at \$1,565, required a different approach to marketing than the approach normally taken by IBM for their larger and more costly machines. It was to be sold to individuals, and IBM wanted to use consumer electronics stores and department stores to sell the new computer, bypassing the normal IBM sales staff.

The marketing campaign used Charlie Chaplin, and was very effective in reaching the desired customer base. The Acorn was renamed the IBM PC 5150, or IBM PC.

In the meantime, the Microsoft partnership was beginning to take shape. Microsoft bought an operating system called QDOS (for quick and dirty operating system) that ran on the 8088 processor from programmer Tim Patterson, who had previously developed it as a port of CP/M. IBM agreed to use QDOS, but renamed it PC-DOS, and let Microsoft market its own version, which they called MS-DOS, leading to the creation of a clone industry a few years later. If MS-DOS hadn't been freely available, there wouldn't have been a huge market of commodity computers that were capable of running Windows. In short, Microsoft really owes its entire success to the IBM PC and the PC clones.



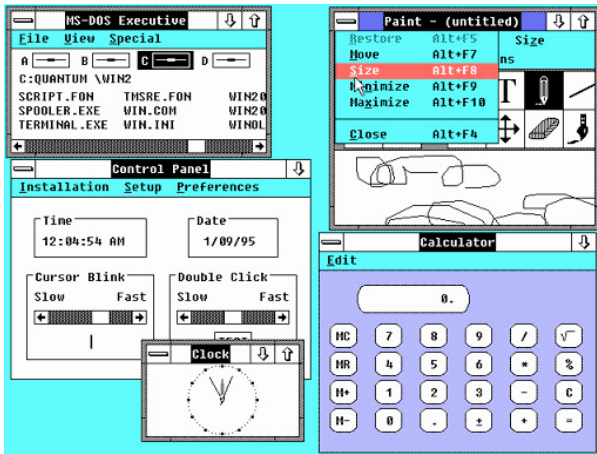
Charlie Chaplin

In addition to PC-DOS, the programs VisiCalc and EasyWriter were bundled with the PC, although the first version of EasyWriter was not very dependable.

IBM's sales went beyond expectations the first two years, as they sold nearly 3/4 of a million units, tripling the marketing goals.

The IBM PC was more popular with businesses than the Mac, even though it didn't have a GUI. **Bill Gates** and Microsoft began developing useful applications for the Mac which helped increase sales. Microsoft's early partnership with Apple allowed them access to the Mac OS which led to the development of their own GUI, Windows 1.0. Microsoft saw the Mac OS as a threat to their non-graphical operating systems for IBM PCs, MS DOS and knew that they had to develop a GUI to compete.

Steve Jobs had quoted a saying of Picasso that "good artists borrow, but great artists steal" in describing what the Macintosh had gotten from Xerox PARC. Microsoft might say the same about what they got from Apple. In November of 1985, Microsoft's Bill Gates showed Windows at COMDEX. Windows appeared to copy many of the same metaphors and icons as the Mac GUI with just the names changed, for example the Trash Can in Mac, became the Recycle Bin in Windows (and later the Dumpster in X-Windows for SGI Workstations).



Windows 2.0 screen

Apple objected and threatened to sue Microsoft, and Gates became very angry over the threat. Ultimately the two companies came to an agreement, and Apple agreed to license the Macintosh's "visual displays" to Microsoft to use in software derived from Windows 1.0. Microsoft agreed to continue developing its Mac products. They also proceeded to develop Windows 2.0, which they released in November of 1987.

Apple's executives felt that this version was a breach of the contract that was signed earlier, given how much Windows 2.0 resembled the Macintosh GUI. Apple filed suit against Microsoft in federal court on March 17, 1988 for violating Apple's copyright, and Microsoft countersued. However, the judge in the case ruled in

Microsoft's favor that most of the contested violations were not in fact violations of Apple's copyright due to the fact that ideas cannot be protected by copyright.

The relationship between the companies was strained for decades, as Apple appealed the ruling. The case made it all the way to the Supreme Court, which declined to hear the arguments. Online author Tom Hornby has an excellent series of articles on the Mac/PC history, including the Apple/Microsoft lawsuit at <http://lowendmac.com/orchard/06/apple-vs-microsoft.html>

Windows became more popular not because it was better than the Mac OS, but because it was more open, and could run on millions of IBM PCs and Mac Clones. Apple never licensed the Mac OS to clone makers except for a brief period in the mid 1990s. This caused Apple to lose market share, but kept the quality of their product more consistent than with IBM clones. Windows had flaws because it was built on top of the non-GUI MS-DOS, and it would behave differently on each type of PC clone.

In 1986 Steve Jobs left Apple after disagreements with the board of directors and founded a new company called NeXT which would develop NeXTStep, a GUI for its Unix based workstations in 1988. This became the first GUI to simulate a three-dimensional screen. Later when Steve Jobs returned to Apple, NeXTStep would merge with the Mac OS to create Mac OS X.

Around the same time as NeXTStep, in the late 1980s, other Unix workstation manufacturers wanted a piece of the GUI action. In 1987 the X Windows System for Unix workstations became widely available. Around 1989 several Unix-based GUIs were introduced. These included Open Look, by AT&T and Sun Microsystems, and Motif for the Open Software Foundation by DEC and Hewlett-Packard. Motif's appearance is based on IBM's Presentation Manager, a rival GUI to MS Windows.

16.4 Amiga



Although the Macintosh and the PC were the two most important personal computer contributors to the graphics area, they were certainly not the only personal computers that impacted the market. Atari, Tandy, and Commodore all developed computers that helped push the success of the home or personal computer revolution. Of these, from a graphics standpoint, arguably the most influential computer was the Amiga.

By the end of the 1970s, the Apple II, the Tandy TRS-80 (Trash-80), and the Atari computers were available on the market, and Commodore was marketing the PET, or Personal Electronic Transactor. They used 8-bit processors, like the MOS 6502 and the Zilog80. In each case, the graphics capabilities were primitive. For example, the Apple II video controller displayed 24 lines by 40 columns of upper-case-only text on the screen, with NTSC composite video output for display on a monitor, or on a TV set by way of an RF modulator. There needed to be better graphics capabilities for these products to be as successful as their potential showed.



TRS-80



Commodore Pet

Jay Miner started working at Atari in the late 1970s. He was instrumental in pushing the capabilities of the electronics by combining the necessary components into a single chip, known as the TIA, or Television Interface Adaptor. The TIA was to become the display hardware for the Atari 2600 game console, and was the forerunner to the chip set which was the basis of the Atari 8-bit family of home computers, known as ANTIC and GTIA.



Lorraine Concept – Courtesy of Secret Weapons of Commodore

In the early 1980s Jay, along with other Atari staffers, had become disillusioned with management and started a new company in Santa Clara, called Hi-Toro. They worked on a new 16-bit (Motorola 68000 based) game console. This project, which then was code-named Lorraine, resulted in a design that could be upgraded to a full-fledged computer. Commodore International assumed ownership of Hi-Toro. It was at this time that the video-game market was beginning to fail, so the new owners began changing Lorraine's design to become a home computer, the Amiga.

Jack Tramiel invested \$500,000 in the Amiga Lorraine project, hoping to use the results of their development for a series of 32-bit machines that would replace Atari's existing home computer line. As Amiga's financial health got worse, Commodore took over the entire Amiga staff and the Lorraine project, just before Tramiel could assume ownership. He subsequently sued Amiga for fraud in the matter of the development of the three VLSI chips, which Amiga alleged didn't work, canceling the deal. Tramiel felt that the chips did work, and were going to be part of a the new Commodore computer.

In June 1985 the first production of an Amiga, the A1000 began. It had 256K RAM, which was later updated to 512K as standard which was enormous for its time. It also had a previously unknown 4096 color palette, and had a 14MHz Motorola 68000 processor. It also allowed direct to video tape recording with its integrated composite video output connection. The Amiga 1000 could have been a serious competitor to IBM's PC, but Commodore focused it specifically for home use, primarily as a replacement for the Commodore 64.

In 1986 Amiga's engineers started to design the A2000. This was to be the replacement to the A1000, with a bigger box, more expansion capabilities and an updated OS. The A2000 (and its cheaper version the A500) were released in 1987. The A500 had only one expansion slot and a single memory-upgrade slot, and became the single most popular Amiga ever.



a500



a2000

For its time, the Amiga had some of the most impressive sound and graphics (through several coprocessors) available for the home user. It was also used for commercial entertainment production during the 1980s. Newtek marketed a special graphics rendering solution of the Amiga, called the Video Toaster. (The Video Toaster was used to render the space ships in the first season of *Babylon 5*). NewTek also created the Lightwave 3D rendering program on the Amiga, which they eventually ported to the PC. The support of overscan, interlacing and **genlocking** capabilities, and the fact that the display timing was very close to broadcast standards (NTSC or PAL), made the Amiga the ideal computer for video purposes, and was used in many studios for digitizing video data (sometimes called **frame-grabbing**), subtitling and interactive video news.

The chipset which gave the Amiga its unique graphics features consisted of three custom chips, OCS, ECS and AGA, nicknamed Agnus, Daphne (Denise), and Paula (Portia). Daphne was basically a non-programmable chip responsible for transferring the raw bit data through a hybrid integrated circuit to the RGB port. Paula was a sound chip that allowed 4 channel hardware DMA driven stereo output.

Agnus took care of the multimedia capabilities, providing DMA for sound and graphics, handling memory, and performing video timing (PAL or NTSC versions). The video timings were deliberately chosen to make it possible to use the Amiga with common household TV sets, and the Amiga had output ports for monochrome video signal, and separate RGB monitor connections.

A newer version of Agnus (used in most of the A500 and A2000 computers) was called Fat Agnus. It could handle a full megabyte of RAM. (Super Agnus, an even more recent version was able to support 2 MB RAM, and was able to change between PAL and NTSC video signal timing.)


The basic resolution of an Amiga display (sometimes called LoRes for low resolution) was 320×200 by 60 Hz (NTSC timing), or 320×256 by 50 Hz (PAL timing). In these resolutions, it was able to display 2, 4, 8, 16 or 32 colors in a palette based manner simultaneously from 4096 colors (4 bit for each of the RGB components).

The number of colors on screen could also be increased:

- EHB, or Extended HalfBright – an additional bit plane was used to display 64 colors, but the second 32 colors were half the brightness of the first 32.
- HAM, or Hold-And-Modify, where six bit planes were used, but only 16 colors were defined by the palette; the remaining 48 “colors” described how to modify the previous pixel color.
- A special mode existed (mainly used for games) called dual playfield mode, where two screens of maximum 8 colors were behind each other. One of the colors in the front screen was disabled and changed to transparent (for pixels having this color the other screen is visible).


The Amiga included a hardware BitBLT co-processor, which was used to create and move several dozen additional objects in the bit map each frame time, saving and restoring the background as necessary. The “Blitter” also provided hardware support for line drawing and polygon filling functions. The operating system, AmigaOS, was quite sophisticated, combining an elegant GUI like that of the Apple Macintosh with some of the flexibility of UNIX while retaining a simplicity that made maintenance rather easy. The Copper processor was a 3 instruction co-processor running in parallel with main CPU, allowing for the creation graphics effects with minimal CPU load and intervention.

MEET THE COMMODORE FAMILY




64C PERSONAL COMPUTER**

- Large disk RAM memory
- Sprite graphics for games
- Music synthesizer built in
- High resolution graphics
- 16 colors of the first low reflective beige casing
- Uses built-in monitor or CRT
- Output for external amplifier
- Accesses plug-in application cartridges



128D PERSONAL COMPUTER**


- Built-in 32K disk drive
- 320K RAM for software applications
- User accessible 40K floppy disk
- Compatible with IBM PC™
- Full assembly language interface to many IBM™ programs
- 100% of programs available on software
- Ideally suited to the home, small business and education



PC5**

The first in a new generation of entry level low cost home office computers.


- Full IBM compatibility to run all popular IBM PC™ software
- Single 300K 5 1/4" floppy disk with optional second drive of 300K
- Five IBM PC™ compatible expansion slots to let your system grow
- MS-DOS 3.2 and OS/2™ (industry standards)
- CPU has RS232C floating point processor (optional)
- Parallel printer port
- RS-232C Port



PC10**

IBM PC™ compatibility to run all popular IBM PC™ software.


- Advanced Graphics Adapter card for stunning colour and monochrome graphics
- Functions are: 1. IBM colour graphics adaptor 2. Hercules graphics adaptor 3. Plantronics colourbus adaptor 4. IBM monochrome text adaptor
- Dual 300K 5 1/4" floppy disk drive
- Five IBM PC™ compatible expansion slots to let your system grow
- MS-DOS 3.2 and OS/2™ (industry standards)
- Full IBM floating point processor (optional)
- Parallel port
- RS-232C Port



PC20**


IBM PC™ compatibility to run all popular IBM PC™ software.

- Advanced Graphics Adapter card for stunning colour and monochrome graphics
- Functions are: 1. IBM colour graphics adaptor 2. Hercules graphics adaptor 3. Plantronics colourbus adaptor 4. IBM monochrome text adaptor
- Dual 300K 5 1/4" floppy disk drive plus 20MB internal hard disk drive
- Five IBM PC™ compatible expansion slots to let your system grow with you (two occupied)
- MS-DOS 3.2 and OS/2™ (industry standards)
- Full IBM floating point processor (optional)
- High speed DMA hard disk controller
- Parallel printer port
- RS-232C Port




PC40**

- 300K CPU 16 MB
- 10 MB processor clock (switchable to 8 MHz)
- 10 MB random access memory (RAM)
- 1 MB RAM as standard, configured as 512K Base Memory, 17K Expansion Memory
- 200W power supply
- 2 DMA hard disks
- 1 1/4 MB floppy disk drive 5 1/4" — 300K second floppy disk drive optional
- 1 fully PCAT™ compatible expansion slot
- 2 slots with 160 pin 32 pin connector, 16 bit bus
- 2 slots with 160 pin 32 pin connector, 8 bit bus
- 3 slots occupied by — Graphics Adaptor, Parallel Serial Interface, Hard Floppy Disk Controller
- PS/2 Serial interface — 9 pin sub-D connector
- Contrast adjustable printer interface
- Real time clock/calendar, battery buffered
- Keyboard switch
- Advanced Graphics Adapter Card for stunning colour and monochrome graphics
- Functions are: 1. IBM Graphics Adaptor, 2. Hercules Graphics Adaptor, 3. Plantronics Colourbus Adaptor, 4. IBM Monochrome Text Adapter




180C COLOUR MONITOR

18" diagonal screen, 1800 x 1000 pixels, 18" x 18" x 18" (H x W x D), 18" x 18" x 18" (H x W x D), 18" x 18" x 18" (H x W x D)



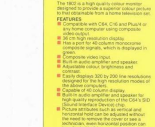
1541 DISK DRIVE

5 1/4" floppy disk drive, 1000K capacity, 1000K capacity, 1000K capacity




1901 COLOUR MONITOR

19" diagonal screen, 1900 x 1000 pixels, 19" x 19" x 19" (H x W x D), 19" x 19" x 19" (H x W x D), 19" x 19" x 19" (H x W x D)




MPS 1200 DOT MATRIX PRINTER

1200 x 600 dpi, 1200 x 600 dpi, 1200 x 600 dpi



BM 15 TTL MONOCHROME MONITOR

15" diagonal screen, 1500 x 1000 pixels, 15" x 15" x 15" (H x W x D), 15" x 15" x 15" (H x W x D), 15" x 15" x 15" (H x W x D)




1031 MONITOR

10" diagonal screen, 1000 x 1000 pixels, 10" x 10" x 10" (H x W x D), 10" x 10" x 10" (H x W x D), 10" x 10" x 10" (H x W x D)

COMMODORE FAMILY OF COMPUTERS

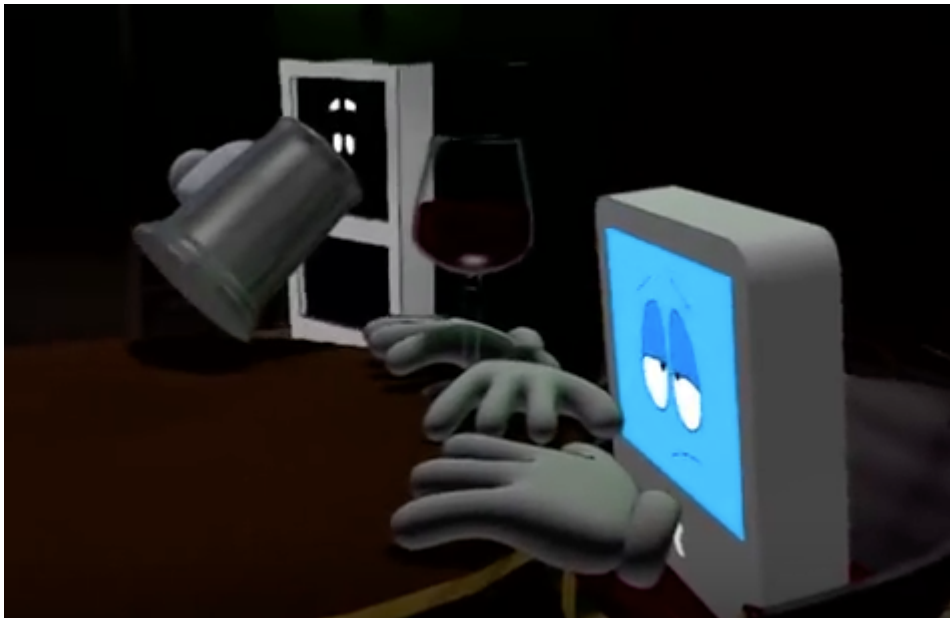
Model	Case	Disk Drive	Memory	Monitor	Printer	Mouse	Keyboard	Parallel Port	Serial Port	Expansion Slots	RAM	ROM	OS	Video	Audio	Power	Weight	Dimensions (H x W x D)
64C	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
128D	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
AMIGA 500	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
AMIGA 1000	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
AMIGA 2000**	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
AMIGA 500	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
PC5	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
PC10	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
PC20	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
PC40	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180



BY COMMODORE®

AMIGA

Movie 16.7 Only Amiga!



Eric Schwartz animated tribute to the Amiga on its 25th anniversary
<https://www.youtube.com/watch?v=iNR5vxAR22A>

Movie 16.8 Revolution: Amiga and Toaster



1991 demo of the Amiga and the Newtek Video Toaster card
<https://www.youtube.com/watch?v=seznQmDp2pU>

16.5 Timeline of the GUI

The following timeline can be traversed by moving the slider from left to right. Each blue dot is another selection.

Note: Original [As We May Think](#) article, by Vannevar Bush, is in the Atlantic Monthly archives.

Chapter 17: Virtual Environments

Virtual Environments

“Artificial life, a major subfield of complexity studies, is ‘fact-free science’, but it excels at generating computer graphics.”

John Maynard Smith, Evolutionary theorist



Virtual Reality Laboratory at the Johnson Space Center, NASA (2011)