Chapter 19

Siemens PLM Software (Unigraphics)[1]

Author's note: As discussed below, this organization has had a multitude of different names over the years. Many still refer to it simply as UGS and, although that name is no longer formally used, I have used it throughout this chapter.

McDonnell Douglas Automation

In order to understand how today's Siemens PLM Software organization and the Unigraphics software evolved one has to go back to an organization in Saint Louis, Missouri called McAuto (McDonnell Automation Company), a subsidiary of the McDonnell Aircraft Corporation. The aircraft industry was one of the first users of computer systems for engineering design and analysis and McDonnell was very proactive in this endeavor starting in the late 1950s. Its first NC production part was manufactured in 1958 and computers were used to help layout aircraft the following year.

In 1960 McDonnell decided to utilize this experience and enter the computer services business. Its McAuto subsidiary was established that year with 258 employees and $7 million in computer hardware. Fifteen years later, McAuto had become one of the largest computer services organizations in the world with over 3,500 employees and a computer infrastructure worth over $170 million. It continued to grow for the next decade, reaching over $1 billion in revenue and 14,000 employees by 1985. Its largest single customer during of this period was the military aircraft design group of its own parent company.

A significant project during the 1960s and 1970s was the development of an in-house CAD/CAM system to support McDonnell engineering. Known as CADD (Computer Aided Design and Drafting), it was first implemented on an IBM 360/40 computer equipped with an IBM 2250 display terminal starting around 1966. In 1967, McDonnell Aircraft and Douglas Aircraft merged to form McDonnell Douglas Corporation (MDC)[2].

By 1976, the software had gone through 15 revisions and was running on IBM 370/168 mainframes using IBM 3250 displays. Tektronix 4014 and the company's own DGS (Distributed Graphics System) terminals were also utilized. The DGS consisted of either a Digital PDP 11/34 or PDP 11/70 computer interfaced to Evans & Sutherland Picture System II displays. Graphic manipulations such as pan and zoom were handled locally by the DGS while geometric construction was performed on the mainframe host computer. Remote DGS systems communicated with the host at a relatively slow 9600 bps. McDonnell Douglas at one time was using 80 DGS systems, 100 3250s and hundreds of 4014s.

Over the years, there were some limited attempts to market CADD to the general public. MDC's operating divisions were adamant that the software should not be sold to

[1] UGS is one of the few companies in this industry that has an extensive history readily available. This data has been maintained on a web site, http://www.plmworld.org/museum, by John Baker, a long term employee of the company. Much of the early part of this chapter is based upon this material.

[2] McDonnell Douglas merged with Boeing in 1996.

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any company that it perceived to be a direct competitor and as a consequence CADD, unlike Lockheed's CADAM, never really got off the ground as a commercial product. Among the few commercial customers were Timex and Cessna Aircraft. The latter was sold the software since its aircraft did not compete with anything produced by MDC. One competitor that did use the software was Northrup, but only because it was a partner with MDC on the F-18 program. The fact that the company wanted $250,000 for CADD software probably didn't help.[3]

Figure 19.1
Evans & Sutherland graphics System Running CADD

A major portion of McAuto's business consisted of providing commercial timesharing services, especially to engineering and manufacturing concerns. Typical of this activity was providing Finite Element Analysis (FEA) on a remote batch basis. McAuto was one of the first company's to offer the use of remote graphics terminals to prepare FEA models for analysis and to view the results graphically. The typical terminal used for this type of service was the Tektronix 4014 and the software was an internally developed package called FASTDRAW.

Clients could use FASTDRAW to build a model, submit it for analysis using programs such as ANSYS or MSC NASTRAN and then view the results. Eventually, this program was ported to Digital VAX computers and sold as an adjunct to Unigraphics. The president of McAuto in the early 1980s was Joe Quakenbush and John Clancy was the vice president in charge of the Unigraphics activity. In February 1983, Robert Fischer, the former president of National CSS, becomes president of McAuto replacing Quackenbush who retired due to health reasons. Clancy became vice president for Industry/Product Management.

Unigraphics started with a company called United Computing

United Computing was founded in 1963 by John Wright and several associates. Their first two-room office was above a hairdresser in Torrance, California. Within a few years the company moved a few miles away to Carson. The new facility had previously been a post office and occasionally people would come looking to buy stamps or mail a package.

[3] Lavick, Jerry J., *Siggraph '76 Proceedings*, Pg. 279

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United Computing's first product, introduced in 1969, was UNIAPT, a minicomputer based version of APT (Automatic Programmed Tool) as described in Chapter 3. APT was a part programming language used to compute tool paths that were subsequently post processed and punched onto a paper tape. The paper tape was then read into an NC machine tools where the program controlled the movement of the machine cutter, producing the part that was described using the APT language.

Figure 19.2
John Wright, Founder of United Computing

UNIAPT was one of the first NC programming systems sold directly to end users. Previously, most companies created their NC programs using time-sharing services provided by large providers such as McAuto and UCC (University Computing Corporation). The UNIAPT software followed basic APT principals fairly closely. APT commands were entered via a keyboard and there was no graphic feedback as we know it today. The system did have the ability to plot results, however. Moderately complex surfaces could be machined using an optional module called USURF.

Figure 19.3
DEC PDP-8 based UNIAPT System

United Computing was one of the first companies to license the ADAM software from Pat Hanratty's Manufacturing and Consulting Services (See Chapter 15). Supposedly this was a worldwide exclusive license except for Japan. Since Hanratty had

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his own way of defining “exclusive” it is not clear what restrictions the contract had on either party. Although the initial version of ADAM had been developed by MCS to run on the REDCOR RC-70 minicomputer with a Computek terminal, the code was intended to be machine independent. United Computing fairly quickly ported the software to a General Automation SPC-16 minicomputer and a Tektronix display. They also added a menu-driven user interface.

The software, UNI-GRAPHICS, was introduced in October 1973 at the Society of Manufacturing Engineers CAD/CAM II show at the Hilton Hotel in Detroit. These shows were the forerunners of what eventually became AUTOFACT. The software provided basic two-dimensional modeling and drafting capabilities. The company promoted this new software as a graphical front-end to UNIAPT. United had just six programmers working on the development of UNI-GRAPHICS at the time.

The typical configuration in addition to the SPC-16 minicomputer included either a Tektronix 4010 or 4014 terminal, an alphanumeric display for commands and messages, a 32-button program function keyboard, a tablet and stylus and a Tektronix 4631 hardcopy unit. Cursor control on the Tektronix terminal was typically with a pair of thumbwheel switches or joystick if the tablet was not used. A multi-user version of the software was introduced in August 1974 on the General Automation SPC-16/65 and the package was renamed Unigraphics without the hyphen.

United sold its first Unigraphics system to Los Alamos National Laboratory in New Mexico in September 1974 but the system’s installation was delayed until early 1975 while the company added support for Vector General graphics terminals and Xynetics flat-bed plotters. The first industrial installation was at an Alcoa facility in Lafayette, Indiana followed soon thereafter by another system at the U.S. Army depot in Corpus Christi, Texas.

In February 1975, the Unigraphics hardware was upgraded to the General Automation 1830 system and the graphic workstation was given the “Model 319” nomenclature. A typical configuration is shown in Figure 19.4.

Figure 19.4
Unigraphics Model 319 Terminal

In September 1975, United Computing introduced its first integrated NC product, Graphic Machining. Although MCS’ ADAM system had NC modules, they were

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problem plagued and United decided to develop its own software rather than try to fix the ADAM code. Eventually, this NC experience would become one of the company's technological backbones.

McDonnell Douglas acquired United Computing in April 1976. The company stayed in Carson and was operated as a McAuto subsidiary.

Unigraphics Under McAuto

Starting in 1976, McDonnell Douglas and the subsequent owners of Unigraphics continued to enhance this core software product and the vast suite of applications built on top of it. One of the first major enhancements was the addition of a user programming language, GRIP (GRaphics Interactive Programming language). Although the basic code for this capability was included in the ADAM software United licensed from MCS, it required considerable software effort to make it work effectively. Over the years, GRIP would be one of the key features along with its NC capabilities that distinguished Unigraphics from its competitors.

When McAuto acquired United Computing, one of the major problems was that Unigraphics ran on General Automation computers. These were not popular with most engineering organizations and McAuto began shipping a Data General Eclipse version in June 1976. The company had been delivering UNIAPT on smaller Data General Nova systems for some time as well as on Digital PDP-8s. Although Data General had a real-time operating system, RDOS, United developed its own operating system, TSS (Time Slicing System), which permitted multiple users to run independent sessions of Unigraphics. The company felt the need to do this since RDOS only allowed a single process to be running at any one time. The Data General version of Unigraphics was followed by a Digital PDP-11/70 implementation in early 1977.

The first Unigraphics user group meeting was held in December 1976 at United's Carson facility. Among the nine companies attending were ALCOA, Caterpillar, Harris Corporation and Los Alamos National Laboratory. The next year, at the August user meeting, there were 25 attendees and the meeting had to be moved to the local Douglas Aircraft plant.

In March, 1977, the company was successful in marketing Unigraphics internationally. Baker Perkins Ltd, of Peterbrough, England, a manufacturer of food processing equipment, purchased a four seat Unigraphics system. The software ran on a Data General S200 with 128KB of main memory, a 96MB removable disk drive, a 9-track magnetic tape backup system, a paper tape punch/reader and a Calcomp 960 plotter. The complete system including the Unigraphics software sold for over $400,000. The S200 computer required an air conditioned room for the CPU and disk drive and the Tektronix terminals required controlled lighting for the users.

In April 1978, the company launched Unigraphics version R1 where the "R" stood for "Restructured." The new software supported 256 data layers and chain selection of graphical entities. R2 followed in July 1978 and R3 just three months later. R4 was released in March 1979. The latter was mostly a bug fix. At this time, it was not possible to simply patch an existing release. To fix bugs, a software company had to ship a complete copy of the software. It was an awkward way to fix minor bugs.

About the same time, McAuto made some significant changes in the management of what was still being run as United Computing. The original United Computing

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operation was shut down and the Unigraphics product line became part of a newly formed CAD/CAM Division of McAuto. This division included other design related activities such as CADD, Fastdraw and some DNC software. John Wright and other early United employees who were still around left the company and George Meister, an early CAD pioneer employed by MDC's Douglas Aircraft Division took over the Unigraphics operation. Meister had actually worked with Pat Hanratty at Douglas Aircraft developing software for designing wiring harnesses for commercial aircraft.

The first release under the new McAuto management was called D1. The "D" stood for double-precision math. In February 1980, the Unigraphics development operation moved to a new facility in Cypress, California. At the time, it was surrounded by strawberry fields most of are long since gone.[4]

By 1980, McAuto had revenues of over $400 million, 5,500 employees and was supporting over 20,000 remote terminals and nearly 300 computers. Of the company's revenue, $46 million involved CAD/CAM systems. While this would have made it one of the leading companies at the time in terms of revenue, the fact that over 70 percent of this revenue was generated by internal aircraft divisions resulted in little external awareness of what the company was trying to sell.

The Unigraphics User Group started to become more important around this time. They began publishing a newsletter called "Interact" in August 1980 with Dave Berry of Harris Corporation as the editor. At that time the user group's officers were Tom Meagher of Caterpillar as chairman, Don Leake of Harris as vice-chairman and Christ Tayon of Valeron as secretary/treasurer.

Unigraphics development under the new McAuto management picked up momentum during 1980. In September, Version D2 was released with a view-independent coordinate system as well as new NC and geometry editing modules including the ability to create and edit sculptured surfaces. This version also saw the introduction of a finite element modeling module called GFEM. From this point forward, Unigraphics was an effective three-dimensional design and manufacturing system.[5] A maintenance release, D2.1 came out in February 1981 with support for the Digital VAX computer. The company announced that it would also support Data General 32-bit systems. The next release, D3.0, in April 1982, was the first Unigraphics software that supported raster displays and color (up to seven different colors).

In October 1981, John Clancy was promoted to vice president of McAuto with responsibility for all the company's CAD/CAM activity. One result was that McAuto's St. Louis headquarters became the worldwide headquarters for Unigraphics. George Miester continued to run the Unigraphics development and support operation in Cypress, reporting to Clancy. By this time, the company had installed about 100 systems external to MDC.

Unigraphics was strong in NC since that was the area where United Computing had started and the company claimed to have over 1,000 postprocessors available. According to the November 1981 issue of *CAD/CIM Alert*:

> "UNIGRAPHICS qualifies as a genuine 'sleeper' – a fine product that for some reason, is not well known – in spite of the fact that the

[4] www.plmworld.org/museum/the_80s.htm
[5] www.plmworld.org/museum/the_80s.htm

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MCAUTO UNIGRAPHICS convention booth is one of the most dramatic. At NCGA '81 and elsewhere, MCAUTO installs a DNC mill alongside its CAD/CAM system and actually machines the parts created on the graphics system before your very eyes!..... We rate UNIGRAPHICS 'excellent' in user-friendliness, 'excellent' in 3D mechanical design, 'poor' in schematic drafting, and 'sorely lacking' in market identity. This system deserves serious consideration by anyone looking for a CAD/CAM system for 3D mechanical design and drafting."[6]

Low cost systems

In the early 1980s there was a great deal of interest among CAD/CAM system vendors to develop lower cost systems, especially for situations where a customer wanted to purchase just one or two seats. Since most early systems were built around a minicomputer core that was designed to support as many as a dozen terminals, the entry level cost for a single seat configuration was often $200,000 or more, especially if the minicomputer was something like a VAX 11/780. McAuto's initial attempt to provide a lower cost alternative was the ADS-100 (Autonomous Design Station) which started at $100,000 (the equivalent to about $200,000 today).

The ADS-100 was a fully functional stand-alone system consisting of a Data General S140 computer, a 25MB disk memory, an 8-inch 1.2MB floppy disk, a Megatek raster display, an alphanumeric display and a single user Unigraphics software license. A storage tube display version of the ADS-100 was also available. As shown in Figure 19.5, the system even included the furniture. The hard disk was used to store the operating system and Unigraphics software while design files were stored on the floppy disk.

Figure 19.5
Low-Cost ADS-100 System (plotter and paper tape reader/punch were optional)

[6] *CAD/CIM Alert*, November 1981, Pg. 7

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A variation of the ADS-100 without the computer portion was marketed as the DDS-100 (Dependent Design Station). These single user systems were designed to be connected to a central CPU. This unit was later called simply the D-100.

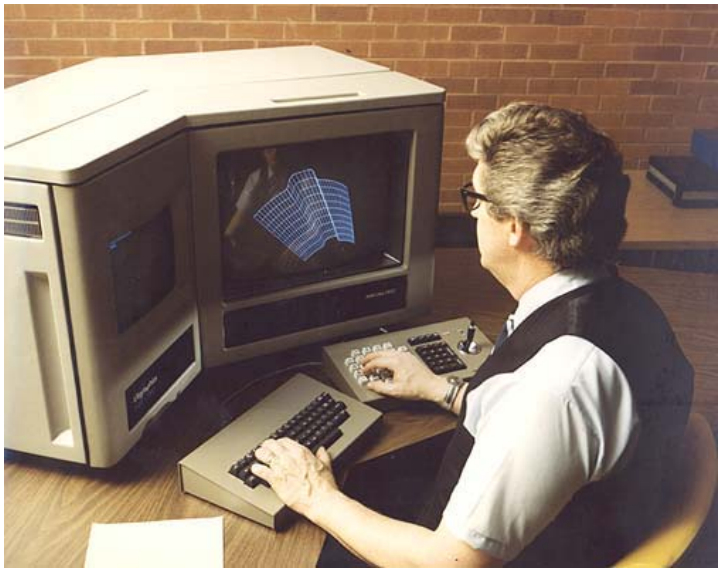

Figure 19.6
D-100 terminal showing keyboard and program function keyboard (PFK)[7]

Unigraphics II

In mid-1982, Unigraphics was basically still the original MCS ADAM software although significantly revised by United Computing and subsequently by McAuto. The development manager at this time was Tom Rafferty who would join Auto-trol Technology a few years later as head of its ill-fated Mosaic project. Rafferty convened a meeting of senior technical managers on the Queen Mary in Long Beach harbor to discuss the need for a major overhaul of Unigraphics. Additional meetings over the next month resulted in the launching of a major development project that eventually resulted in a substantially new product subsequently called Unigraphics II. Internally, this group was referred to as "Snow White and the Seven Dwarves". In addition to Rafferty, the group consisted of

- George Allen
- Chuck Grindstaff
- Vic Hambridge
- Chris Mehling
- Gary Newell
- Paul Sicking
- Wil Valenzuela

John Baker points out on his web site that all of the "Dwarves", with the exception of Gary Newell who passed away in the spring of 2000, are still with the

[7] http://www.plmworld.org/museum/hall/Hall_Workstations.htm

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Unigraphics organization.[8] In fact, as of mid-2007, Chuck Grindstaff was the executive vice president responsible for all UGS product development and marketing.

While work got underway on Unigraphics II, the company continued to release new versions of the existing Unigraphics product. September 1982 saw the announcement of Version D4.0 with an implementation of GRIP extended to work with NC applications, IGES support, and three-dimensional mass properties. This software began shipping in February 1983. Version D4.1 was released in mid-1983. It took full advantage of 32-bit architecture based on work being done for Unigraphics II. The full use of the 32-bit capabilities on Digital and Data General computers resulted in significant performance improvements. This was the last release of the original Unigraphics that contained any significant enhancements. While there were Releases D5.0 and D6.0, they were mainly maintenance releases, particularly for user of older 16-bit computer systems.[9]

In August 1983, McAuto announced Unigraphics II Version 1.0. The earlier software was now called Unigraphics I. The new software entailed a virtually complete re-architecting of the part data model including adding associative relationships. In addition, there were a large number of enhancements and new approaches to creating models and making drawings including:

- Unigraphics File Management (UGFM) system
- New view and layout capabilities to support drafting
- Perspective views
- View dependent editing
- General part merge as a replacement for patterns
- User defined attributes
- Major improvements in drafting functionality
- Dual dimensioning
- Associative dimensions, labels and other annotation
- Grouping of objects
- Major enhancements in CAM and GFEM
- First support for sheet metal operations
- Improved tools for writing user macros.
- User-definable drafting standards.
- The ability to machine multiple surfaces.
- FORTRAN-based post-processors..
- Better access to the Unigraphics database for user applications.

Unigraphics II was implemented on 32-bit Digital VAX and Data General MV systems. While there was limited support for the older Tektronix display hardware, it was obvious that these devices were being phased out as supported terminals. Actual shipment of non-beta software to customers did not occur until early 1984. The Unigraphics II software could read older Unigraphics data but going the other way meant that associativity information would be lost.

[8] http://www.plmworld.org/museum/the_80s.htm
[9] Ibid

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Major shortcomings of Unigraphics II were the lack of hidden line removal and the ability to produce shaded images.[10] Unigraphics II was generally well received in the marketplace. As an example, Continental Can placed a $3.5 million order for a 40 workstation system later in 1984.[11]

Unigraphics terminals and platform support

In the early 1980s, Unigraphics was supported on both 16-bit and 32-bit computers from Digital and Data General. The terminals were Tektronix 4014s with a 5" alphanumeric display typically mounted on top of the 4014 and a 32-button function keyboard. These were connected to the host computer via a 9600 bps (bits per second) link, whether it was connected locally or remotely. Unigraphics did not take advantage of the 4014's limited refresh capability, using the small alphanumeric display for menus and messages. During the period, when Unigraphics systems were minicomputer based, the software was sold on a "per system" basis. Therefore, the cost "per seat" came down significantly as additional terminals were installed.

At AUTOFACT III in Chicago in November 1981, McAuto demonstrated a new Unigraphics user interface and a new system configuration that consisted of a Data General Eclipse C-130 computer, a Megatek color raster display and a 12-inch alphanumeric display priced at somewhat less than $100,000.[12] One problem with all McAuto terminals described in this section is that they were interfaced to the central computer over a standard 9600 bps serial interface. This frequently had a negative impact on performance. The one exception was the D-135 that increased this speed to 19,600 bps.

In the mid-1980s, McDonnell Douglas' primary platform for Unigraphics was minicomputers from Data General and Digital incorporating graphic terminal that used display technology purchased from Megatek but assembled by McDonnell Douglas. At the 7th Annual Unigraphics User Meeting in February 1983, Data General announced the MV1000, the most powerful computer that supported Unigraphics at the time. It could be equipped with up to 18GB of disk storage and 16MB of main memory. McAuto estimated that a fully configured MV10000 could support 12 to 14 Unigraphics terminals.[13]

In mid-1983 McAuto introduced a low-cost monochromatic raster workstation called the D-90 which could be used with either Data General or Digital computers. It sold for $17,500[14]. It was basically intended to replace terminals that used Tektronix storage tube displays.

The company also launched a new low-end system built around a 32-bit Data General MV-4000 computer. Called the M-150, it was priced at $98,000 with one workstation and $115,000 with two. Unlike the earlier ADS-100, the M-150 could handle advanced software such as solids modeling and machining multiple surfaces.[15]

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[10] *Computer Aided Design Report*, April 1984, Pg. 7
[11] *Anderson Report*, December 1984, Pg. 2
[12] *CAD/CIM Alert*, November 1981, Pg. 6
[13] http://www.plmworld.org/museum/the_80s.htm
[14] *Anderson Report*, August 1983, Pg. 3
[15] *Computer Aided Design Report*, August 1983, Pg. 11

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McAuto was totally agnostic as far as which graphics vendors it worked with. In late 1983 it signed a contract with Evans & Sutherland for PS 330 displays and then in late 1984 introduced a new workstation, the D-2300, based on Megatek's Merlin 9200 with 3,072 by 2,304 resolution. This unit supported real time pan, zoom and rotation of both wireframe and shaded images.[16] It would be nearly a year before any D2300s were delivered. They were overly expensive at more than $60,000 per unit (this did not include the CPU or any software) and somewhat unreliable.

In May 1984, McAuto introduced two new design stations, the D-120C and D-120CE models. The C obviously stood for color. There were also M (monochromatic) versions of these raster terminals that had the same capabilities as the color systems. According to the UGS history web site:

> "The two new units were basically upgraded D-100's and were the last design stations sold that were packaged as free-standing furniture. The "E" models had extended graphics capabilities that supported local hardware dynamic rotation of wire frame images as well as support for panning and continuous zooming using the joystick controls. While these stations could still be used with Unigraphics I, many of the enhanced capabilities such as increased graphics memory, the local dynamics, gray scale control of the background, etc. were only supported with Unigraphics II.
>
> The D-120C systems had a list price of $48,000 and the D-120CE systems were sold for $53,000. Note that these systems could also have optional shader hardware added which allowed users to display shaded images of UniSolids models. These were static images and users had to perform a software rendering of a model and then the image would be automatically displayed with what was really a second graphics driver hooked to a common display screen. This was also the only way to create hidden-line images from a UniSolids model. Up until then, users had to purchase a special second terminal that was only used to show shaded images and they had to manually switch the input before they started the rendering operation."[17]

A new terminal, the D-125, was introduced in early 1985. It was a modular unit along the lines of the D-90 with plastic cases for the keyboard and PFK. No monochrome version of the D-125 was offered as the company moved to only support color displays. A basic D-125 sold for $43,000 while a D-125CE with extended graphics capabilities had a list price of $48,000. This was followed by the D-135 in mid-1986. In addition to a 19,600 bps interface, this terminal incorporated a 1MB graphics memory enabling it to handle more complex images than D-125 machines that had only 192KB. The D-135 was the last significant terminal to carry the Unigraphics label.[18]

During the later part of the 1980s, the company reduced its dependency on specially configured hardware systems and began to support industry-standard UNIX

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[16] *CAD/CIM Alert*, October 1984, Pg. 3
[17] http://www.plmworld.org/museum/the_80s.htm
[18] Ibid

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workstations as described below. By 1990, the company supported a variety of workstations from Digital, Hewlett-Packard, and Sun Microsystems.

McDonnell Douglas and the AEC market

McAuto had long been involved in providing timesharing services to civil engineering users. It was one of the first organizations to provide MIT's ICES software on a time-sharing basis as described in Chapter 5. Within McAuto, the AEC activity was known as the EDAC division for Engineers, Designers, Architects and Constructors. Initially, little AEC software was developed internally by McAuto, especially none for the architectural market. Meanwhile, Applied Research of Cambridge England, which was founded in 1969, was developing two packages for use by architects, Building Design System (BDS) and Graphic Data Systems (GDS). In March 1981, McAuto signed an exclusive license agreement with Applied Research to market GDS and BDS. A few years later, in mid-1985, McAuto acquired the company outright along with its software for $12.5 million.

GDS was a fairly straightforward drafting package particularly applicable to architectural and engineering drawings. BDS was implemented to facilitate the design of repetitive buildings such as schools and hospitals. It could not handle sloped roofs, curved walls or walls that met at anything other than a right angle. BDS was a conceptual design and modeling package. In order to produce working drawings, data had to be transferred to GDS. On the other hand, there was no link for transferring GDS data to BDS.

Initially, the software ran on Prime computers using Tektronix 4014 graphic display terminals. In the 1981 time frame, the software was quite expensive. According to *A-E-C Automation* Newsletter, GDS software ranged from $73,000 for two seats on a Prime 150 to $140,000 on a Prime 550-2. BDS software on the same systems was $150,000 to $287,000. This was just for the software, it did not include any of the hardware.[19] Prices were reduced substantially over the next several years. By 1983 an entry-level GDS system including a Prime 2250 computer and a Tektronix 4114 terminal sold for just $100,000 while the BDS software was an additional $38,000. A four-station system was $191,200.[20] One strategic issue the company never fully resolved was that the AEC products were predominately offered on Prime computers although a Digital version was available by 1983, while Unigraphics was available for Digital and Data General systems. The company was also slow in offering existing time-sharing software on the Prime platform. As an example, by 1985 COGO had been ported from time-sharing systems to Digital minicomputers but not to Prime computers which were used by the majority of GDS and BDS customers.

A new AEC division was established in early 1984 under Bill Vickroy. The company scored its first big coup when HNTB (formerly Howard, Needles, Tammen & Bergendoff) , a major engineering firm, decided to install VAX-based GDS systems in 33 offices.[21] A few months later, the company announced that GDS would also be available on the Digital Micro-VAX.[22]

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[19] *A-E-C Automation Newsletter*, May 1981, Pg. 3
[20] *A-E-C Automation Newsletter*, April 19831, Pg. 1
[21] *Anderson Report*, January 1984, Pg. 2
[22] *CAD/CIM Alert*, August 1984, Pg. 6

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In mid-1985 McAuto signed an agreement with Moss Systems of Horsham, England to market that company's topographic modeling and highway design software package also called MOSS. At about the same time, Auto-trol Technology also signed a distribution agreement with Moss Systems.

IBM as both competitor and partner

Although IBM competed with McAuto in the overall CAD market, that did not stop the company from signing McAuto as a reseller of IBM 4361 computers. On December 5, 1984 McAuto announced that it would port Unigraphics II software to the IBM platform. A system consisting of a 4361 Group 5 processor with a 30MB disk drive, four 5080 terminals, Unigraphics II software including NC functionality and an IBM 7375 plotter (same device as the HP 7585) was to sell for $600,000. McAuto planned to sell just turnkey systems and announced that it would not sell unbundled software for the 4361.

Although initial plans were to utilize only a limited amount of the 5080's local graphics capability, the company did use the main display rather than a separate alphanumeric display for menus. McAuto announced that by the end of 1985 it would offload many graphics functions to the 5080. This version of Unigraphics never gained much traction in that IBM's sales force was not particularly interested in bringing a software vendor into a customer when that software vendor also sold other computer platforms.

McAuto sold 11 Unigraphics systems utilizing the 4361 before the agreement with IBM dissolved. Eventually 10 of the 11 converted to either Digital or Data General computers and remained Unigraphics users.[23]

The name games start

The company covered in this chapter has had more different names during the past 25 years than any other company in the industry. In early 1985 McDonnell Douglas dropped the McAuto name and created several specialized companies, each with its own name and identity. These were McDonnell Douglas Aerospace and McDonnell Douglas Information Systems.

As part of the latter organization, the CAD operation was called CIMTECH which stood for Computer Integrated Manufacturing Technologies Company. That did not last very long and in April 1985 CIMTECH was renamed McDonnell Douglas Manufacturing Industry Systems Company or MISCO. A few months later John Clancy became president of McDonnell Douglas Information Systems Group, the new name for McAuto. George Meister relocated to St. Louis and became vice president and general manager of the MISCO.

Other key individuals at this point in time on the mechanical side of the company were:

- Art Francis – vice president, marketing
- Guy Rose – vice president, sales
- Phil Crater – vice president, operations
- Tom Rafferty – director, research and development

[23] Interview with John Baker on July 18, 2006

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The counterparts in the AEC group were:

- Gary Alexander – senior vice president and general manager
- David Lonsdale – vice president, engineering services marketing
- Ray Pittman – director, engineering services
- John Purcelli – vice president, operations
- John Valentino – vice president, national sales
- John Emerson, manager, AEC development

The AEC part of the company was not immune from the name game. In May 1988, the Architectural, Engineering and Construction Systems Company as it was then known, changed to the Built Environment Group.[24] This was later changed to Built Environment Technologies. Both groups were part of McDonnell Douglas' Systems Integration Company.[25]

The name was changed once again in early 1987 to McDonnell Douglas Manufacturing and Engineering Systems Company with Clancy as its president. It was usually referred to subsequently simply as M&E.

UniSolids and Parasolid

UniSolids was developed by McDonnell Douglas in early 1982 based on PADL (Part and Assembly Description Language) from the University of Rochester. PADL-1 was a CSG (Constructive Solid Geometry) modeler that created solid models by combining and subtracting solid primitives. The 1982 demonstration version of this software simply handled blocks and cylinders that were oriented along the X, Y or Z axis. It was never sold but it did prove that the concept was viable.

The solids modeling software was first shown publicly at the 1982 AUTOFACT conference in Philadelphia. The McAuto staff put together a very impressive demonstration of UniSolids. According to Baker:

> "…a model of the Liberty Bell was designed with UniSolids, passed to Unigraphics where a tool path was created using GRIP NC, post processed and then transferred to a 3-axis milling machine via McAuto's DNC system. There a robot (programmed with the Place software) placed blocks of foam board into an automatic fixture on the milling machine where they were machined with the shape of the Liberty Bell (including the crack) and then the robot removed the finished blocks and inserted them in a box, closed the cover and delivered the completed package to the McAuto presenter where he presented it to someone in the large crowd of people watching the demonstration, which was repeated once every hour."[26]

Version 1.0 of UniSolids, based on PADL-2, was delivered to customers starting in May 1983. This initial version of UniSolids was a stand-alone program that initially was not very tightly integrated with Unigraphics. As an example UniSolids did not support some of the advanced surface definitions contained within Unigraphics. It was

[24] *Computer Aided Design Report*, June 1988, Pg. 16
[25] *Computer Aided Design Report*, October 1990, Pg. 2
[26] http://www.plmworld.org/museum/the_80s.htm

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difficult to produce drawings from UniSolids models and it was equally difficult to incorporate two-dimensional Unigraphics shapes into UniSolids models. UniSolids sold for $50,000 and was available initially only on the Digital VAX system. Version 1.1 with improved performance also provided support for Data General MV systems when it was released in September 1983. This was followed by Version 2.0 in November 1984 which enabled a user to import Unigraphics profiles and use them to extrude solid models.

In 1988, McDonnell Douglas acquired Shape Data from Salt Lake City-based Evans & Sutherland. E&S was primarily a hardware manufacturer and its major market was flight simulation. Hence, it never made much sense as to why the company acquired Shape Data whose main product was a solids modeler released in 1975 called Romulus. Shape Data's most recent software at the time of this acquisition was a boundary representation or B-rep solid modeler called Parasolid that was not an end user package but rather component software that other software firms could use in their products.

For the next several years Shape Data's resources were directed at adding Parasolid technology to Unigraphics. This they did quite well. Unigraphics Version 7.0 released in December 1989 included Parasolid as an option called UG Solids. It differed from Unisolids in that it was tightly integrated with the Unigraphics data structure much like the company's surface modeling technology.

Unlike competitive system and the earlier Unisolids package, no translation of data from surface definitions to solids or the other way was required. Graphical manipulation of solids models was no different than the manipulation of wireframe models. The transition from wireframe and surface design to solids design was perhaps the best in the industry at the time. Operators doing drafting or NC programming did not need a UG Solids license unless they were going to make changes to the model.

Jumping on the PC CAD bandwagon

In October 1985 McDonnell Douglas announced a new organization, the PC Productivity Systems (PCPS) division, with plans to create a PC version of Unigraphics I with price of $2,000. It didn't happen quite that way. The company's first PC package was a product called Crossroads which was introduced at the 1986 NCGA conference. Crossroads was a blend of new software, code ported over from Unigraphics and licensed software. Basic geometry functions were taken from Unigraphics while the graphical user interface used the GEM DESKTOP from Digital Research. The software ran on IBM PC/XT and PC/AT computers that required additional memory, a floating-point co-processor, a graphics card and a 20MB hard disk.

Crossroads was a three-dimensional graphics package with a variety of surface types including ruled and spline surfaces. In its initial implementation, these surfaces could only be used to calculate mass properties. No NC software was available for machining the parts designed with Crossroads. Further restricting the marketability of this package was the fact that no translator between Crossroads and Unigraphics was immediately available. From a user interface point of view, it looked surprisingly similar to current PC-based systems as shown in Figure 19.7.

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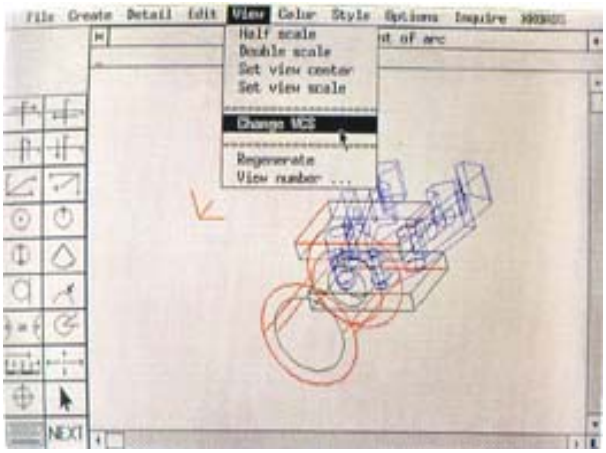

Figure 19.7
PC Productivity Systems Crossroads User Interface

McDonnell Douglas planned to market and sell Crossroads through the new PCPS organization. Actual sales were handled by a dealer network rather than the company's own sales force with the initial list price set at $2,995. Shipments of this product began in August 1986, about five months later than originally planned. By the end of the year the company had sold just 250 copies worth perhaps $750,000 at retail. Probably as a result of the products poor sales, the company consolidated the PC Productivity Systems group with its other mechanical and AEC CAD operations. The plan was to continue selling Crossroads through a dealer channel but by June 1987 McDonnell Douglas was cutting the product's advertising budget.[27]

Computer Aided Design Report reported in its June 1987 issue on an extensive evaluation of mechanical PC CAD software the publication had performed. Crossroads did not fare very well, rated behind MCS' Anvil 1000, AutoCAD and Computervision's MicroDraft but ahead of Intergraph's MicroStation.

> "Crossroads strikes us as a poorly conceived product. Few engineers can make effective use of three-dimensional models in PC-based systems. Three-D is used for design studies, assembly modeling, N/C programming, and finite element analysis. Yet Crossroads to date offers none of those capabilities…… After working with the product, it's clear why it is selling poorly…. Crossroads may get a second chance if it can be integrated with McDonnell Douglas's (sic) Unigraphics II in a sensible way. As a satellite to more powerful systems, it could still have a mission."[28]

In a mid-year report, Daratech did not include Crossroads as one of the ten top selling PC CAD packages – it simply lumped it in with "other."[29] McDonnell

[27] *Computer Aided Design Report*, March 1987, Pg. 11
[28] *Computer Aided Design Report*, June 1987, Pg. 1
[29] *Computer Aided Design Report*, October 1987, Pg. 15

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Douglas threw in the sponge on Crossroads in February 1988 due to poor sales. In retrospect, the problem with the Crossroads product was the fact that PCs of that era simply did not have sufficient processing power to adequately handle the complexity of the software package's three-dimensional capabilities. By the time a user added memory and other performance enhancing features to a PC the cost was probably not much less than some of the low-end UNIX workstations.

Unigraphics II matures

For the first year and a half after its launch, customers were slow to make the transition from Unigraphics I to Unigraphics II. This switch picked up momentum in March 1985 when the company began shipping Unigraphics II Version 2.0 with improved performance and reliability. Version 2.0 also included a mechanisms module, improved NC capabilities and improved procedures for defining default operations. The last full release of Unigraphics I, Version D6.0, was shipped to customers in August 1985.

The Unigraphics business unit seemed to shift into a higher gear in 1985 after doing about $104 million in revenue in 1984. The software was available on Digital's new high-end VAX 8600 systems and for the first time, unbundled software was being sold. Varco-Pruden, a manufacturer of metal buildings, closed a $3.3 million deal for software only. By mid-1985 there were 377 companies using Unigraphics systems, about half running Unigraphics I and the other half using Unigraphics II. About 57 percent were using Digital computers while the rest were Data General systems.

Version 3.0 was released in November, 1985. It contained enhanced visualization capabilities including a new package, UniPIX, based on Brigham Young University's BYU-Movie software. This program created high quality images of Unigraphics models. MISCO, as the company was then known, also began shipping GRIP programs submitted by users. It was referred to as the GRIP International Library. Initially, the library was distributed on magnetic tape to customers upon request. Later it was put on CD-ROM and distributed with the Unigraphics software.

The 10th Annual Unigraphics User Meeting was held in Long Beach, California in February 1986. While the previous user meeting had dwelled on problems associated with making the transition from Unigraphics I to Unigraphics II, this meeting was focused on the newer software packages. MISCO also used this meeting to announce that UniAPT would no longer be supported and that maintenance fees were being suspended. In reality, the technical personnel in Cypress who had UniAPT expertise continued to help users on an informal basis, probably until 1995.[30]

In March 1986, the company announced Unigraphics II ACCESS-50 which enabled users to access Unigraphics software on a central computer from a PC. ACCESS-50 used the same GEM DESKTOP from Digital Research that was being used by the PC Productivity group. Unigraphics II Version 3.2 marked an important transition for the company. It incorporated support for the Digital VAXstation II/GPX, the first commercial workstation-class product this software ran on.

By the fall of 1986 Unigraphics II was being upgraded at a fairly rapid pace. Automatic finite element mesh generation software had been added as well as complex surface trimming and more comprehensive assembly design. Perhaps the most significant

[30] http://www.plmworld.org/museum/the_80s.htm

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technical development in late 1987 was the introduction of Unigraphics software that would update NC tool paths when the underlying geometry changed.[31]

The company announced in January 1987 that it would no longer sell Data General hardware although it would continue to sell unbundled software for DG machines for a limited time, probably not past the end of 1988. This raised such a storm of protest at the user meeting in February that the company agreed to provide enhancement releases for five years and full maintenance and support for six years.[32]

Major changes in product and management

At the user meeting that year, the company announced a major change in how software would be priced in the future. Until this point, the company had sold software on a per system basis with different prices for small and large machines. Customers could run as many terminals off each system as the computer could physically handle and at a performance level the users were comfortable with. The new approach priced software and maintenance on a "per seat" basis. A license management program, Access Control, managed the number of users authorized to use each software module.

The company was fairly liberal in helping customers make this transition. Some were able to reduce maintenance charges while others simply "banked" unused licenses until they were needed. Phasing in the new license management strategy started with the Design/Drafting module in Release 4.1 in March, 1987. Release 4.1 also included support for Digital's VAXstation 2000.[33]

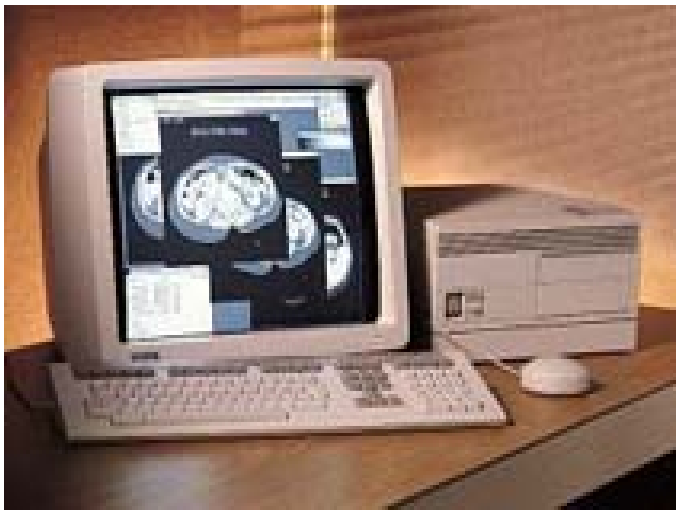

Figure 19.8
Unigraphics II Running on VAXstation 2000

In October 1987, Clancy resigned as president of the company's CAD operation and subsequently became president of Valisys, a vendor of NC quality assurance software.[34] John Mazzola was appointed executive vice president of the Manufacturing

[31] *Anderson Report*, November 1987, Pg. 7
[32] http://www.plmworld.org/museum/the_80s.htm
[33] Ibid
[34] *Anderson Report*, November 1987, Pg. 2

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and Engineering Systems Company, reporting to Jeremy Causley, group executive vice president of McDonnell Douglas Information Systems Group.[35]

Unigraphics II Version 6.0 was released in December 1988. It incorporated advanced hidden line removal, NURBS curves, curvature analysis and a new program, UG Detail Drafting. The latter program was a lower cost version of Unigraphics intended to support users simply interested in producing engineering drawings. It incorporated pre-programmed macro commands and GRIP programs that facilitated this type of work. The user interface included a large tablet menu with nearly 400 commands laid out on it. This package was in the company product line until Version 10.0 was released several years later.

Version 7.0 was released in December 1989. It included UG/Solids, based on the recently acquired Shape Data Parasolid modeler. UG/Solids was much more tightly integrated with Unigraphics than the company's previous solids modeler technology. Solid models could be machined using standard Unigraphics NC software. This was an extra cost module which was provided as a no-cost upgrade to existing UniSolid customers. It did not however, support parametric definitions. That would have to wait for V 10.0.

Figure 19.9
John Mazzola

By 1990, the use of dimension-driven modeling software was becoming the technology of the future. PTC and SDRC were making waves with Pro/ENGINEER and I-DEAS. McDonnell Douglas' response to these competitive products was a Parasolid-based package called UG Concept that was released with Version 8.0 in March 1991. It enabled a user to create solid models that could be modified by simply changing dimensions. Geometry could be unconstrained, constrained or over constrained. The software used color codes and symbols to illustrate these conditions. Sketches defined in two dimensions could be used to create extruded solid shapes.

Once a model was created in UG Concept it could be transfered to Unigraphics where it could be further refined although Unigraphics could not make changes by simply

[35] http://www.plmworld.org/museum/the_80s.htm

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modifying dimensions. UG Concept also used a simplified menu structure that was the start of a new user interface for the Unigraphics suite of software.[36]

General Motors and EDS change the future of Unigraphics

On June 27, 1984 GM agreed to buy Electronic Data Systems (EDS) for $2.5 billion. On October 18, 1984 the merger was finalized, and EDS became a wholly owned subsidiary of GM. As a result of this acquisition, virtually all of GM's data processing activity including a large number of individuals and a substantial amount of computer hardware was transferred to the EDS subsidiary. In addition, EDS hired many new people to the point that it caused a housing boom in the Detroit suburbs.

A huge data center was established in Auburn Hills, Michigan to support GM's data processing requirements as well as those of other clients. Within a few months, EDS as it was still known, began to take charge of GM's computer efforts in engineering design and analysis. By late 1986 it was apparent to EDS that the smorgasbord of systems being used throughout GM for engineering design had to be rationalized. EDS then set out to select one or more "preferred providers."

Probably no business development had a greater impact on Unigraphics than its selection by General Motors in November 1987 as that company's primary supplier of CAD technology. GM began looking at how computer graphics could improve automotive design in the early 1960s (see Chapter 3). As CAD systems matured the company implemented a combination of purchased turnkey systems from numerous vendors including Computervision, Applicon, Calma and Auto-trol as well internally developed software. The latter category included a package called the Corporate Graphic System which was used by many GM division for body design. By 1987, numerous GM organizations were also implementing PC based CAD systems, particularly AutoCAD. Unigraphics was not one of the systems installed at GM at this point in time except for some robotic programming software.

GM called the consolidated system they were looking for C4 for CAD, CAE, CAM and CIM. GM's evaluation process was extremely thorough, comparable in many respects to large federal government procurements at the time. As part of the evaluation, vendors were required to perform a Live Test and Demonstration that exercised virtually every software module sold by each company.

As anyone who has worked with EDS at that time knows, the company had a huge corporate ego. They believed that since GM was the largest industrial company in the world, it could dictate standards in areas such as CAD technology. The plan was that EDS would work with the selected software vendors to establish these standards. According to *Computer Aided Design Report* the standards would encompass:

- "Geometric representations – the math used to describe car designs
- display drivers – the way CAD/CAM programs communicate with graphics terminals and work station display adapters
- user controls – the ways humans communicate with CAD/CAM applications
- communications between CAD/CAM systems and between CAD/CAM and non-graphic data bases

[36] *Computer Aided Design Report*, October 1990, Pg. 2

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- hardware independence – so that applications can run on many brands of computers"[37]

These were all good objectives although most companies that were not selected as preferred suppliers would object to not having a say in their development. The plan was to take three years to develop the standards and then publish them for other vendors to adopt. It sounded good on paper but not terribly practical.

By the end of 1987, EDS had narrowed the selection process down to CADAM and Unigraphics and ended up choosing both. Interestingly, EDS dealt directly with CADAM, Inc. in this selection process, not with IBM. In spite of this, CADAM was not used extensively by GM and Unigraphics clearly became the preferred software package.

One result of EDS' selection was the increased need to support Unigraphics on UNIX workstations from Apollo, Sun and Hewlett-Packard. The Apollo version was demonstrated at the March 1988 National Design Engineering Show in Chicago. In mid-1988 the company signed a $15 million OEM deal with Apollo shortly after they had signed a $20 million deal with HP.[38] About this same time, the company added NURBS (Non-Uniform Rational B-Spline) surfaces to Unigraphics, eventually replacing the older parametric-cubic surfaces. In spite of being shut out of the GM deal, Digital continued to be a big user of Unigraphics software. By April 1988, it had installed 500 Unigraphics systems around the world.[39]

Unigraphics becomes an EDS division

The EDS subsidiary of GM acquired McDonnell Douglas Systems Integration Co. on November 4,1991 for $350 to 400 million. Over 2,000 MDSI employees became EDS employees with this transaction. The Unigraphics activity became the EDS Unigraphics Division and most of the former MDSI managers led by John Mazzola stayed with the new organization. Mazzola, as president, reported to Hank Johnson, the head of EDS' Manufacturing and Distribution Services business unit.

Johnson was no stranger to the CAD industry having managed the marketing of GM's Corporate Graphic System for EDS. With the acquisition, this EDS operation also took over the development and marketing of Parasolid. The Graphic Data System (GDS) activity, on the other hand, ended up in another EDS division also reporting to Johnson.

At the time of the acquisition, EDS was a 70,000 person, $7 billion computer services company with about 40 percent of its business coming from parent GM.[40] In June 1992, EDS Unigraphics moved into a new headquarters building in Cypress, California. Version 9.0 of Unigraphics II was released in August, 1992 followed by 9.1 in December. The company ended up supporting this software release with many patches for several years due to the lengthy rollout of Version 10.0. It was the last version to use the Unigraphics II nomenclature.

Product data management

The company's first PDM product was Infomanager which enabled users to find files distributed around a network and to facilitate electronic review, approval and release

[37] *Computer Aided Design Report*, December 1987, Pg. 8
[38] *Anderson Report*, March 1988, Pg. 7
[39] *Anderson Report*, April 1988, Pg. 3
[40] *Computer Aided Design Report*, December 1991, Pg. 11

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of drawings. The initial version was released in early 1990 using the Ingress relational database management program.

Release 2.0 also supported Oracle. By 1993, this product was being called Information Manager. Drawings, model assemblies and related data were organized in folders much like today's Windows' file system. Data could be viewed by an authorized user even if it was checked out for modification by another user.

Typical prices in late 1990

Following are prices for some of the Unigraphics software modules in late 1990 on a per license basis:

- Basic Unigraphics II $15,900
- Surface Geometry $6,700
- UG Concept $9,700
- Hidden Line Removal $2,500
- Basic NC $7,200
- Advanced NC $15,600
- GRIP $10,000
- Infomanager Server $22,000
- Infomanager Client $2,200

McDonnell Douglas provided a floating license manager that resulted in customers needing fewer licenses, especially of infrequently used applications, than they had workstations. At this point in time two-thirds of the company's business was in the United States, a far higher portion than competitors such as Computervision and IBM.[41]

EDS Unigraphics moves to meet PTC competition

Starting in 1988 and picking up speed within a few years, Parametric Technology was revolutionizing the CAD industry with its Pro/ENGINEER software as described in Chapter 16. EDS recognized the impact PTC was having on its market as it saw customers switching from Unigraphics to Pro/ENGINEER. The need for significant changes to Unigraphics was very clear. As an example, in mid-1992, the company lost a 2,000 seat order at Caterpillar to PTC. The company needed to have a streamlined user interface, use solids as the basic geometric building block and incorporate dimension-driven parametric modeling. In the fall of 1992 EDS announced Unigraphics Version 10.0 with these features and with delivery expected to start in mid 1993.

The Version 10.0 story actually started back on March 17, 1988, St Patrick's Day. On the UGS History web site, John Baker does an excellent job of describing what went on that day and subsequently. (Note: at this point in time the official release level of Unigraphics was Version 5.1.

> "On March 17th, St. Patrick's Day (which turned out to be somewhat significant), there was a meeting in Cypress attended by key Development and Marketing personnel that would prove to be one of the most important gatherings in the history of the company. It was at this

[41] *Computer Aided Design Report*, October 1990, Pg. 2

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meeting that a proposal was discussed about the need to produce a totally new product to replace Unigraphics. By this time it was generally acknowledged that a solid geometry based CAD system was highly desirable (remember this was before the acquisition of Shape Data) and that the company should begin to explore what it would take to accomplish that. Based on previous history, most people who walked into this meeting assumed that what we were really talking about was something that could be called UGIII however that did not sit well with the head of development, Bob Loss. It seems Bob had a strong aversion to naming this future product UGIII (you see at that time there was this feeling that products which carried a designation of "3" never quite turned out as well number "2" did, for example, look at how well the Apple III did). Anyway, Bob refused to let anyone use the word UGIII during the meeting since he was convinced that if we left the meeting with that name on our lips, that we would never be able to stop using it. So in order to avoid saying that "name" during the discussions that took place, the participants resorted to the use of a nonsense word, in this case "Kleenex Box" (there was one sitting in the middle of the conference room table) whenever they needed to say the "name" of the proposed new product. Well just before the meeting broke up someone commented that since it was St. Patrick's Day that maybe we could use that as inspiration. So this is how the "***Shamrock Project***" got its name.

Note however that while the Shamrock Project was originally intended to result in a totally new product, many factors became apparent over time which forced the company to slowly modify that vision to one where it was decided rather then pursuing a "revolutionary" process, that it would be more of a "radical evolution" of the existing Unigraphics II product. So while the original vision of that meeting was never realized, it started a series of events and activities that eventually lead to the development of Unigraphics V10.0. Remember that many forces were to come to play over the next several years, including the changing fortunes of McDonnell Douglas, the acquisition of Shape Data Ltd and the technology, as well as the ideas and vision of their people, that was now available, winning the GM business and the impact that their requirements suddenly had on the long term plans and then all of this coming to together with the sale of the Unigraphics organization to EDS in 1991. So in the end the impact of this meeting was akin to the proverbial stone dropped into the pond that started a ripple that eventually became a tidal wave.

However, there was one rather interesting legacy from that St. Patrick's Day meeting back in 1988. When the V10 project finally got into full swing, it was decided that as part of the marketing effort to position this product in the marketplace, that there would no longer be any use of the designation "Unigraphics II" in any company publication or marketing collateral."[42]

[42] http://www.plmworld.org/museum/the_80s.htm

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Earlier versions of Unigraphics had utilized a Program Function Keyboard (PFK) as a primary command entry device similar to the unit used with mainframe-based CADAM. As the number of functions the software handled grew increasingly large, this resulted in an awkward user interface. Some commands were eight levels deep in the user menu structure. Version 10 dramatically streamlined the user interface. Menus were no more than three levels deep and the interface adopted the OSF MOTIF architecture (similar to Windows today). The result according to EDS was that some drafting tasks would require only 20 to 30 percent of the operations previously needed and that solid modeling could be done with 50 percent fewer operations. The problem was that this would require substantial retraining of users.

Unigraphics Version 10 used Parasolid Version 5.0 and was expected to be substantially faster for most modeling operations. The new software implemented model creation and editing techniques that were far more efficient than older version of Unigraphics. The most fundamental change was that solid modeling was now a core capability rather than an optional module. Trimming surfaces no longer required selecting surface edges in the right order. Version 10 also incorporated a constraint manager as part of the basic Unigraphics software, replacing the UG Concept software described earlier in this chapter. While Pro/ENGINEER worked only with fully constrained models, Unigraphics Version 10 worked with underconstrained models as well. In fact, the software would suggest constraints that could be accepted or rejected by the user.

The new software incorporated a true assembly modeler. Existing Unigraphics software required that the user copy parts into a single model. The new software took the more up-to-date approach of simply referring to component models. Changes to part models would subsequently be reflected in the assembly model. Drafting now had bi-directional associativity with the design model and the overall software suite had more comprehensive analysis software available, some developed in house while others were the result of strategic partnerships with companies such as PDA Engineering.

A sneak preview of Version 10.0 took place at the November 1992 Autofact conference in Detroit. One of the major changes to the user interface was that the new Unigraphics software no longer required a PFK device. Field testing of Version 10.0 started in March 1993 on Hewlett-Packard workstations running the HP/UX operating system. A controlled release began in October to customers who requested the new software but four months later at the 18th Annual Unigraphics Users Group meeting it still was not in full production. It was June 1994, when Version 10.3 was released, the new software could finally be considered ready for serious use.[43] The transition to the new implementation of Unigraphics turned out to be far from painless. Some applications such as NC would not incorporate the new user interface until Version 11. But nearly everyone agreed that this was the right way to go.

Perhaps indicative of the company's future direction, EDS Unigraphics did not try to do everything itself. Rather, the company developed an impressive list of business partners including Mechanical Dynamics, PDA Engineering, ICAD (conceptual design software), CGTech (NC verification software), Valysis (quality assurance software), Technomatix (robotics programming) and LightWorks Design (visualization). Typical Unigraphics Version 10 software configurations sold for $20,000 to $25,000 per seat.

[43] http://www.plmworld.org/museum/the_90s.htm

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EDS Unigraphics announced in November 1995 that it planned to release a Windows NT version of Unigraphics in early 1996. Version 11.0 was released in January 1996 with enhanced surface modeling and expanded assembly modeling capabilities. A year later, Version 12.0 incorporated the new UG Scenario set of CAE products. Version 12.0 lasted just six months before it was replaced by Version 13.0 which implemented the company's new WAVE technology described below.

AEC activity under EDS and afterwards

As mentioned earlier, when EDS acquired McDonnell Douglas' CAD operation in November 1991, the AEC and mapping activity was set up as a separate organization, EDS/GDS Solutions, independent of the Unigraphics mechanical group. At first it was not clear that there was much of a future for GDS within EDS, but by mid-1992, led by Eric Loken, it seemed to be regaining some momentum. Other key players at the time were Kevin Sheehan who ran sales and marketing, Ray Pittman who was in charge of operations and John Emerson who handled research and development.

The overall group included about 320 people, some in Saint Louis but with most of the software developers in England. In 1992 EDS/GDS Solutions released a new PC version of GDS called MicroGDS. This was a Windows implementation that supported multiple user access to drawings, multi-window entity manipulation, and multiple drawings open in a single session. The software was originally developed in Cambridge England by CADCorp. It was priced at $3,500 and was sold by a direct sales force in that GDS Solutions did not have an established reseller organization at the time.

During a brief introductory period, the company offered a free copy of MicroGDS to buyers of a turnkey GDS system that included a Digital VaxStation 4000 which was priced around $25,000. GDS was also ported to the Hewlett-Packard Series 700 UNIX workstations since EDS coordinated all of General Motors' computer activity and HP was an approved platform at GM. Previously GDS had only been supported on Digital workstations but these were not approved for use at GM.

A-E-C Automation Newsletter ran an extensive two-part profile on EDS in its November and December 1992 issues. Several items become clear upon reading this profile.

- EDS/GDS Solutions believed that it could take EDS' expertise in managing large information technology projects and apply that experience to the AEC and mapping (GIS) markets.
- The focus was swinging away from GDS and the AEC market more towards the GIS market. The company's GIS software was feature-based rather than using traditional layer technology.
- EDS was built around large support contracts and selling $3,500 MicroGDS software packages against a mass marketer such as Autodesk just did not fit the profile.
- While GDS was a good drafting oriented package for civil engineering and architectural applications, the company lacked the complex plant design software that was needed to pursue heavy engineering and construction customers. GDS was never a factor in the world of large engineering companies such as Bechtel and Brown & Root.

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- EDS/GDS Solutions had started working on a Advanced Traffic Management System that was built around the concept of a centralized traffic control center and intelligent highway sensors and traffic monitors. This activity would eventually end up as the basis for a Bentley Systems transportation management organization in Denver, managed by Pittman.
- The company did have some significant users. GDS was the preferred software at HNTB, one of the largest engineering firms in the country and it was also being used on two huge projects in Boston, the reconstruction of the Central Artery and the design and construction of the multi-billion dollar Deer Island waste treatment plant.[44]

It eventually became clear that there was no real synergy between GDS Solutions and EDS and in mid-1993 EDS sold the company to a group of outside investors led by Murray Holland, a Dallas lawyer. The company's named was changed to Graphic Data Systems Corporation and all 270 people then working in this area for EDS ended up with the new company including most of the existing management team. At the time, about 6,800 GDS licenses were installed at 1,200 companies and government agencies worldwide.[45]

This arrangement did not last long and in 1994, GDS was acquired by shareholders of EDS, GDS and UGC Consulting of Englewood, Colorado. The resultant company was called the Convergent Group. Graphic Data Systems Corporation continued as a separate wholly owned subsidiary of Convergent. In an article in *GIS WORLD*, GDS President Mark Epstein stated that the acquisition served two purposes. "It was a mechanism for UGC to leverage the consulting and financial resources of EDS. Also, GDS gets industry expertise in management and the sales cycle."

The GDS activity was moved to Colorado where it functioned separately from the existing UGC activities in the GIS arena. The GDS vice-president of product development at the time was Joe Astroth who subsequently ran Autodesk's GIS activity.[46]

In early 1997 Convergent decided that while its GIS activities were profitable, GDS as an on-going enterprise was not earning its keep. The company ceased further R&D investment and set out to find a buyer for the GDS portion of the company. By mid year it had an agreement with Informatix Software International, headquartered in Cambridge, England, to acquire the development and marketing rights to the MicroGDS and Piranesi product lines.[47] Piranesi was an interactive rendering package originally developed in the UK. As of 2006, these packages were still being marketed by Informatix.

EDS Unigraphics at mid-life

Five years after General Motor's EDS subsidiary acquired Unigraphics, many users and industry observers were still somewhat confused over the company's direction. Some believed that Unigraphics' primary interest was simply providing design technology to GM and its suppliers. Others were concerned that in consulting situations,

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[44] *A-E-C Automation Newsletter, November and December 1992*
[45] *Engineering Automation Report*, August 1993, Pg. 12
[46] Rajani, Purvi, *GIS WORLD*, December 1995
[47] *A-E-C Automation Newsletter*, May 1997, Pg. 3

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EDS would automatically favor Unigraphics software even if was not the best fit for the client. Both of these perception were inaccurate.

EDS Unigraphics was very interested in expanding its customer base to encompass a broad range of users while EDS' consulting activities never seemed to involve Unigraphics to a significant extent except in regards to GM. By early 1996, there were nearly 45,000 seats of Unigraphics software installed at 4,500 customer sites worldwide. Less than 20 percent of this installed based was at GM and its suppliers.

Unigraphics executives including president John Mazzola talked extensively about the synergy between Unigraphics and EDS' consulting activity and how their combined resources could significantly benefit customers. This could cover everything from strategic planning to operational consulting and making the best use of emerging technology. EDS was even prepared to apply its "outsourcing" talents to taking over and operating a company's engineering computing infrastructure much like they did for GM. As good as all this sounded, it never really caught the imagination of large users and Unigraphics ended up functioning much like most other technical software firms.

Since 1993, Unigraphics had been working with customers helping them make the transition to Version 10. By 1996, about 80 percent had made the move. In the interim, a number of point releases had been delivered to users. Version 11 came out in early 1996 based on Parasolid Version 6.2. It contained extensive geometry enhancements, improved speed both in geometric manipulations and visualization and more comprehensive user development tools. Version 11 also contained improved assembly modeling capabilities.

Users wanted to work with increasingly complex models and computer performance was not keeping up with this requirement. Unigraphics compensated for this by filtering assembly model data and loading just a subset of information that the user needed for the task at hand. As an example, if a user was working on a small subassembly only the data needed to detect interferences with the rest of the model needed to be loaded.

By early 1996, Unigraphics was starting to get more serious about product data management. Two products were being offered. UG/Manager provided multi-user access to part and assembly data for small workgroups while IMAN was intended for larger design groups and those who needed this data in other departments. There was a conflict within the company in that some wanted IMAN to be positioned as an enterprise-wide solution while other saw it as having more limited capabilities.

With Version 11, Unigraphics was available running under Windows NT on both Digital Alpha and Intel platforms as well as on traditional UNIX platforms. The NT implementation had the look and feel of the UNIX workstation version. Initially, just basic design and drafting was available on this new operating system. It took most of 1996 to complete the port to Windows NT.[48]

On June 7, 1996 GM completed the spin-off of EDS as an independent company with Lester M. Alberthal Jr. as CEO. The expectation was that this would provide EDS Unigraphics with more flexibility to pursue non-GM business. As part of the spin-off, EDS negotiated an agreement with GM to standardize on Unigraphics software, consolidating some 26 different systems then in use and to eventually install an additional 10,000 seats of Unigraphics software. During the first six months of 1997, 2,100 new seats were installed bringing the total to 7,000.

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[48] *Engineering Automation Report*, February 1996, Pg. 6

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By March 1997, the company was shipping Unigraphics Version 12 which implemented bi-directional associativity between design and analysis modules under the UG/Scenario nomenclature. Unigraphics started reporting a fairly steady stream of new accounts including Bell Helicopter, VisionAire, Ericsson and the Swiss technical university, ETH Zurich.

EDS Unigraphics out from GM's shadow

Throughout its entire life, Unigraphics had existed in the shadow of a much large industrial companies, first McDonnell-Douglas and then General Motors. Although EDS was a multi-billion dollar enterprise, at least it was in the computer services industry and its top executives intimately understood the dynamics of that business even if they did not have a similar grasp of the CAD industry. In the year or so after the EDS spin-off from GM, EDS Unigraphics seemed to shift into a higher gear and achieve a momentum they have maintained ever since.

Because the company had been owned by GM, it had been very difficult for Unigraphics to obtain major business from other automotive OEMs. They had, however, shipped over 6,000 seats of Unigraphics software to more than 950 automotive component suppliers. On the other hand, Unigraphics was doing well in the aerospace sector with major orders from BE Aerospace, British Aerospace, Ilyushin, Antonov, Northrop and Boeing Defense.

More and more, Unigraphics marketing emphasized enterprise-level productivity. One tool towards this goal was greater ability to share data between applications. The company called this the "Product and Process Pipeline" which consisted of the Parasolid solid modeling kernel, IMAN product data management and Internet/intranet communications. Over the next seven years the company would redefine and refocus this concept but even by the fall of 1997 the strategy was well in place.

Unigraphics Version 13 introduced an exciting new tool for top-down engineering design. WAVE (What-if Alternative Value Engineering) was a technique for defining a complex product such as an automobile in a way that enabled designers to make fairly significant changes and have these changes propagate throughout the entire model. Two key elements of WAVE were the WAVE Associativity Manager and the Visual Editor. As an example, once an automotive model was built using these tools, it was possible to change the wheelbase on the vehicle and have it go from being a four-door sedan to a two-door coupe.

Within basic Unigraphics, the company emphasized new sketching techniques, virtual product mockup, high performance visualization and the start of integrating design with analysis. The visualization used an Hewlett-Packard developed concept called DirectModel. By 1997 Unigraphics had ratcheted up its relationship with HP to the point where it had become one of the strongest and longest lasting strategic partnerships in the CAD industry. About this time, Unigraphics also began offering lower cost versions of its software including UG/Creator for $5,995 and UG/Designer for $9,995.[49]

Parasolid becomes an accepted component technology product

Prior to the early 1990s, every CAD software vendor developed its own geometric modeling core. In fact that is what most companies thought distinguished them from their

[49] *Engineering Automation Report*, September 1997, Pg. 6

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competitors. Spatial Technology, now a Dassault Systèmes subsidiary, was the early leader in providing geometric modeling software with its ACIS product. Unfortunately, ACIS suffered from a lack of geometric completeness, the timeliness of new releases and quality issues.

In 1994, SolidWorks switched from the early use of ACIS to EDS Unigraphics' Parasolid prior to the release of SolidWorks 95. Most other vendors were initially reluctant to follow suit in that they were concerned about using such a critical piece of software when it was controlled by a competitor.

As Parasolid became a more and more important element of Unigraphics software, EDS/Unigraphics acquired Parasolid as noted earlier and invested significant resources in improving the geometric coverage and performance of the software. By 1997, problems with ACIS were serious enough that additional vendors decided to make the switch to Parasolid including Bentley and Intergraph's Solid Edge business unit.

EDS Unigraphics acquires Intergraph's mechanical business unit

In October 1997, EDS and Intergraph announced that they planned to form a new company consisting of Intergraph's mechanical business unit, Unigraphics and a small amount of EDS' consulting activity that was directly related to supporting Unigraphics. EDS would own the majority interest in this unnamed company while Intergraph and the company's employees would own minority interests. Altogether, the company would have a little over 2,000 employees, 350 from Intergraph and 1,700 from EDS Unigraphics.

The Intergraph activity consisted of both the company's older EMS software as well as Solid Edge, a new mid-range mechanical CAD package. There never was any question but that the plan was to encourage EMS users to switch to either Solid Edge or Unigraphics. This was particularly important in regards to the large Navy CAD-2 contracts Intergraph had won in the early 1990s. According to John Mazzola, the Intergraph group would function as a separate activity with its own product development and marketing.

Mazzola expected the new company to do between $400 and $450 million in 1998 of which $80 million would be hardware resale. He saw the two products targeted at different market segments, Unigraphics at its traditional large manufacturing firms while Solid Edge would focus on smaller manufacturing companies.

Since Unigraphics used Parasolid as its modeling kernel and Solid Edge planned do the same with Release 5.0 due out in the March 1998 timeframe, it seemed that Unigraphics would be better able to integrate the two packages together than would Dassault with CATIA and SolidWorks which used dissimilar modeling kernels. That definitely proved to be the case.

UGS Goes Public and Completes Intergraph Mechanical Acquisition

In subsequent months the planned deal with Intergraph changed significantly. Instead of establishing a jointly owned new company, EDS restructured EDS Unigraphics in early January 1998 as a separate enterprise called Unigraphics Solutions with John Mazzola as its president and CEO. This entity then purchased Intergraph's mechanical systems business unit, including both Solid Edge and EMS, for about $100 million which EDS loaned the new company.

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EDS then sold three million shares of Unigraphics Solutions to the public at $14 per share on June 18, 1998. EDS still retained control over UGS since each share of stock it owned had ten votes compared to a single vote per share for those shares owned by the public. One negative aspect of the establishment of an "independent" company was that Unigraphics Solutions (or UGS as most people referred to it) received none of the sales revenue from the previously mentioned 10,000 seats of Unigraphics sold to GM although it did subsequently receive substantial maintenance and support revenue.[50]

After acquiring Solid Edge, UGS implemented a four-prong business strategy consisting of Parasolid, Unigraphics, Solid Edge and IMAN. In 1998 revenues were running at about a $400 million annual rate and the company had nearly 80 sales offices around the globe.

Under UGS, the Solid Edge product seemed to thrive, much as SolidWorks was under Dassault's ownership. Some people apparently did know how to make high-tech acquisitions work. UGS focused Solid Edge on the machinery industry, particularly companies that built manufacturing equipment. This market segment did not require complex surface geometry but it did require that the software handle large assemblies. By late 1998 assemblies with 5,000 parts were being handled by Solid Edge without any obvious problems. The Solid Edge team demonstrated fairly quickly that they were comfortable with this business concept.

Technically, Solid Edge personnel focused on making the software easier to use. One result of this was Solid Edge STREAM technology which used inference logic to predict user interactions. Solid Edge Version 6 was released in December 1998 with additional modeling enhancements, a sheet metal design module and new capabilities intended to facilitate the design of plastic parts.

Modeling now included the ability to drag-and-drop features. Gradually, the company was also improving Solid Edge's surface geometry functionality. With Solid Edge Version 6 and Unigraphics Version 16.0, the two packages were able to read each other's part files and could incorporate the other's parts into assemblies. By early 1999 the company was shipping 1,000 copies of Solid Edge a month and had a number of customers with over 100 copies.

UGS never had any intention of enhancing EMS or soliciting more customers for that software package. Basically it went on life support. The largest EMS customer by far was the U.S. Navy in that Intergraph had won the lion's share of the Navy's CAD-2 procurement in the early 1990s. Initially, the Navy had purchased Intergraph UNIX workstations with EMS and MicroStation software. When the Navy decided to switch to Windows NT PCs to save money, EMS could no longer be supported. The contracts were modified so that UGS was able to provide Solid Edge and Unigraphics to Intergraph Federal Systems which in turn provided the software to the Navy.

By early 2000, the company had shipped 20,000 copies of Solid Edge and was delivering Version 8 with significant assembly design enhancements.[51]

Interest in PDM heats up

By 1998, Product Data Management was taking on increased importance at UGS. The company's primary PDM software, IMAN, had an extremely strong data architecture

[50] *Engineering Automation Report*, August 1999, Pg. 9
[51] *Engineering Automation Report*, March 2000, Pg. 5

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that facilitated the implementation of solutions that covered distributed user groups and had excellent integration with Unigraphics plus the ability to handle non-UGS data. When IMAN Version 4 was released in late 1997, UGS introduced Distributed IMAN (D-IMAN) which facilitated the distribution of product data across multiple sites of an enterprise. In mid-1998, UGS released IMAN V5 which incorporated numerous enhancements to D-IMAN and other modules of this product suite.

D-IMAN enabled users at any site to find necessary files by performing a remote find operation on the IMAN Object Directory Services (ODS) database. The ODS acted as a master index for all the information the different sites wanted to publish and make available to authorized users. Each site or development team decided when it wanted to release design data and who they wanted to share it with. There were tools in IMAN that facilitated much of the process such as automatically releasing a certain class of documents once the design had reached a particular state of approval.

High-speed communication services were just becoming readily available at that point in time and accessing project data from sites distributed over a large geographic areas was still extremely time consuming. Networks were easily overburdened by constant activity between uses and remotely located files. D-IMAN resolved this problems by using a process of controlled replication. Data created at remote locations was readily available through the ODS. Replication was synchronized at times that were convenient for each site.

Analysts such as Wayne Collier of D.H. Brown stated:

> "The federated capabilities of the D-IMAN module provide the kind of flexibility that large-scale customers need to manage product information in a distributed enterprise. D-IMAN allows customers to model the rules and data structures that are unique to each individual site in a federation – an essential component of virtual enterprises."[52]

IMAN V5 also incorporated new Web functionality that eliminated much of the need to develop and support different software for each client machine type supported by IMAN. The company considered this to mean that IMAN was “Web-enabled.” The next release, Version 6, was to be Web-centric” rather than just Web-enabled. In addition to the full implementation of IMAN that UGS continued to provide, a stripped-down version called UG/Manager as described earlier was also available.

UGS starts flying on its own

Although EDS continued to own a controlling interest in UGS, there was little evidence that EDS exerted much influence on the company’s day-to-day operations. As an example, in September 1998 UGS held the first of a series of annual briefings for the media and industry analysts. Held in Newport Beach, California, there was little presence by EDS management and only one presentation by someone from EDS extolling the potential synergy of the relationship between the two companies. As much as they talked about that synergy, it seems like it rarely occurred.

Unigraphics Version 15 was targeted for release in late 1998. This release had a user interface that conformed more closely to the Windows NT style, a significant

[52] *Engineering Automation Report*, September 1998, Pg. 6

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enhancement considering that nearly 50 percent of Unigraphics software shipments were the NT version. Parasolid was also gaining momentum although it only amounted to about 2 percent of UGS' overall revenue. In particular, UGS was having some success licensing Parasolid to NC software firms including Gibbs, DP Technology and CNC Systems. New versions of Parasolid continually enhanced the kernel's geometric coverage, performance and reliability.

The company's analyst briefing in July 1999 was particularly upbeat. Mazzola stated that the company had received 25 orders in the first half of the year that involved 50 or more seats of software or over $1 million of total revenue. UGS was in the process of phasing out the resale of computer hardware and for a while, this put a damper on the company's overall sales growth but it was a necessary move as reselling hardware was quickly becoming a profitless business for systems companies like UGS. At the briefing, the company was very enthusiastic about Solid Edge, IMAN and Parasolid. One could see that UGS was quickly becoming a premier vendor in the industry and one concern among writers and analysts was that EDS didn't do anything to screw it up.

In early 2000 UGS began shipping Unigraphics Version 16. In addition to many hundreds of individual enhancements, this was the first release that was developed using Windows NT as the primarily programming environment. In the past, the UNIX version was developed and then converted to run under Windows NT. From this point forward it was done the other way around. The most significant new application was DesignStudio which provided high-end surface design commonly associated with industrial design software such as Alias Studio and CDRS (which had recently been acquired by PTC and renamed Pro/DESIGNER.). The other major emphasis of Version 16 was what UGS was now calling "Predictive Engineering." There were three components that made up this initiative:

- process wizards that facilitated the design of standardized processes such as mold design
- analysis
- optimization and design capture.[53]

The following month UGS surprised many in the industry when it acquired what was left of Applicon (See Chapter 7) for $10 million, mostly to obtain that company's programming talent in Ann Arbor, Michigan. Eventually, most Applicon users switched to Unigraphics and/or Solid Edge.

General Motors continued to be a major part of UGS' business. Although the company did not receive any of the revenue from the 10,000 licenses GM purchased from EDS just before UGS was spun off as an independent company, it did garner substantial service and support revenue. In June 2000, GM awarded UGS a $139 million contract for additional software and services.

This was probably the largest non-government contract in the history of the CAD industry. The primary software covered by the contract was 30,000 seats of iMAN (nomenclature had been changed from IMAN), many of which had already been installed. In actuality, this contract covered the prior year as well as the next two years. By mid-2000, GM had over 8,600 seats of Unigraphics software installed and most legacy systems had been phased out.

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[53] *Engineering Automation Report*, February 2000, Pg.12

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UGS in the 21st century

In late June 2000, John Mazzola announced that he would be retiring in early 2001 after 35 years with UGS and predecessor incarnations of the company. Then, on July 12th, a second UGS press release stated that Tony Affuso, who had been made COO when Mazzola announced his pending retirement, had been named President and CEO effective immediately and that Affuso was also assuming Mazzola's seat on the Unigraphics Solutions Board of Directors.

The first reaction was that Mazzola was being prematurely pushed out. That turned out not to be the case. At the 2000 summer analyst meeting, Mazzola said that he had originally stated that he would retire on March 31, 2001 or when a replacement was found (the last point was left out of the June press release). He also stated that he encouraged the board to give Affuso the job and the Board went along.

Tony Affuso was the Executive Vice President of Products and Operations and COO at the time he was promoted to CEO. He had joined Unigraphics in 1991 when EDS acquired the company from McDonnell Douglas. Prior to that, Affuso had been with EDS working on the implementation of the C4 project at GM. As a bit of trivia, he had been a manger at Xerox where, in 1983 he was part of a team that evaluated CAD systems including Unigraphics but selected a non-Unigraphics system.[54]

At the 2000 analyst meeting Mazzola (Affuso was not at the meeting due to a travel conflict) spent a fair amount of time discussing the company's success in growing revenue while at the same time being extremely profitable. While the overall industry had been struggling to grow much more than 10 percent annually during the previous few years, UGS had been growing by better than 25%. This was in spite of the fact that the company had been exiting the hardware resale business. In the two years since UGS went public, the company had grown from 5,600 customers to over 13,500.

Figure 19.10
Tony Affuso

Mazzola was frustrated by the fact that Wall Street failed to recognize the company's accomplishments and its potential. UGS stock sold for just 14 times earnings and a little more than one times revenue while Dassault Systèmes sold for over 100 time

[54] http://www.plmworld.org/museum/the_00s.htm

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earnings at the time and nearly 20 times revenue. A major problem was that EDS still owned 86% of UGS and controlled 98% of its voting rights.[55]

Adding high-end visualization software

The next major development occurred on September 5, 2000 when UGS and Engineering Animation Inc. jointly announced that the two companies had reached a definitive agreement allowing UGS to acquire EAI in a cash tender offer expected to be worth about $205 million. The agreement called for shareholders of EAI to receive $13.75 cash for each share of EAI common stock owned, 18 percent more than what the stock had previously been selling for.

EAI was a well respected vendor of high-performance graphic visualization software that had run into some financial difficulties due to problems with how revenue was being booked. By the time UGS agreed to acquire the company, most of these problems were behind it and EAI was regaining financial viability.

The initial plans were that EAI would be financially structured as a subsidiary. Key EAI executives including vice president Martin Vanderploeg, one of the founders of EAI, and vice president and CTO Jeffrey Trom planned to remain with the company while chairman and CEO Matthew Rizai EAI left the company. Eventually EAI became the focal point for UGS' factory automation and visualization activities under the E-factory brand. This acquisition also added EAI's JT interoperability data format to UGS' product offering.

Meanwhile Solid Edge continued to pick up momentum. In 1999 the company had initiated a marketing program called Solid Edge Origin under which it had distributed 900,000 copies of a stripped down version of Solid Edge. 120,000 recipients took the time to register to use this software and an unreported number ended up converting to the full Solid Edge package. The Solid Edge business unit, which was still managed by Bill McClure, continued to focus on the machinery manufacturing industry.

In 1998 the company had touted the fact that Solid Edge could handle assemblies with nearly 15,000 discrete parts. By late 2000 this number was up to 60,000. Solid Edge Version 9 began shipping in November 2000 with a new optional Engineering Handbook module developed by MechSoft.com of Austin Texas. The company also introduced software for converting two-dimensional drawings to three-dimensional models. Initially this software, Xpand3D, was based on technology developed by Manufacturing and Consulting Services (see Chapter 15) but was eventually replaced with internally developed software.[56]

The company's name was changed once again in early 2001, this time to simply UGS. The move reflected the fact that UGS developed and marketed more than just Unigraphics software. At about the same time, world headquarters for UGS was moved from St. Louis to Cypress.

Acquisition of SDRC and a major corporate restructuring

On May 23, 2001 EDS announced an agreement in principal to purchase Structural Dynamics Research Corporation (SDRC) for approximately $950 million in cash, or $25 per share. Concurrent with that purchase, EDS also planned to buy the 14

[55] *Engineering Automation Report*, August 2000, Pg. 9
[56] *Engineering Automation Report*, November 2000, Pg. 4

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percent of its UGS subsidiary that was publicly held. That offer to the UGS stockholders was expected to be $27 per share or approximately $170 million. After complaints from UGS stockholders that the price was too low it was subsequently raised to $32.50 per share. It would end up taking until October 1, 2001 for EDS to complete the acquisition of SDRC and the outstanding UGS stock.

The new company was initially known as EDS PLM Solutions. At the time the deal was first announced, EDS stock was selling for about $60 a share. In mid-2002 EDS ran into some accounting problems of its own that pummeled the company's stock. The share price dropped to just above $10 per share before recovering to about $25 in mid-2006. This would eventually have a major impact on the future of EDS PLM Solutions.

The result of these two transactions was UGS was once again wholly owned by EDS but was now be a much larger enterprise. The plan was to combine the two companies under the UGS name as EDS' fifth line of business, albeit as the smallest of the five. Tony Affuso, UGS president and CEO, became the president of this new EDS business unit with more than $1 billion in reported annual revenues.[57] Headquarters were moved to Plano, Texas in order to be closer to EDS headquarters.

More details of the merger were described at the annual UGS press and analyst meeting that July. Of the 24,000 customer UGS and SDRC had, only about 1,000 were customers of both firms according to Affuso. Chuck Gindstaff, who then had the title of executive vice-president of operations at UGS, described in detail to the attendees how they planned to merge I-DEAS and Unigraphics. The plan was to release several additional versions of the two packages with increasingly tight integration between them until around the third major release, I-DEAS and Unigraphics would be one and the same. In mid-2001, I-DEAS Version 9 and Unigraphics Version 18 were both close to being released but they were able to add improved geometry exchange capabilities before the software actually shipped.

Part of the integration plan included increased use of the JT data format UGS had picked up when it acquired EAI and was used to produce lightweight tessellated data used by iMAN and some visualization programs. The other important exchange format was the eXT format which was an XML wrapper around the Parasolid XT format. There were several presentations by EDS executives trying to explain why the new combination of SDRC and UGS under the EDS banner would lead to a significant increase in large scale systems integration business.

While both company's had strong CAD/CAM solutions, SDRC was stronger in the integration of analysis software into the design process and its Metaphase software was significantly stronger than UGS' iMAN product. On the other-hand, SDRC had been unable to penetrate the mid-range market and had nothing comparable to Solid Edge. SDRC brought Ford and Nissan to the table while UGS, of course, counted GM as its premier customer. Overall, the two companies complemented each other fairly well, especially if they could follow through on the I-DEAS/Unigraphics strategy described by Grindstaff.[58]

The new generation of software was subsequently given the NX designation. First out of the chute was Unigraphics NX (what under other circumstances would have been referred to as Version 19). The NX stands for NeXt generation software. Announced on

[57] *Engineering Automation Report*, June 2001, Pg. 3
[58] *Engineering Automation Report*, August 2001, Pg. 3

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October 8, 2002, Unigraphics NX came with an easier to use user interface, knowledge-driven task automation tools, better capabilities for editing models imported from other CAD systems and improved tools for exchanging models with I-DEAS.

Over the next several years, the company met most of its NX delivery goals, both for timeliness and content. Unigraphics NX 2 came out in August 2003 with improved usability, enhanced knowledge-based design and better data exchange. The intent was not to translate I-deas (the new EDS nomenclature for I-DEAS) models but to basically rebuild them in Unigraphics starting with the I-deas history and feature data.

About the same time, the company released Solid Edge Version 12 which also had an improved user interface as well as enhanced assembly modeling capabilities. In Version 12, EDS replaced the original two-dimensional to three-dimensional conversion tool from Version 9 called Xpand3D with a new Create 3D tool that worked much better.[59]

By late 2002 Solid Edge was probably a match for SolidWorks in most areas other than advanced surface modeling. The Solid Edge business unit decided to skip Version 13, especially after the problems Autodesk had with AutoCAD R13. Version14 was announced in early 2003 with significant enhancements to surface modeling. Solid Edge customers were now building models with over 100,000 individual parts. With this release, Solid Edge could now exchange data more effectively with I-deas.[60] By the time Version 15 was released in late 2003, Solid Edge compared favorably with main stream design packages of just a few years earlier.

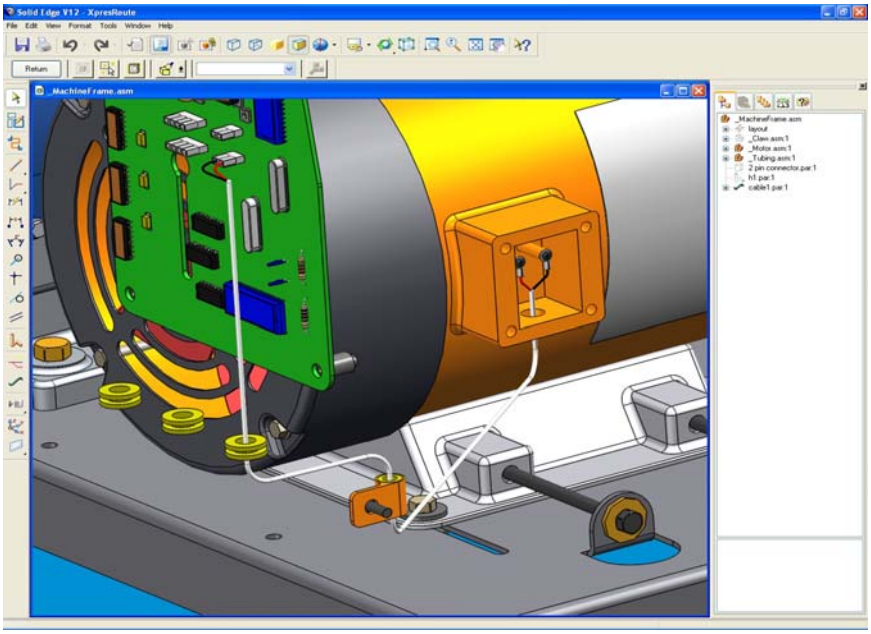

Figure 19.11
Solid Edge Version 12

[59] *Engineering Automation Report*, November 2002, Pg. 3
[60] *Engineering Automation Report*, March 2003, Pg. 4

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Two More Changes in Ownership

On November 11, 2003, EDS announced the EDS PLM Solutions would henceforth be called UGS PLM Solutions. (At this point I have lost track of the number of times the name for this business activity has been changed.) A month earlier, EDS had announced that it was planning either a new IPO or a private offering for a minority stake in the company. EDS' own financial problems were probably the driving factor behind this announcement.

After reporting disappointing financial results for 2003, EDS announced that it was considering the sale of UGS PLM Solutions after receiving what it termed significant interest from several parties.[61] On March 14, 2004 EDS announced that it had reached a definitive agreement to sell its UGS PLM Solutions unit for $2.05 billion in cash to a group of three private equity firms: Bain Capital, Silver Lake Partners, and Warburg Pincus. UGS at the time had annual revenues of about $900 million and earnings of just over $100 million. The sale closed on May 27, 2004 and the company's name was changed to UGS Corporation with Tony Affuso continuing as president and CEO. Each of the investors had an equal stake in the company.[62]

The software migration to NX continued on schedule with the release in April 2004 of I-deas 11 NX Series. From a business point of view, a significant development was the acquisition of Cambridge, England-based D-Cubed, Ltd., a developer of well respected constraint management software used by many CAD vendors. It nicely complemented the company's Parasolid software.

One of the interesting aspects of the new UGS was that in spite of the fact that it was privately owned it decided to release quarterly financial data. Revenues for the quarter ending June 30, 2004 were up 11 percent to $236 million with operating profits of $29 million. During a conference call discussing the company's results, Affuso was particularly upbeat about the company's prospects, especially in regards to its PLM opportunities. He gave five reasons users were poised to more aggressively install comprehensive PLM solutions:

1. Companies are now interested in generating greater sales, not just in lowering costs.
2. Manufacturers want to streamline their business processes.
3. Competitiveness means enhancing product commonality and reusing components (up to 50 percent in the automotive industry).
4. Strategic partnerships are increasingly important.
5. They want a single source of process information.

According to Affuso, if you looked at the most basic PLM component, the managing of engineering documents, only about 30 percent of the company's customers were doing this adequately. As you explore more complex aspects of PLM such as configuration management, that percentage went down dramatically. The basic message was that was still a lot of room for growth of the business.[63]

On September 15, 2004 UGS announced NX 3, the timely culmination of a three-year project to bring together the company's Unigraphics and I-deas software in a single

[61] *Engineering Automation Report*, March 2004, Pg. 8
[62] *Engineering Automation Report*, April 2004, Pg. 1
[63] *Engineering Automation Report*, August 2004, Pg. 10

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product. NX 3 is the version in which I-deas users were able to migrate data without the need for data translators. Instead of translation, NX 3 regenerated I-deas geometry using the same algorithms used in I-deas itself. The software was not only able to read I-deas three-dimensional part and assembly models, but also read drawing files with complete fidelity and maintain the associative relationships between models and drawings.[64]

Then in January 2007, UGS Corporation announced that it was being acquired by Siemens AG for $3.5 billion – a nice profit for the three private equity firms that had paid a little over $2 billion less than three years earlier. UGS was initially renamed UGS PLM Software and became part of Siemens' Automation and Drives Division when the deal closed a few months later in May 2007. Affuso remained chairman and CEO of the company although two senior Siemens executives joined the company, Tilo Brandis as president and Peter Bichara as executive vice president and CFO.

In mid-2007, UGS began shipping NX Release 5 with a stripped down user interface, emphasis on handling large assemblies efficiently and direct model editing that avoided some of the problems of pure history-based modeling and enabled users to directly edit existing geometry. Brandis was unable to permanently join the UGS team in Plano, Texas due to family health reasons and was replaced as president by another Siemens executive, Dr. Helmuth Ludwig. Of course the acquisition required one more name change, this time to Siemens PLM Software.

As this is being written, it is too early to tell how similar the Siemens acquisition will be to General Electric's disastrous acquisition of Calma more than 20 years earlier as described in Chapter 11, but so far it seems to be working well.

[64] CADCAMNet.com, September 16, 2004

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