SUN MICROSYSTEMS® & A STRATEGIC ANALYSIS
OF THE WORKSTATION INDUSTRY

by

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ABSTRACT

The technical workstation industry has been the fastest growing segment of the computer industry, with an annual compound growth rate of over 30% per year from 1981 to 1987. The industry has recently been characterized by several factors which have altered the nature of competition from being primarily technology-driven to that which is based on a multitude of complex strategic variables. Advancements in hardware and software technology have opened new markets, giving rise to the need to alter marketing and distribution strategies. The entrance of large computer companies into the industry has created the need for strategic alliances in order for workstation manufacturers to keep pace with technology improvements and to subsidize their continued growth.

Sun Microsystems rose to the number one position in 1987, when it surpassed Apollo Computer in sales revenues. With Sun's past success and the fast-paced industry evolution, Sun faces many challenges and strategic choices in order to maintain its leadership and continued growth in the upcoming years.

This thesis presents a discussion of the workstation industry and the nature of competition as a basis for analyzing the strategic challenges facing Sun.

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CHAPTER 1
INTRODUCTION AND METHODOLOGY

This paper presents a discussion of the competitive strategies of the leading companies in the workstation industry as a basis for analyzing the alternatives facing the leading company, Sun Microsystems. Seven strategic variables are defined as the key factors which shape competition within the industry. The material presented is based on approximately 20 interviews with key individuals at leading companies in the industry, in addition to a large body of articles from trade journals, newspapers, industry reports, and data from market research firms.

The structure of the workstation industry has evolved since its inception in 1981 from an industry with less than $25 million in revenues and a few specialized participants, to a $3 billion industry in 1988 with several larger computer companies competing for the same markets as the smaller niche and medium-sized players. As workstation technology has developed, improvements in the price/performance of the equipment and the availability of a large library of software have opened new market segments and altered the nature of competition within the industry.

Several factors make the workstation industry an interesting subject for analysis:

- The workstation industry has been the fastest growing segment of the overall computer industry in the last several years, growing at a compound rate of over 30% per year from 1981 to 1988.
• Many computer giants have entered the industry, and some of the early entrants, such as Sun and Apollo, are fast becoming billion dollar companies.

• The evolutionary pattern of the industry, influenced by technological factors, is similar to that observed in other emerging high-tech industries, such as the personal computer and the supercomputer industries. As technology improves, more commercial markets have emerged in addition to many new technical segments, and therefore, workstation companies must reorganize to serve the needs of both technical and commercial markets.

• As a result, competition among the leading participants in the industry is based on a multitude of complex strategic variables, including:
  • Adherence to industry standards
  • Price/performance leadership
  • Strategic alliances
  • Manufacturing
  • Channels of distribution
  • Market focus
  • Range of product offerings

Sun Microsystems was chosen as the subject of the case analysis for several reasons:

• Sun has been a very aggressive company, with the prolific expansion of its product line, and its success at bringing other important players into the industry to help influence the direction of industry standards.

• Sun emerged as the leading company in 1987, mainly as a result of its relentless promotion of industry standards and its effective marketing approach.
- Sun's strategy has significantly reshaped competition within the industry, and as a result, has caused key elements of the industry structure to change.
CHAPTER 2
SUN'S CHALLENGE

Sun's Company History and Past Performance

The workstation industry was pioneered by Apollo Computer of Chelmsford, Massachusetts when it launched its first system in 1980. Sun was the second entrant to the industry in early 1982 when Sun's 27-year-old co-founders Andy Bechtolsheim and Vin Kholsa recruited Stanford business school classmate Scott McNealy and Berkeley's UNIX® guru, Bill Joy, to form the company. Sun's first product was a workstation which Bechtolsheim built out of spare parts scrounged from Silicon Valley supply houses while at Stanford.¹ All founders were still with the company in early 1988, with the exception of Kholsa who withdrew from the day-to-day operations to retire at the age of 30.

Sun's workstation shipments grew 50% every six months from 1982 to the end of 1987. Exhibit 1 shows Sun's growth in shipments in the past several years. Earnings have more than tripled and the stock price has more than doubled since the company went public in March, 1986 (Barron, 1988). Sun surpassed Apollo in earnings in 1985, when Apollo suffered a loss for the year due to slow sales in the design automation market, which had comprised 63% of Apollo's sales. Sun, on the other hand, had spread it sales more evenly between different application market segments.

In 1987, Sun surpassed Apollo in revenues, with $754 m in sales for the calendar

¹ The name Sun is an acronym for Stanford University Network, the communications project for which Bechtolsheim designed this first workstation.
year 1987. For its third fiscal quarter, which ended March 25, 1988, Sun reported an 81% gain in revenue to $260 million, from $143 million a year earlier. However, margins were trimmed by escalating prices for scarce memory chips, and net income rose to $14.3 million, a 40% gain from a year earlier (Bulkeley, 1988). To support their rapid growth in revenues, Sun's employment level grew by 40% in 5 months from July to November, 1987, when it had 5200 employees. Exhibit 2 shows the growth in revenues since 1982 for the leading workstation companies. Exhibits 9 and 10 show Sun's consolidated income statements and balance sheets.

Strategic Choices Facing Sun

After six years of spectacular growth in the workstation industry, Sun Microsystems' 33-year-old President & Chief Executive Officer, Scott McNealy, is faced with the challenge of how to keep his company on the same fast track it has been on since its founding in 1982. There are several options for directions in which to take the company:

- Expand into a broad-based, general-purpose computer company along the lines of a Digital Equipment Corporation;

- Concentrate on high-end desktop graphics supercomputers like those manufactured by new entrants, Stellar and Ardent;

- Focus on a few market niches where Sun had been successful in the past, such as computer-aided software engineering and design automation;

- Focus on the potentially high-growth low-end workstation markets, primarily commercial applications, with products that compete with the new generation of personal computers offered by such strong forces as Apple, IBM, and Compaq.
Sun has taken steps in each of these directions. The questions that Sun must answer are (a) which direction(s) to pursue, and (b) what changes would be required to carry out the future growth?
CHAPTER 3
INDUSTRY OVERVIEW

Workstation Definition

A workstation is a high performance, single-user, multitasking computer, with extensive networking and graphics capabilities. They are usually characterized by a 32-bit computer with a large high-resolution display, virtual memory, multitasking operating system such as UNIX or VMS, and large varying amounts of RAM memory and disk storage. In the full line of computers, workstations are bracketed on the low end by personal computers (PCs) and on the high end by multi-user minicomputers. The price range for workstations is approximately $5,000 to $200,000.

Workstations can be grouped into low-end, mid-range, and high-end classes. Low-end systems are priced from around just under $5000 to $20000 and infringe on the turf of personal computers. These systems are typically offered in a desktop configuration, with 2 MBytes to 32 MBytes of physical memory. Disk storage can vary from around 40 MBytes to 600 MBytes. These workstations are suitable for 2D design and drafting, software development, computer-aided publishing and commercial applications. The critical factors influencing vendor success in this category are the availability of third-

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2 Prior to 1988, industry analysts referred to these workstations as technical workstations. The "technical" distinction has been dropped with the increase in the number of commercial applications.

3 UNIX is a multitasking operating system developed initially by AT&T's Bell Labs, which became popular because of its capabilities and AT&T's low-cost licensing program. VMS is DEC's proprietary operating system for their VAX computers.

4 The price ranges for these systems are ballpark estimates, compiled from company literature and several industry reports, which differed widely in the way in which the workstations were classified.
party software, manufacturing capability, reliability, and alternate distribution channel expertise. Sun, DEC, Hewlett-Packard, and Apollo all offer competing products in this range. There are several personal computer manufacturers which offer systems having features similar to these low-end workstations, including IBM, Apple, and Compaq.

Mid-range systems offer more power to handle 2D & 3D graphics applications. Prices range from $20,000 to $80,000. These systems are typically offered in a deskside configuration, and can be configured with 2 MBytes to 32 MBytes of physical memory. Disk storage can vary from around 40 MBytes to 5.6 GBytes. Typical uses in this class are for those applications requiring more compute power than low-end applications, such as finite element analysis, electrical and mechanical design and drafting, and computer-integrated manufacturing. DEC, Hewlett-Packard, and Apollo also offer products in this class.

High-end platforms, sometimes referred to as desktop graphics supercomputers, couple high-performance computing and 3D graphics, with performance around 10 MIPS. New entries from Stellar and Ardent might be as high as 30 MIPS by the end of 1988. Prices range from less than $40,000 to around $200,000. Most of the systems in this class are based on the RISC processor technology.

They are used for applications which require sophisticated graphics and are computation intensive, such as solids modeling, electronics design, visual simulation, scientific modeling, animation, geophysical science, medical imaging, defense and artificial intelligence. The needs of the applications in this class are driving the technology; the demand for more graphics and compute power is insatiable. Silicon Graphics, Sun, Apollo,

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5 Million instructions per second
6 Reduced Instruction Set Computer
and Hewlett-Packard all offer systems in this range. Gross profit margins appear to be about 10% higher on the high-end systems than on the low-to-mid-range systems.\footnote{From annual report data, the gross margin percentage, calculated as (net sales - cost of sales / net sales) was about 57% in the last two years for Silicon Graphics, who sells high end systems, versus approximately 48% for Sun and Apollo who sales are primarily low-to-mid-range systems.}

**Differences between workstations and personal computers**

On the low-end, workstations have been competing for the markets traditionally held by personal computers, by offering the business and commercial user more compute power, and better graphics and networking capabilities to tie several systems together. The distinction between a personal computer and a low-end workstation has been reduced significantly since the generation of the first workstations in the early 1980s. During 1987, there were a few key events that caused the distinction between these two products to blur (International Data Corp., March, 1988 and Burdick, 1988). Some of the actions taken by workstation companies to infringe on the traditional low-end PC markets and to provide protection of their technical markets from PC companies are:

- Major workstation companies reduced the prices of their low-end systems to match those of the high-end PCs.

- Workstation companies added 80x86 compatibility through co-processors which run on the workstations, giving workstation users access to the huge base of IBM-compatible\footnote{MS-DOS has been the primary operating system for 80286-based systems. The new IBM systems based on the 80386 processors will use the OS/2 operating system.} software. Particularly Sun, Apollo, HP, DEC, Apple, Symbolics, and NEC have such options.

- Sun introduced its own 80386-based system in April, 1988.

- Workstation manufacturers signed up commercial VARs to penetrate commercial markets, such as financial services, banking, real estate, and insurance. The multi-windowing capability offered on UNIX-based systems was welcomed by...
portfolio managers and financial brokers who must monitor several events simultaneously.

- Workstation designers moved their high-end products to higher performance chips, based on RISC principles. The RISC architecture is offered in systems by Sun, Apollo, HP, Silicon Graphics, IBM, AT&T, Edge, MIPS, Prime, and Xerox.

- Workstation manufacturers upgraded their 68000-based machines to faster clock rates, and developed special hardware for increased floating point mathematics calculations.

From the PC manufacturer's direction, many changes in technology have caused the traditional PC companies to infringe on the lower-end technical workstation markets. These changes include:

- Personal computer manufacturers introduced 32-bit systems. These included the Apple Macintosh II, the IBM PS/2 Model 80, and the Compaq Deskpro 386 systems, which offer integer performance of 1 MIPS or more, comparable to low-end systems from Apollo and Sun.

- Many of the PCs introduced features such as UNIX and workstation quality graphics resolution.

Personal computers were initially developed in the late 1970s with a single user, single tasking work environment in mind, targeted for the business office and home environments with spreadsheet and word processing applications.

In contrast, workstations started with the engineer and technical professional in mind. They were designed from the start as systems with multitasking and networking capabilities intended for several workstations to be connected into large shared operating environments. In contrast to PCs, workstations provided more sophisticated graphics,
greater storage capacity, networking capabilities, and a UNIX-based multitasking operating system. Early workstation applications were design automation, software development, scientific research, and publishing.

These events have caused the **key criteria distinguishing workstations from personal computers** to become: (a) the primary operating system, (b) the distribution channel, and (c) the market focus. Other key differences between workstations and PCs are in the areas of integer performance, typical resolution and graphics capability. Exhibit 3 summarizes some of the key differences between workstations and personal computers.

**Differences between workstations and minicomputers**

On the high end, workstations differ from minicomputers in that minis usually have a central processing unit with several "dumb" user terminals connected to it. With these computers, all the compute power is controlled from the central computer, and the compute power available to the terminal user is highly dependent on the number of other users on the system. In contrast, workstations have their own powerful processing units, and can access the compute capabilities of other workstations in the network as well.

Workstations in the mid- to high-end ranges have been stealing market share from the minicomputer industry. It was not initially clear that workstations would become a substitute for minicomputers, even after Apollo began installing its first systems in the early 1980s. At first glance, they appeared to be highly specialized systems for technical (mostly design) applications. But as the software and networking capabilities improved, the workstations became more popular with traditional minicomputer users, who were anxious to have their own isolated compute power, yet still have all the data-sharing advantages of a
multi-user minicomputer. Workstations can perform many of the tasks of the minicomputer at far less cost.

Another factor that hurt minicomputer manufacturers was their reluctance to embrace industry standards. Ken Olsen, President of Digital, assails backers of the standard operating system, UNIX, as "peddling snake oil." Minicomputer manufacturers have the attitude that standards give the computer makers less leverage over customers, letting customers shop around. This is exactly opposite to the philosophy of the workstation vendors, who feel they have greater leverage by giving the customers the option to not be tied to any one computer manufacturer, recognizing that systems from different manufacturers are optimized for certain tasks. Market researcher, International Data Corp., forecasts a weak 5% growth rate for minicomputers in 1988, while sales of desktop computers will surge ahead by as much as 16% (Wilke, 1988).

The Workstation Industry

Apollo can be credited for creating the initial industry, by selling unique workstation products to the customers of the traditional minicomputer markets. The product idea quickly caught on, as users were anxious to have their own computing power at their finger tips, without the bottlenecks associated with overloaded multi-user systems.

The workstation industry has been the fastest growing segment of the overall computer industry in recent years, growing at a compound annual rate of over 30% per
year from 1982 to 1987. The industry has grown from revenues of $20 million in 1982 to $2.7 billion in 1987. Growth is projected to be between $4 & $5 billion by the early 1990s.9 Exhibit 4 shows the estimated growth of the industry through 1992.

Sun's entry into the industry in 1982 was quickly followed by others, which included giants like Digital Equipment Corporation, Hewlett-Packard, and IBM, as well as niche players such as Silicon Graphics and Symbolics. These top 7 companies together accounted for 95% of the industry revenues in 1987. Exhibit 5 shows the breakdown of the industry shares for 1986 and 1987 by vendor. Exhibit 6 shows the breakdown of workstation shipments for 1987 by vendor, which shows Digital Equipment surpassing Sun in total shipments for 1987 (International Data Corp., March 3, 1988, p. 3-4).

Porter described the four phases of industry evolution as (1) introduction, (2) growth, (3) maturity, and (4) decline (Porter, 1980). In early 1988, the workstation industry was in the growth phase, characterized by the following:

- rapid technological growth in both software and hardware
- widening buyer groups and new markets
- a scramble for new distribution channels
- an increase in importance of the marketing function
- many competitors
- the formation of many strategic alliances
- emerging standards
- a shift toward less overcapacity in manufacturing and more mass production
- high revenue growth and strong profits

Each of the factors that have affected the industry evolution is discussed below.

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Evolution of the Workstation Industry

The complexity of the workstation industry has changed significantly since its inception in the early 1980s, when there were a few specialized companies selling workstations to highly technical buyers, primarily for design automation and software development applications. Many variables other than technology now play an important role in the competitive strategies of the workstation companies, and have altered the nature of competition within the industry. The industry evolution in the 1980s has been characterized by the following:

- New, less technical markets have been opened as a result of the increased availability of applications software and because of advancements in technology which have driven down system costs. These markets overlap with those targeted by personal computer manufacturers.

- From the personal computer direction, many advances in microcomputer technology have caused the traditional PC companies to infringe on the lower-end technical workstation markets.

- Technological advancements in graphics and computational capabilities have created new high-end markets, such as visual simulation, scientific modeling, imaging, animation, and artificial intelligence. The needs of the high-end markets are different than those of the low-end, thus increasing the complexity of the marketing, sales, and product development organizations.

- Many large computer companies have entered the industry, bringing with them large manufacturing, marketing, and sales organizations, along with a large existing customer base. This has placed increased importance on the need for the workstation companies to form strategic alliances with other major players in the computer industry.

- The need to offer a wider range of workstation products has resulted from
competition from the larger companies, and from distribution channels and customers who prefer not to have to deal with many different types of computer systems. Workstation companies appear to be proliferating their product lines as a means of penetrating many different market segments.

The significance of this evolution is that new variables have become important for gaining a competitive advantage as the industry has matured. The workstation company must constantly monitor the external events to anticipate the changes. It is doubtful that minicomputer manufacturers properly anticipated that workstations would become a substitute for minicomputers, even after Apollo began installing its first systems in the early 1980s. At first glance, they appeared to be highly specialized systems for technical applications. But as the software and networking capabilities improved, the workstations became more suitable for the traditional minicomputer markets, a stolen market share from the minicomputer manufacturers. Just as was the case with minicomputers, workstation vendors must continually be anticipating the next substitute for workstations. The implications for future industry evolution are discussed in the Conclusion section.

Nature of Competition

The workstation industry has evolved from the early 1980s when Apollo and Sun were the only companies, selling mainly to technical design engineers. In the mid 1980s, the nature of competition changed when computer industry giants such as Digital, Hewlett-Packard and IBM entered the industry. The entry of the larger firms increased the need for workstation vendors to offer a wider range of products to compete with the notion of one-
stop shopping offered by the larger companies. It also increased the need for workstation companies to seek out strategic alliances to leverage valuable resources in staying abreast of the rapidly changing technology and to provide the much needed cash to subsidize future growth.

In addition, many smaller, more focused, niche players such as Silicon Graphics and Symbolics entered the industry. This created additional competition for price/performance leadership for certain market segments.

In 1987, the industry structure changed even further as products from personal computer manufacturers, Apple, Compaq, and IBM were introduced with performance characteristics similar to those of traditional technical workstations. In addition, workstations migrated into non-technical (i.e., commercial) applications. One of the largest new growth areas was financial services for Wall Street traders and portfolio managers. Both these factors caused the channels of distribution and sales strategies to become important competitive variables.

The main theme of this thesis centers around the competitive strategies of the leading workstation vendors. Seven strategic variables have been identified as the key components of the competitive strategy within the workstation industry, and are listed below:

- Adherence to industry standards
- Price/performance leadership (includes technology)
- Strategic alliances including:
  - cooperative development agreements
  - relations with third-party suppliers
- Manufacturing
- Channels of distribution
- Market focus
- Range of product offerings

A brief description of each variable follows.

**Adherence to industry standards:** Adherence to standards is not a new issue for the workstation industry, and it has been the focus of much attention in recent years. Sun's adoption and promotion of standards has been the most significant factor in its success. Sun can be credited for it surfacing as a major competitive issue and it becoming a major customer demand, when it widely publicized that its early workstations were built around readily available components. Other workstation companies resisted initially, but as of early 1988, almost all have adopted the basic standards, however reluctantly, for networking, windowing, graphics, and the UNIX operating system.

These standards included the UNIX multitasking operating system, a widely used non-proprietary bus which provided a common interface for many third-party peripherals, and Motorola's 32-bit MC680x0 family of processors.

Sun's licensing of its SPARC chip design to outside manufacturers is a good example of where Sun has taken action to promote standards where there were none. On the other hand, HP has taken a different approach, and it does not make its RISC design available to the rest of the industry. It still remains to be seen if any standards will emerge, since there are so many different designs and manufactures available.

Networking standards exist in either a homogeneous or heterogeneous environment. A homogeneous environment is where many workstations from the same manufacturer are
linked together, sharing data, files, and computational power. In a heterogeneous environment, workstations are linked in a large network of different sizes of computers from more than one manufacturer. Ethernet and the IBM token ring are two hardware configurations that are commonly used in heterogeneous environments. Networking software is a bit more complicated, with each of the major vendors offering many of the most popular versions.

Standards have also emerged in the area of the user interface. The use of multiple windows, called "X-Windows," was based on work done originally by Xerox and eventually standardized by MIT. All major workstation companies have adopted this package as their standard user interface. It should be noted that Sun was later than others in adopting X-Windows, since it was trying to promote its own Network/extensible Window System (NeWS) as the industry's standard. It eventually unified NeWS with the X-Window system into X.11/NeWS, intended to address the need for a standard to allow graphics to be transferred across a heterogeneous network.

The importance of standard software and hardware is in its ability to attract third-party software and hardware suppliers to develop products to run on these standard systems. Software developers are very eager to develop software products for the UNIX operating system environment, knowing that there is a large installed base of UNIX users throughout the computer industry, including minicomputers and personal computers as well as workstations.

Despite all the talk about standards, each company in the business - DEC, IBM, Apollo, Sun, HP and others - still has some amount of proprietary features in its workstations which hinder the transparent movement from one platform to another. High
level software presents the most promising opportunity for standards, since if software can be ported between workstations with a simple recompilation, then the software developer and user can take advantage of whatever hardware technology is offered on any given workstation (Robinson, February, 1988). This is especially important with the addition of RISC-based workstations, which in early 1988 were offered by every major workstation vendor with the exception of DEC.

**Price/performance leadership:** The impressive price-to-performance ratio of workstations in comparison to minicomputers was the main reason they were able to steal market share from minicomputers for technical applications. As newer less technical markets emerged, such as in the industrial and commercial sectors, price/performance ratios became even more important as a means of competition among the workstation companies. The battle for price/performance leadership came to a head in April, 1987, when Sun took preemptive action and became the first company to offer a system for less than $5000. DEC and Apollo quickly followed.

Technology is an important part of the price/performance ratio. Technological innovations in the areas of hardware architecture, graphics processing, networking and communication capabilities, operating systems, applications software packages, and user interface management systems have been the main reason for their success over minicomputers. The fact that leading workstation companies are investing in the research and development of new technologies at a healthy rate of between 12%-13% of sales is an indication of its importance in determining the future industry leaders (Zander, 1988; Esdale, 1988).

Workstation vendors are quick to publish the performance of their systems, usually
spoken of in MIPS. In early 1988, the range of workstation performance was .9 MIPS (DEC's VAXstation 2000) to the 10 MIPS systems offered by Sun and Silicon Graphics. The newer graphics supercomputer systems from Stellar and Ardent, targeted for late 1988 and early 1989, will reportedly will reach 20-60 MIPS (Gibson, January, 1988, p. 1). And in early 1988, Apollo announced a new high-end graphics supercomputer for delivery in late 1988.

One of the main issues that has increased in significance in the last year is the use of CISC versus RISC processor architecture. CISC is an acronym for complex instruction set computing and RISC stands for reduced instruction set computing. The chief difference is that a RISC computer works in simple, brief steps, eliminating extraneous instructions so that the computer can execute the most common instructions faster. CISC is the more traditional architecture in which the computer operates with long strings of commands (Malone, 1988). The tradeoffs between using the different architecture designs is that most workstation software is written for the CISC-based systems which offer slower performance, while there is still a lot of development needed to convert (compile) the high-level software for the RISC-based platforms, but performance and cost is favorable. Most workstation companies have adopted the RISC route for their high-end systems.

A fierce battled has been formed between Sun and Motorola, among others, to get leading computer companies to endorse their RISC design as the standard architecture for the 1990's. By the time this goes to print, there will be more vendors in support of each technology, but as of now, Sun has signed up Fujitsu, Bipolar, Cypress, and LSI Logic to manufacture and sell the chip to other computer manufacturers, and has received endorsements from such power-houses as AT&T, through its joint development agreement,
Xerox, and Unisys for its RISC chip. Motorola has also been receiving endorsements at a rapid pace for its RISC chip, the 88000, from such computer makers as Tektronix, Data General, and Convergent Technologies. Motorola's close ties with Apple are expected to be a valuable advantage over Sun and others in the the race to gather support for the next generation of chips (Waldman, 1988).

An important consideration with architecture technology is recognizing when the limits of RISC architecture will be reached in the future and when to switch to other architectures such as parallel processing. A major question facing workstation companies is when will be the opportune time to adopt parallel processing technology at some time in the not-so-distant future, when the performance limits of current single processing architectures (such as RISC) are reached. As Richard Foster of McKinsey & Company stated in his book, **Innovation**, the competitive advantage will go to the company who understands the limits of its own technology, and anticipates when to "jump off the S-curve."

The S-curve is a means of measuring the productivity of a certain technology over time, and to recognize when it has begun to reach its limitations and be overcome by newer technologies. Typically, technologies advance through an S-shaped curve as they mature. At the start of the curve, a significant amount of R&D effort and resources are needed before any results can be seen. Once the bugs are worked out and the early learning process is completed, significant progress is made for very little effort in comparison to the earlier stages. At some point in its life cycle, the limits of the technology are reached, and the results-to-effort ratios look more like the earlier learning stage, when little improvements in technology are realized for large amounts of additional effort. A typical S-curve is shown below (Foster, 1986).
The second S-curve in this drawing could represent the new parallel computing architecture, which may some day replace the current-day architectures. The "efforts" in this example pertain to a wide range of factors such as software availability, manufacturing and design costs, and retraining associated with the adoption of the new technology.

Knowing when to make the leap from the existing single processing architecture to multiple parallel processors is an important consideration for workstation companies. By predicting when the limits of the current technology will be reached, they can shift valuable resources to development efforts on the new technology. Apollo plans to use some parallel architecture on its new high-end graphics workstation, expected for the fall of 1988. Both Stellar and Ardent, new entries on the high-end, also plan to use parallel processing techniques in their new products. Other workstation companies need to closely monitor the amount of additional performance improvements coming out of the traditional architecture and plan when to adopt the alternative technology.

Strategic Alliances: As the workstation industry has evolved, many large computer companies have entered the industry, which has increased the importance of strategic alliances and a broad range of products. It is noteworthy that Digital will become the
industry's installed base leader by the end of 1988 (International Data Corp., 1988), after selling primarily to large existing base of users. Strategic alliances with other players in the computer industry has become a means of accessing new markets and raising money for additional money to fuel their growth.

Many of the workstation companies have formed alliances with buyers, suppliers, and other major players in the computer industry as a competitive lever. With buyers, alliances were in the form of OEM (original equipment manufacturer) agreements, where the workstation vendors offered volume discounts, software and technical support to an OEM who would repackage the workstations with their own products. Agreements with suppliers varied widely from licensing chip designs to chip manufacturers to incentives for third-party software suppliers. A third type of alliance has been cooperative development agreements between workstation companies and other computer companies.

There are many examples of strategic alliances that occurred in the last year:

- Sun agreed with AT&T to develop a joint version of UNIX and a RISC-based computing platform. In addition, AT&T agreed to purchase 20% of Sun. This gave Sun some operating capital it needs to fuel its future growth, and AT&T access to technology in which it was lacking. It also gave both Sun and AT&T the advantage of each other's support for UNIX, which is such an integral part of both companies' products.

- DEC formed an alliance with Apple to jointly develop software to network their systems. This gave Apple access to DEC's large customer base, and gave DEC a low-entry option to accompany their existing VAX product line and an entry into low-end commercial markets.

- Silicon Graphics combined forces with Control Data, who agreed to purchase 20% of SGI's stock, which would give Silicon Graphics the needed cash to fuel its growth into a wider product range, and gives Control Data access into a new industry from the high-powered mainframe business.
• Sun agreed to license its SPARC chip design to leading chip manufacturers, Fujitsu, Bipolar, Cypress, and LSI, in order to gain the advantages of low-cost state-of-the-art chip production technology, and to promote its chip design as an industry standard.

The frequency with which these announcements appeared in the later part of 1987 and early 1988 is an indication that these alliances will continue to be an important factor in 1988 and in the next few years as the industry matures.

Relations with third-party software suppliers has become an important competitive variable. Workstation companies entice software developers to supply products for their platforms by offering equipment discounts, training, and marketing assistance. The leading workstation vendors have portfolios of about 1000 software products from third-party vendors which enhance the workstation's usability. Examples of some of the leading software vendors in different application areas are Manufacturing Consulting Services in mechanical engineering, Mentor Graphics and Recal Redak in electronic design, Interleaf and Context Corporation in electronic publishing, Cadre in software engineering, Technolegde and Intelicorp in artificial intelligence, and Autotrol in architecture and construction.

Manufacturing: Manufacturing costs are the biggest component of cost of sales, which impact gross profit margins. Not surprisingly, the workstation company who can keep an efficient manufacturing operation can pass the savings onto the customer to gain competitive pricing advantages. With shipments predicted to grow at a 29% compound annual growth rate, proper manufacturing capacity planning is a critical competitive variable (International Data Corp, 1987). An example of how manufacturing planning can have a
significant effect on profitability is Apollo, which in 1985, found itself with a brand new factory and a bloated inventory, when its top design automation customers curtailed buying.

Manufacturing efficiency is especially important in low-end systems in order to compete with markets served by high-volume personal computer companies such as IBM, Compaq, and Apple.

The high-growth industry and increases in the need for economies of scale has allowed firms with large manufacturing operations to enter the industry with some competitive advantages. This is the case with the entrance of DEC and HP into the industry in the mid 80s, which brought large scale manufacturing operations in addition to large marketing and sales infrastructures, and immediately became leading contenders. Although IBM's RT-PC workstation has not been a technically competitive product, it possesses the large scale infrastructure to become a dominant force in the future, particularly as the PS/2 acquires more workstation-like features.

Both Sun and Apollo have spent large amounts of capital gearing up their manufacturing operations. Sun started a major new manufacturing facility during fiscal 1987 which resulted in higher overhead costs. Sun's annual report states that cost of sales is expected to increase again in the first part of 1988 as a result of startup costs for a second major automated manufacturing facility. Eventually, this large scale production and attention to automation will pay off. The same is true with Apollo, when it built a large new production plant in Exeter, N.H., planning on sales reaching $600 million in 1985. However, Apollo was stuck with large amounts of overcapacity until 1988 when sales finally reached that level. However, it is in a good position in 1988 to capitalize on this
manufacturing capacity.

The message here is that it’s difficult to plan the exact correct timing for the introduction of additional capacity, but in such a fast-growing industry, those companies which do not take the risk and bring new manufacturing capacity on stream will be overwhelmed by the resources of the larger companies and those with additional capacity.

Channels of distribution: Distribution channels and sales strategies have become an important competitive variable as the industry matures. Initially, workstation companies sold mainly to original equipment manufacturers (OEMs), which added their own design automation software and hardware and resold the systems as a package to end users. About 70% of all workstation sales went through OEMs in the early 1980s. As the idea and the reputation of workstations caught on, and workstation vendors were able to offer software and hardware products from third-party suppliers, an increasing amount of sales went directly to the end user. In 1986 and 1987, sales were split almost equally between OEMs and large volume end users. In 1987, many workstation companies initiated major efforts to penetrate the small-to-medium size end user markets by establishing the value-added reseller channels (VARs). These VARs are considered to be an important link into the fast growing commercial market segments. Each of these distribution channels is described in more detail in the Channels of Distribution section below.

Market focus: Technology improvements in hardware, software, and production processes have opened up new markets. The low-end markets are more commercial in nature, purchases are often made in smaller volumes, the buyers are more price sensitive, and are in need of more technical assistance in selecting and installing the workstation and its related products.
A parallel can be drawn between the migration of workstations into low-end markets and the evolution of the personal computer industry. In each industry, as the software and hardware technology improved, it became easier for less-technical users to take advantage of the technology. As with workstations, personal computers were initially sold to technically sophisticated users who primarily did their own software development.

In the case of PCs, systems were initially sold to computer hobbyists who were anxious to have computing power of their own, and were tolerant of the lack of software and the inherently unreliable systems. They developed their own software and repaired the hardware themselves. Initially, the primary marketing and sales vehicles were trade journals and magazines. As technology improved, prices came down, and more software became available, business and commercial markets opened up. This gave rise to the need for personal computer companies to alter their sales and marketing strategies to work with dealer channels. The new users were less technical and in need of assistance and support, which the dealers could provide.

Just as dealer distribution channels emerged in the personal computer industry, VARs have emerged as the workstation industry's solution to this need. Workstation companies have begun new corporate programs to establish the working relation with the VAR channels. Another major question to be resolved with workstation companies is whether or not retail channels are needed to sell their low-end workstations into commercial and business markets. In order to compete with personal computers, workstation vendors may need to have presence in the retail channels as well as the new VAR channels.
Sun, in particular, appears to have a strong commitment to these channels. It established a new alternate channels group within its corporate marketing division, and launched a new VAR program in November, 1987.

Apollo appears to be also gearing up to deal with these channels through its marketing programs group, although it seems to be less convinced about the value of VARs. In an interview with Paul Esdale of Apollo, who heads their Marketing Programs group, he expressed the need for direct account control in order to adequately seek out new application segments within the existing customer, rather than relying on VARs or OEMs.

To compete in the upcoming years, workstation companies need to carefully nurture these relationships in order to penetrate the new market segments and smaller buyer groups within existing segments. It is not economically justifiable to use the same direct sales force that deal with high volume OEMs and end users to sell to the smaller volume end users. Also, it is impossible for the workstation company to adequately understand and service the needs of each user group in such a variety of different applications. Highly specialized value-added resellers are needed to provide the technical assistance to these new markets.

International Data Corp. estimates that the low-end, more commercial, segment of the industry will account for roughly half of the units shipped in 1988 (IDC, March, 1988). As shown in Exhibit 4, the growth in the industry in the next several years is expected to come primarily from the low-end systems, which are becoming more and more commodity-like over time. This presents many challenges for the workstation companies that are used to dealing with a technical customer base such as large volume end users and OEMs. Other important factors for success in the low-end are the availability of applications software, primarily from third-party vendors, manufacturing capabilities,
reliability, and product differentiation.

The need to alter distribution strategies applies to personal computer manufacturers as well as workstation manufacturers, in order to penetrate the traditional technical markets. Their existing personal computer dealer channels have little expertise in selling to the technical markets. OEMs and VARs look for a wide range of products to provide for their customers. More than ever, users are requiring more technical assistance in selecting a workstation product, because of the uncertainties over complex issues such as:

- Which "standard" is the real standard
- Which architecture, RISC versus CISC is best suited for their needs
- Which manufacturer will be around to support them in the future
- What platforms have the right software and will attract future software developers
- What is required to network their existing computers in a heterogeneous environment

On the high-end, new markets such as simulation, animation, and molecular modeling have arisen as a result of technological improvements in graphics and computational performance. Until 1988, there was a distinction between high-end workstations with lots of compute power and those with complex 3D graphics capabilities. For example, the Sun-4 systems claimed the lead in computational power with 10 MIPS, while Silicon Graphics claimed the best 3D graphics performance. That distinction is disappearing as new systems enter the markets, such as those announced by Stellar and Ardent, which combine the best of the 3D graphics with near super-computer number crunching capabilities, and put Sun, Silicon Graphics, and Apollo in a dangerous catch-up mode (International Data Corp, March, 1988).

Even though the market for these high-end systems is thought to be less than 10% of
the 1988 workstation shipments, these systems, like servers, are good revenue and profit-generators. More importantly, they are likely to become the late-1980s computer of status for the leading edge scientists, researchers, and engineers. They are in a good position to capture more of the mid-range markets, as technology improves, bringing prices down, and as the demands of users increase. It is my feeling that as more and more workstation users and applications emerge, their computing needs will also grow.

Range of product offerings: The range of products offered by a workstation vendor became an issue in the mid-1980s with the entrance of the big computer companies, Digital, IBM, and Hewlett-Packard. DEC and HP were very successful in selling its workstations to a large customer base who already owned their other products, which ranged from terminals to main frames. DEC in particular was able to offer software compatibility across their entire range of computers, and promoted one-stop shopping with their customers (the lack of which was one of the key reasons for IBM's lack-luster performance).

The increase in the product range has also been seen as the vehicle to growth, since the wide range of applications have varying demands for compute power and graphics capabilities. The low-end, which will increasingly be targeted to the more commercial and business-like applications, requires much less compute power than the technical high-end applications.

There are many examples of companies expanding their workstation product lines. Apollo, who initially offered mid-range workstations for design automation applications has recently announced plans to introduce a graphics supercomputing workstation in late 1988. Sun, expanded their line in mid-1987 to include its RISC-based Sun/4 series workstation, which provided the power of a DEC VAX 8800 main frame at workstation prices. Also, Sun
announced an IBM-compatible 80386-based system in early 1988 for its low-end commercial offering. And Silicon Graphics has stated that its new strategy is to expand its product line from its high-end graphics systems into more mid-range offerings.

And the computer industry giants have not been sitting still. DEC expanded its line of workstations with its announcement of the VAXstation 3000 series, introduced in the fall of 1987. HP offers a compute line of products from its Vectra personal computer to its large line of minicomputers. IBM's products range from PCs to main frames. Its new PS/2 personal computer, introduced in mid-1987, will present a threat to the low-end markets once the OS/2 operating systems software is fully implemented to take advantage of the advanced capabilities of Intel's 80386 processor. Another industry giant, Apple, entered the workstation arena by expanding its personal computer product line upward, with its announcement of the Mac II in early 1987.

The Workstation Markets

Exhibit 7a shows the 1987 workstation industry broken down by application area. Exhibit 7b shows Sun's 1987 sales broken down by their application market segments. Exhibit 7c shows a more detailed breakdown of the various market segments for 1986.10 The two leading application areas in 1987 were design automation (38%), and computer-aided software engineering (CASE) (25%). The following definitions have evolved from a recent industry report (International Data Corp., December, 1987).

Design automation includes both design & drafting (CAD) and design engineering &

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10 The categories on the reports vary slightly because companies choose to group their applications somewhat differently. The categories in parenthesis on Exhibit 7c were added to cross reference the groups in 7a and 7b.
analysis (CAE). The design and drafting, referred to as CAD (computer-aided design), applies to 2-D and 3-D design applications such as mechanical, electrical, electronic, architectural and civil computer-aided-design. Design and drafting applications require graphics capabilities, but are less compute intensive than design engineering and analysis applications. Users are primarily designers and drafters and are found primarily in such discrete manufacturing industries as automotive, aerospace, heavy machinery, and consumer goods.

Design engineering & analysis applications, referred to as CAE (computer-aided engineering), are generally accomplished by engineers for such analytical tasks as finite element modeling and analysis, solid modeling, structural analysis, mechanical computer-aided engineering, circuit simulation, and civil engineering. Because this class of applications require more compute power than straight drafting, much of the number crunching is performed on near-supercomputers. Like design applications, CAE tasks are used in designing automobiles, commercial aircraft, running shoes, ski equipment, sailboards, beer bottles, etc.

Software engineering, referred to as CASE (computer-aided-software engineering), applies to software tools used by software developers. Applications range from simple file management and documentation control, to code generators and optimizers. An important requirement for software developers is windowing capability to view the compilation and test of several programs simultaneously. Another important requirement is networking so that the shared compute resources can speed the overall development process.

Technical management and support includes tasks such as computer-aided publishing (CAP), documentation control, project management, network management,
revision and configuration control. These tasks are often performed by a file or data server on a computing network.

**Scientific Research and R&D** applications are usually compute-intensive for basic research in areas such as physics, computational fluid dynamics, thermodynamics, wind tunnel testing, laboratory data analysis, and scientific signal analysis. Users are found in national laboratories (such as Argonne and Lawrence Livermore), research institutions (such as MCC and MCNC) and research labs within large corporations.

**Measurement and Control** applications include automated test equipment and measurement analysis, which typically require real-time response.

**Economic and Financial Modeling** was the biggest growth market in 1987. Wall Street analysts and investment bankers use workstations for econometric modeling and forecasting, portfolio management, stock market forecasting and monitoring, and financial analysis. The multiple windowing feature of workstations allows them to monitor and operate several events simultaneously.

The newer emerging markets include many compute and graphics-intensive applications and applications within the commercial sector. The compute and graphics-intensive applications include areas such as artificial intelligence, geophysical science, scientific modeling, defense research (SDI), and visual simulation, which includes applications such as flight, medical imaging and radar display, molecular modeling, industrial design, VLSI (chip) design, manufacturing simulation and robotics planning. Simulation requires real-time response, and these applications are characteristic of those run on the high-end workstations, such as those supplied by Silicon Graphics.
The commercial sector is projected to be one of the highest growth areas of the future. Some analysts forecast that by 1991, 85% of all workstation revenues will come from the commercial sector, an area that currently represents less than 5% of sales (Leibowitz, 1987). The commercial sector includes such end users as financial investment companies, insurance companies, real estate agencies, banks, hospitals, and the like. The end users in the commercial sector usually are not as technically-oriented as the users in the technical areas, and therefore, rely more heavily on value-added-resellers (VARs) and dealers to provide the technical assistance and support. They typically look to purchase commercially available software packages rather than develop the software themselves.

Channels of Distribution

Most of the workstation vendors, including Sun, have a large direct sales force that deals with three basic channels of distribution. Sales are either direct to large volume end users, through Original Equipment Manufacturers (OEMs), or through Value-Added Resellers (VARs). These groups differ by the amount of service and support and the pricing agreements offered by the workstation vendors. These factors are a direct result of the current and future potential revenues that each of these groups represent. ¹¹

The workstation vendors' gross margin percentages are approximately the same from each of these channels (Esdale, 1988). The gross margin for the leading workstation

¹¹ These three categories are broad and are often broken down into finer segments by workstation vendors for purposes of organizing the sales efforts and the contractual agreements with the different classes of buyers.
companies has averaged approximately 48% of net sales from 1983-1987. Even though the cost of selling (includes sales force & sales support costs) through each channel is slightly different, the workstation vendors typically set their discount schedules to compensate for the differences in the cost of selling such that the overall profit margins are similar. The cost of selling direct and through OEMs in the computer industry is approximately 13-15% of sales. The cost of selling through the small-to-medium size VAR is estimated to be about 10-11% of sales.

Large OEMs that are dealing with high volumes typically receive a larger discount than the other channels. Small discounts are given to end users, bigger discounts to large OEMs, and something in between to the smaller VARs all result in similar profit margins through each of the channels (Esdale, 1988).

**Large volume end users**

These users represent approximately 40-50% of sales. An example of a typical large volume end user is a large corporation like General Motors or McDonell Douglas which has needs for purchasing hundreds of workstations at once, typically for an entire department, or an entire plant. Sales personnel from the direct sales force are assigned as account representatives to each of the large volume customers. These customers are enticed to buy a particular vendor’s workstation by the overall package that the vendor is offering, which includes: availability of third-party hardware and software products, networking capability to other equipment, technical advice, service warranties, and price/performance ratios. These accounts are very attractive, since the switching costs are relatively high once

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12 Gross profit margin was calculated by (net sales - cost of sales) / net sales. Data was taken from the annual reports of Sun, Apollo, and Silicon Graphics.
these companies have decided on a particular vendor, and the probability of repeat business is good.

It is not uncommon for a third-party software or hardware supplier to make the first contact and bring the workstation vendor into touch with the customer for a joint sale. These third-party suppliers typically do not take possession of the equipment on a sale, but will recommend the most appropriate workstation platform for their product.

**Original equipment manufacturers (OEMs)**

OEMs account for around 40% of sales. These companies take possession of the equipment and resell it with their own applications software. About 10% of the OEMs account for 90% of the sales volume in this category. Typical examples of OEMs which resell the workstations with their own software are Mentor Graphics which specializes in electrical design automation systems, Prime Computer which sells mechanical design automation systems, and Interleaf, which is a key supplier of electronic publishing systems.

Some OEMs take responsibility for the servicing of the workstation equipment. Others pass the 90-day warranty supplied by the workstation vendor on to the end user. After the 90-day period, the end user purchases a standard service contract from the workstation vendor.

Another much smaller category of OEM is one which embeds the workstation into its own hardware products. In the past, these OEMs have represented less than 5% of sales. An example of an OEM who embeds the workstation as an integral part of its product is LTX,
which builds electronics test equipment or BTU Engineering which includes the workstation as the central processing unit in their heat treatment furnaces.

OEMs provide the systems integration and technical assistance for the end user. They often get other third-party hardware and software suppliers involved in providing additional features. The workstation vendors give these OEMs a discount which varies with the quantity of systems agreed to over a specified time frame. Discount schedules from the workstation vendors range from 0 - 40%.

Different workstation companies deal with OEMs slightly differently. For example, DEC takes small OEMs, which do less than $500,000 in business per year and interacts through industrial distributors. Sun and Apollo cannot afford to be that arrogant and will deal direct to OEMs who do less than $.5 m per year. In fact, Sun and Apollo assign dedicated account managers from its direct sales forces to their top OEM accounts.

Value-added resellers (VARs)

There are two different categories of VARs: the regional VAR and the larger systems integrators.

The regional VARs focus on the small to medium size end users which typically purchase only a few systems in a single order. These VARs typically deal with customers whose annual revenues are less than $100 million. This channel, being relatively new to the industry, has evolved from the group of third-party hardware and software suppliers which have targeted products to a particular application niche, such as architecture or design automation. These VARs satisfy the needs of the small end user for technical assistance in
choosing the right equipment and locating the third-party applications hardware and software products for their particular needs.

Discounts from the workstation vendors typically vary from 25% - 30%, and they are restricted to a particular geographic area to avoid potential channel conflict with the direct sales force. These VARs represent a means of tapping a potentially large customer base that is not currently justifiable with a direct sales force, whose sales quotas often approach $2m - $3m per year. VARs are an important link between the workstation vendor and new emerging markets. VARs are particularly important in the low-end markets, where profit margins are less than with high-end systems. The margins on low-end workstations make it difficult to service these markets with a direct sales force, but less so for the VAR which has a lower cost structure. The margins on the low-end workstations are higher than that of heavily discounted PCs.

VARs make their profits on the training, technical advice, and systems integration services, rather than the workstation platform itself. Workstation vendors supply some software tools, but little follow-on support compared to OEMs and larger VARs. An example of such a regional VAR is Boston CAD, who might acquire an AutoCad software package from AUTODESK, add a plotter, write the interface software to allow this printer to run on this particular type of workstation, and resell it to the end user. Typically the only software that a regional VAR develops is for the integration of special hardware or software applications tailored to the needs of the end user.

In summary, the regional VAR adds value by (1) opening new niche market segments, (2) servicing a geographical area and customer that is not otherwise justifiable with a direct sales force, (3) adding software, and (4) providing the technical assistance,
systems integration and installation for the small to medium sized end user.

The second type of VAR might be called a large systems integrator, and is dedicated to a particular high volume buyer, such as a large corporation or the government.\textsuperscript{13} Examples of these type of VARs include EDS, a GM subsidiary which acts as the computer equipment spokesperson for General Motors, and AGS, which deals with large financial customers. With the exception of dedicated VARs such as EDS, these systems integrators typically represent more than one buying company. They act as the prime contractor between the end customer, the workstation vendor, and various third-party vendors needed to provide a full scale computing environment. Similar to the agreements with OEMs, the workstation discounts vary from 0 - 40%, depending on the volume purchased. The workstation vendors often assign an account representative from the direct sales force to service and support these accounts. As a result, they are given more support and follow-on service than the smaller regional VARs.

These VARs are sorely needed by the workstation vendors, since the types of accounts they deal with typically require systems integration efforts beyond the resources of the workstation vendors.

Both types of VARs take title to the equipment and add software and hardware from third-party suppliers. They evaluate the needs of the end user, recommend and acquire the appropriate hardware and software, perform the systems integration, deliver the equipment to the end user, and provide the follow-on support.

\textsuperscript{13} Apollo refers to this group as "systems integrators," but their terminology is confusing since the regional VARs also act as systems integrators.
CHAPTER 4

SUN MICROSYSTEMS

Sun's Organizational Structure

Sun's organizational structure, which was revised late in 1987, is displayed in Exhibit 8. Sun has identified several "vertical markets," for each of which it has a separate marketing group. Vertical markets are those application areas whose needs span the range of technologies, including the workstation platform, the systems level software, networking and communications, graphics, as well as application-specific software products offered by Sun and third-party vendors. The vertical markets that Sun has identified are MCAD, ECAD, CIM, AEC, CASE and electronic publishing, as well as emerging markets which include financial services, artificial intelligence, earth resources, oil exploration, simulation and medical imaging (Snelling, 1988).

In addition to marketing resources for each of these areas, Sun has marketing groups within each of the "product" divisions. It has separate divisions for different products and technologies, including workstation platforms, graphics, software, communications, and educational products, which apply across the broad workstation product line. The marketing personnel within the vertical market groups interface with customers and key suppliers to determine the future needs of the products for their particular market segment. They also interact closely with the marketing personnel in the various product groups and play a major role in influencing product development.
The marketing personnel in the product divisions stay on top of the latest technology in each "product" area. By having two separate types of marketing groups, both the markets and the technologies are given close attention.

Since the federal government represents such a large volume account, Sun reorganized at the end of the summer of 1987 to establish a Federal Systems Group, which deals solely with the needs of the government.

The difficulty of achieving such a synergistic organization is shown with examples such as Silicon Graphics and Hewlett-Packard. Silicon Graphics on one hand has had a narrow product line, with an organizational structure designed to support technical development for a limited number of highly-specialized markets. If it is to carry out its stated intention of expanding into a broader line of workstation products, it must reorganize to address the needs of different markets as well as the technology.

On the other extreme is Hewlett-Packard, with a large infrastructure set up initially to support the needs of its technical and scientific markets to whom it sold its instrumentation and minicomputers. When it initially entered the computer industry with minicomputers and personal computers, it established a sector separate from its technical sector to service the needs of its computer markets. When workstations were introduced, they were initially targeted to purely technical audiences. HP placed the workstation divisions within its technical sector, located several states away from its computer business. As workstations applications become more commercial, HP faces an important organizational challenge to blend the technology needs of its workstations, minicomputer and personal computer products, and address the needs of overlapping market segments for their various computer products.
Sun's Strategy

Many of the major workstation companies have similar product strategies and technological strengths, however, none have all of the characteristics of Sun's strategy. Sun's major characteristics can be summarized by the following:

- Its relentless promotion of industry standards
- Its price/performance leadership
- Its proliferation of its product lines into the low-end markets
- Its aggressive marketing techniques
- Its alliances with other important companies in the computer industry

Promotion of Industry Standards

McNealy described the strategy for Sun's past success as,

"...just a fast ball down the middle; nothing fancy, nothing tricky."

Sun's objective was to provide the highest performance open systems workstations, servers, and software based on industry standards, all within a heterogeneous distributed computing environment. Wherever standards were not available, Sun created them, openly published the interface specifications, and offered attractive licensing agreements to
encourage others to adopt the same approach. Like IBM’s approach with its personal computer products, this was a radical departure from the tradition of using proprietary technology to lock customers into one company’s products. By basing systems on standards, it makes it easier for software and hardware developers to port products to Sun workstations, and computer users can integrate Sun’s workstations with a variety of other computer products.

This open systems approach appeals to computer buyers, who feared locking themselves into a proprietary technology. From Sun’s lead, customers began demanding that their systems be "open," using industry standards to work with products from different manufacturers (Leibowitz, November, 1987). This caused other workstation companies, including Apollo, Digital, and Hewlett-Packard to give in and support standards as well. As McNealy put it,

"In the past, computer companies have been able to charge a premium for proprietary technology. In the future they will have to offer a discount (Gannes, 1987)."

Key aspects of Sun’s open systems product design philosophy include the use of standard technologies such as the UNIX operating system, VME system bus, Ethernet local area network and Motorola 680X0 microprocessors. Sun has integrated these multiple technologies in an open system architecture to provide a high performance computing environment for the technical professional.

Sun recognized from the start that the technical computing world was heterogeneous, since certain machines excel at specific tasks. To meet these needs, Sun developed the Network File System (NFS) within its Open Systems Network (OSN™) strategy to address
the need for improved network services in Sun networks as well as in heterogeneous multi-vendor networks of systems running UNIX together with other operating systems such as VMS and MS-DOS. In accordance with its commitment to encourage the development of industry standards, Sun published specifications of the NFS protocols and placed implementations of the underlying communications protocol in the public domain. To encourage other vendors to implement NFS, Sun is licensing source code at a low price. To date, Sun has licensed NFS to over 130 commercial and university users (Sun, Form 10-K, 1987).

Sun has played a key role in promoting UNIX as the standard operating system for the industry. It developed its own version of UNIX, called SunOS, which combined the features from the popular versions from Berkeley and AT&T. UNIX was initially developed by AT&T's Bell Labs, which offered inexpensive licensing agreements to anyone who wanted a copy. It was quickly adopted by many universities and research labs which were able to buy a copy for $300, compared to the thousands of dollars for other operating systems.

The dual versions of UNIX emerged when Bill Joy, then a graduate student at Berkeley, rewrote the software to run on the department's VAX computer. When the word of the version spread, the school was swamped with requests from VAX customers for the new UNIX software. When Joy joined Sun as a co-founder, he led the effort to develop the SunOS software. By being the first workstation company to offer UNIX, Sun had an advantage with the many scientists and engineers that had grown to "know and love" UNIX (Barrcn, 1988).

By adopting industry standards, Sun gave over 500 third-party software and hardware vendors the incentive to develop over 1000 products for their equipment, which in turn has enhanced the utility of their systems and stimulated workstation sales. Sun
maintains an active program, known as Catalyst, that promotes the development of third-party applications software and hardware products for Sun workstations. Sun's incentives to these developers includes equipment loans, special discounts, and dedicated marketing and support personnel who assist the suppliers in adapting their products to the Sun environment. In addition to the marketing support, Sun lists these products in a Catalyst reference catalog for its customers, demonstrates these products at sales offices and trade shows, and distributes promotional literature through its sales offices. Apollo's Partners' Program is very similar to Sun's Catalyst program.

Sun's strategy to promote standards has refocused the competition within the industry on factors other than proprietary technology. Instead, companies are forced to shorten product cycles, improve price/performance, and rely on standards as a means of reducing manufacturing and development costs and broadening markets for their products. Apollo, DEC, HP, Silicon Graphics, and IBM to a lesser extent, have all since adopted the same industry standards to varying degrees, but still continue to promote certain proprietary parts of their systems. Sun has been quite effective in promoting the value of industry standards to their customers.

Price/performance and Range of Products

Sun has kept R&D spending high, at around 13% of sales in 1987, in order to rapidly introduce new products (Zander, 1988). This includes products which clearly have replaced existing ones as well as those targeted at new markets.

The rate at which Sun introduces new products has been its defense against
competition from companies which might "clone" its products, since Sun's products use off-the-shelf hardware and software. To date, the rate at which it introduces new products has been with little regard to obsoleting existing products. Sun has issued new workstations every 12 - 18 months on the average. In comparison, personal computer models tend to stay on the market for two years or more, and mainframe computers are typically upgraded every four to five years. Says top executive Carol Bartz, who runs Sun's government business,

"We wouldn't hesitate to bring out a new product at a price and performance level that absolutely destroyed an existing line. Why should we wait for the competition to do it? That's a brand new concept in this business, and we've proved you can make money doing it (Gannes, 1987, p. 90)."

Sun's range of workstation products has evolved from mid-range workstations targeted at the technical professional to high- and low-end products as well. Sun's products range in price from under $5000 for a single, high-performance desktop workstation to $100,000 for a fully configured workstation environment. Their low-end systems accounted for about 25% of Sun's revenues in 1987 (Gannes, 1987). In November, 1985, Sun began volume shipments of its third-generation Sun-3 family of workstations, and continued to expand that line in 1986 with the introduction of the high-performance Sun-3/200 series and again in 1987 with the introduction of the low cost Sun-3/60 line. As of January, 1988, Sun had shipped over 50,000 workstations, about 70% of which were the low-to-mid-range Sun-3 products.

In July, 1987, Sun expanded into the high-end arena when it introduced its high-speed fourth generation Sun-4 family of workstations, servers and board-level central
processing units. The Sun-4 family is based on the scalable processor architecture (SPARC) microprocessor and can deliver up to 10 MIPS performance. SPARC incorporates many reduced instruction set computing (RISC) concepts and was designed by Sun in cooperation with certain of its suppliers in an effort to significantly improve price/performance and to establish industry standards. In early 1988, it improved the price/performance of that same line when it introduced the Sun-4/110, which sells for $19,000 and is estimated to provide 7 MIPS (million instructions per second) performance.

Sun started a price-cutting snowball on its low-end in April, 1987, when it priced its 3/50 entry level systems below $5000. The 3/50 is based on the Motorola 68020 processor, has a monochrome display, and around 1.5 MIPS performance. Instead of matching Apollo's prices and going for high margins, McNealy and his crew executed this preemptive move to cut prices and concentrate on building market share. This gave Sun a tremendous price/performance advantage over the competition until DEC, Apollo, and HP all followed suit by lowering the prices on their entry-level systems. McNealy, confident that sales would increase more than enough to offset the price cuts, stated:

"Clearly the market would bear a higher price, but we think there's an elasticity of [demand] greater than one in the marketplace (Leibowitz, November, 1987)."

By examining Sun's financial reports, it appears that Sun might be selling these low-end systems below cost, as loss leaders. The remaining margins could be realized through upgrading the systems through the addition of servers and more disk capacity, future sales of higher-level systems to the same customers, and maintenance and service revenues, which amount to about 12%-20% of the installed system value per year. It was a classic case of giving away the razors to sell the razor blades (Burdick, 1988).
Sun's latest new bold move was in April 1988, when it announced a new desktop system, the Sun 386™, based on the Intel 80386 microprocessor, with suggested prices ranging from $8000 - $14000. They are positioned to compete with the high-end PCs from IBM, Compaq, and Apple. The new systems are intended to bridge the gap between the commercial world of MS-DOS, the standard operating system for IBM-compatible PCs, and the technical world of UNIX by offering both operating systems. In an interview, Scott McNealy said,

"That's going to give us the edge [over other PC manufacturers]. No other high-performance machine out there today can run UNIX and DOS like this one."

The systems were developed by Sun's East Coast division, headed by Barry Folsom, who joined Sun in 1985, after running DEC's unsuccessful Rainbow personal computer line. The new 80386-based family expands the number of different architectures Sun has to support to three: the Intel 80386 based systems, the Motorola 68000 family based systems, and those based on its own SPARC architecture. There are several advantages to Sun's new products over other personal computers (PCs) offered from IBM, Compaq and Apple. The new machines offer the multitasking capabilities of UNIX as well as MS-DOS with its large software library, have an advertised peak performance of 5 MIPS compared to 2 MIPS maximum for other PCs (Wall Street Journal, April 7, 1988), offer twice the memory, and have the circuitry and software necessary to plug into a heterogeneous networking environment (Schlender, April 6, 1988).
Strategic alliances

Sun has formed several important strategic alliances. Sun designed its own microprocessor chips for its high-end Sun-4 workstations., after an unsuccessful attempt to convince Motorolla to develop a RISC chip. Instead of buying the best available components, it opted for the best available chip making technology by licensing the design, along with the necessary software, to several key chip producers. It licensed its SPARC14 chip design to four major chip manufacturers, Fujitsu, Bipolar, Cypress, and LSI Logic. The SPARC chip is a high powered device that employs RISC (reduced instruction set computing) techniques, which make it easier and cheaper to manufacture than a conventional microprocessor. By licensing its design to major chip manufacturers, Sun was able to take advantage of state-of-the-art low-cost chip manufacturing technology. It also hopes that by inviting other manufacturers to build clones using this chip technology, it will become an industry standard, thus attracting more software suppliers and increasing the attractiveness of Sun's systems. It faces stiff competition from Motorolla, who has recently been promoting its own RISC chip, in the effort to promote its chip as an industry standard.

Bill Joy, a Sun co-founder and vice president for technology development, said concerning the standardization of chip technology (Schlender, March 18, 1988):

"We're talking about the PC-ization of the entire computer industry."

Sun formed a key technology-sharing alliance with AT&T in October, 1987 when AT&T announced that it would license Sun's SPARC chip design to develop a family of high-performance minicomputers and workstations. In addition, Sun and AT&T would jointly

14 Scalable Processor Architecture.
develop a standardized version of UNIX, which had become the operating system choice of the workstation industry. This version of UNIX will incorporate the features of AT&T's version 5.2 plus the features of Sun's version of UNIX, called SunOS, which evolved from Berkeley's 4.2 version. The intended result of this development is a computer platform that would become the major computing environment for the 1990s and an alternative to IBM systems. To further cement these agreements, AT&T agreed in January, 1988 to acquire up to 20% of Sun's stock over a three-year period, giving Sun about $300 million in much needed cash to fuel its future growth. More than a dozen worried computer companies have protested the ties between Sun and AT&T, claiming an unfair advantage for Sun in working with AT&T to standardize UNIX. These companies want to participate in the development, so as to be well prepared for its arrival in 1989. Some analysts feel that Sun could become an alternative to Olivetti, in the future, as AT&T's supplier of workstations and personal computers (Guyon, April 15, 1988).

All the publicity surrounding SPARC has caused other chip manufacturers to step up the promotion and development of their own RISC-based chips in attempts to short-circuit the SPARC as the standard setter, which was initially announced in July, 1987. In December, 1987, Motorola confirmed that it too was developing its own RISC chip, the 88000. In March, 1988, MIPS Computer Systems introduced a new RISC product, the R3000, claiming to offer twice the performance of any competing chip on the market (Schlender, March 29, 1988). Advanced Micro Devices also introduced a similar chip. DEC is also rumored to be studying RISC (Malone, 1988).

In addition to Sun, many workstation companies have adopted the RISC technology on

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15 Many versions of UNIX have been developed by outsiders since AT&T's Bell Labs began licensing the software years ago, including the popular version from Berkeley University.
their high-end products, including Hewlett-Packard, IBM, Prime, Xerox, MIPS, and Edge Computers. The RISC design has sparked a lot of controversy in the industry. Although there is limited software available for the chips, their increased processing speeds and lower manufacturing costs create the potential for becoming the standard microprocessor design of the 1990s. In comparison to its rival technology, called CISC (complex instruction set computing), the RISC chips work in simple, brief, steps, while a CISC computer operates with long strings of commands. There is considerable inertia in getting the huge installed base of CISC users to migrate to RISC, which cannot happen until there is considerably more software available for the RISC architecture.

In line with the development of a joint UNIX version and a new computing platform, Sun and AT&T announced a prototype version of a new product called Open Look in April, 1988, aimed at transforming the forbidding UNIX operating system into one that is "user-friendly" to non-technical users. The graphical user-interface, designed by Sun with the help of Xerox, is intended to provide on screen images and an ease-of-use much like Apple's Macintosh and IBM's PS/2 personal computers. Open Look was launched at turbulent times, since Apple initiated a law suit in April, 1988 against Microsoft and Hewlett-Packard, charging infringement of Apple's copyright covering certain visual features similar to the ones Sun, Xerox, and AT&T have incorporated into Open Look.

This action represented one more step in Sun's attempt to penetrate the low-end business markets. It is also typical of Sun's initiatives to promote their products as industry standards, since they have invited dozens of software companies, chip makers and other computer makers to publicly endorse Open Look and the new refined version of UNIX. Lotus Development Corporation, maker of the popular spreadsheet package 1-2-3 for personal computers, and Ashton-Tate Corporation, developer of the Dbase family of database
management programs for personal computers, both have expressed a commitment to
develop programs to run under the new UNIX and Open Look (Schlender, April 11, 1988).
Both Xerox and Unisys also announced plans in early 1988 to follow Sun's UNIX/SPARC
blueprint (Schlender, March 18, 1988).

Marketing Efforts and Channels of Distribution

When Sun entered the industry in the early 1980s, its areas of market concentration
were primarily computer-aided-software engineering and the simpler design automation
applications. Apollo and Sun co-existed with little rivalry for the first couple of years, as
Apollo was targeting the higher-end design automation applications. In the mid-to-later
1980s, the competition increased as each began targeting the other's traditional market
areas.

Sun has made an effort to keep its revenues spread more evenly than Apollo over
several different markets. Where Apollo had 68% of its revenues attributed to the design
automation area in 1986, Sun's sales were spread more evenly between computer-aided
software engineering, design automation and desktop publishing. In 1987, Sun encroached
on Apollo's turf when it increased its presence in the design automation area. As shown in
Exhibit 7b, Sun's biggest market in 1987 was in the design automation area, comprising
33% of its sales, an increase over the 1986 level of 24%. In addition, Sun reduced its
dependence on the computer-aided software engineering markets, which dropped to 23% of
its business in 1987 from 38% in 1986, and increased its presence in new emerging
markets from 12% in 1986 to 19% in 1987.
Two of Sun’s important new market areas are the federal government and Wall Street. Sun reorganized in the summer of 1987 and created a Federal Systems Division, which operates out of Washington, D. C., to support the government’s needs. Says Carol Bartz, who hea$t the new division,

"The federal government is the largest user of computers in the world, and its appetite for workstations is just overwhelming."

Sun’s government sales, primarily to the military and the intelligence community, tripled to $30 million for the fiscal year ending June 30, 1987. This market segment is dealt with through large systems integrators, or VARs who act as prime contractors between the government agency and the computer companies (Gannes, 1987).

Another new emerging market for Sun has been the financial community on Wall Street. Sun’s workstations are used in several large financial firms such as Morgan Stanley, L. F. Rothschild, the Athena Group, and Kidder Peabody.

Other new emerging markets include artificial intelligence, earth resources, oil exploration, simulation and medical imaging (Snelling, 1988). Sun has established a separate marketing organization within the corporate marketing group to evaluate the needs of these markets. This organization, in turn, interfaces with the product development groups to influence the technology development for these new market segments. When interviewed in January, 1988, Henry Snelling, the manager of this group, expressed a need for more sophisticated graphics to address the needs of these applications. He felt that this was the weakest link in Sun’s technology for penetrating these new areas.
Sun's public relations team has capitalized on many opportunities to publicize Sun's strategy, and as a result, has become a Wall Street favorite. It has received much publicity on many issues, including its company officers, its promotion of standards, the licensing of its SPARC architecture, its new 80386-based system, and its agreements with AT&T.

Sun has a large direct sales force who deal with OEMs, large volume end users, and VARs. The average Sun salesperson brought in nearly $3 million a year in revenue in 1987, more than twice the industry average (Gannes, 1987). In the early 1980s, sales were mainly to OEMs, who resold Sun's products with their design automation applications. As the technology improved and more third-party software became available, sales became more equally split between large volume end users and OEMs.

Sun's marketing activities targeted for the OEMs and large volume end users include advertising in technical computer publications, periodic direct mailing to customers and prospects, and attendance at trade shows. An active user-group program is maintained that includes the sponsoring of an annual nationwide meeting of users, quarterly newsletters and regular exchange of information between Sun and its users. Sun also sponsors as series of seminars to specific OEM, university, commercial, and government customers and prospects, designed to familiarize attendees with the capabilities of Sun's product line (Sun, Form 10-K, 1987).

Sun's field support organization includes software analysts, hardware engineers and technicians who provide sales, installation, and technical assistance. Sun's customer education organization administers customer training in technical software and system maintenance (Sun, Form 10-K, 1987).
In November, 1987, Sun launched a major new effort to open the VAR distribution channels. At its press announcement in November, 1987, Scott McNealy said,

"The VAR marketplace represents a significant opportunity for Sun to diversify its distribution base worldwide. The program will enable Sun to capitalize on the vertical marketing clout of VARs, penetrating new markets with value-added systems solutions."

VARs are selectively authorized to sell certain Sun products with specific value-added applications in a restricted geographic area, with Sun administering a tightly controlled program to minimize cross-channel conflict with the direct sales force and OEMs. Sun assigns a field sales representative and an account manager to each VAR from its direct sales force. The systems integrators which participate in Sun's VAR program are eligible for many benefits, which include the following (Sun, November 2, 1987):

- A lead referral program, in which the Sun's field sales force distributes quality end-user leads to VARs.

- A cooperative marketing program, which covers advertising, direct mail campaigns, product literature, education, trade shows and special events.

- A representatives program, through which Sun assigns a field sales representative and an account manager to assist in the VAR's sales efforts. The representatives act as a liaison between the VAR and Sun, answering questions about prices, programs, products, terms and conditions.

- Extensive sales tools. Sun provides VARs with videos, slide presentations, proposal materials, competitive analyses, and extensive product literature.

- Product training and extensive technical courses for VARs, in addition to ongoing in-field sales development training, including one-day seminars.

- A corporate hotline with assigned Technical Support Engineers that service the VAR account.
• A hardware maintenance program to enable the VAR to augment his own strengths with Sun's service organization. Customer service obligations are handled by Sun's qualified field engineers.

The strategic move was designed to extend Sun's presence in key vertical markets, such as computer-aided design, software engineering, manufacturing, and publishing, and to open the channels to newer markets. The program was also intended to play a particularly important role in moving Sun workstation technology into commercial applications not already served by Sun. The systems sold in these markets are typically the low-end systems, where profit margins are less than high-end systems, making them hard to justify with a direct sales force.
CHAPTER 5
THE COMPETITION

Apollo Computer

Apollo pioneered the industry when it launched its first workstation in 1980. It quickly dominated the infant industry, and experienced terrific growth and profitability until 1985, when it experienced an operating loss after becoming caught in the slump in the semiconductor and electronics industry. In contrast to Sun, Apollo had concentrated its sales on a few large OEM customers in the design automation area, who curtailed buying during this period. Apollo found itself sitting on top of excess inventory and manufacturing capacity. In addition to a slow-down in its main business, Sun was stealing sales with its promotion of its open systems architecture and its adherence to industry standards.

Following the loss in 1985, Apollo turned a small profit (2.3% of sales) in 1986, and continued to improve (to 4% of sales) in 1987 (Apollo annual report, 1987). However, Apollo lost its leadership in revenues in 1987 to Sun and Digital Equipment Corporation.16

Apollo responded swiftly to its loss in 1985 by converting its systems to support standards and expanding its application and customer base.17 It invested heavily in opening

16 See Exhibit 2.

17 Although Apollo offers the UNIX operating system, it continues to push its proprietary Aegis software.
up its architecture and offering industry standards. They plan to introduce a new operating system in June, 1988, called Software Release 10, which combines both UNIX versions Berkeley's Version 4.3 and AT&T's System 5.0. In addition, they have adopted all major communications standards, such as Ethernet and IBM's token ring. However, Apollo continues to promote its Domain networking environment in installations with large numbers of Apollo-only systems. It typically uses Ethernet in heterogeneous environments.

There is much debate as to whether Sun or Apollo offers the better networking environment and to what degree each has adopted "more standard" standards. Industry specialists claim that Apollo's networking is optimized to link large numbers of Apollo computers, while Sun's is more suitable for an environment using computers from several different manufacturers. To address the issue of compatibility with the wide range of IBM PC-AT products available, Apollo offers an IBM PC-AT bus in their low-end workstations.

Apollo has placed a lot of emphasis on third-party software through its Apollo Partners Program. They have identified about 50 leading companies and have placed dedicated managers on each of these accounts. In addition, they offer these vendors things like development discounts, newsletters, prioritized service, and press releases.

Apollo has approached the market in a slightly different manner than Sun. Until 1986, over 60% of Apollo's sales were from the design automation market, whereas Sun's sales were split more evenly between software engineering, publishing and simpler design automation applications. At this time, in addition to experiencing a slow-down in the design automation markets, Apollo realized that Sun was going after the lower-end markets with less expensive monochrome systems, targeting applications which had less graphics

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18 All workstation vendors have chosen slightly different approaches to offering AT&T's UNIX operating system, which is recognized as a key industry standard. However, the Unix issue will take on a new light when the Sun/AT&T joint version is released.
requirements. In 1986, Apollo began to shift its market focus to include these lower-end markets and new commercial segments as well.

Until 1986, about 70% of Apollo's sales went through the OEM channels, with the remainder to large volume end users. Their first big OEM accounts were Mentor Graphics, which specialized in electronics design software, and AutoTrol and Calma, primarily for mechanical design applications software. After the OEM channels market dried up in 1985, Apollo shifted its sales channels focus to sign up more large volume end users. As of 1987, Apollo's sales mix had changed to large volume end users accounting for about 50% of its sales, while the OEMs' share had decreased to about 45%, and the VAR channels had increased to just under 5%.

Apollo appears to be also gearing up to deal with these channels through its marketing programs group, although they seem to be less convinced about the value of VARs. In an interview, Paul Esdale, who heads Apollo's Marketing Programs group, expressed the need for direct account control in order to adequately seek out new application segments within the existing customer. He felt that dealing indirect through OEMs or VARs reduces the account control to penetrate new application areas within the same account. He predicted that 20% of their business would be through VARs by 1990.

Symmetron is an example of an Apollo VAR, which sells to tool & die and mold making shops that have less than $50 m in annual revenue. They add software that they develop themselves and do not take possession of the Apollo equipment.

Apollo, like Sun, offers a full line of workstations, yet it has concentrated more on
performance than on price. As far as pricing is concerned, its strategy has been to keep pace with Sun. Apollo has placed more focus on the mid-to-high-end markets where graphics performance is important, and as a result, has an excellent reputation for its graphics capabilities.

In line with this strategy, Apollo announced in March, 1988 that it would introduce a dramatic new workstation, the DN10000, in the fall of '88, with near-supercomputer capabilities. It embraces a number of new technologies, including parallel processing, RISC architecture, and 64-bit addressing (double the 32-bit design of most minicomputers and workstations). It has 4 parallel processing chips, each with a performance range of 15-25 MIPS per processor (Esdale, 1988). This new line is expected to compete with a new category of workstations, referred to as graphics supercomputers, developed by startups Stellar Computer of Newton, Massachusetts and Ardent Computer of Sunnyvale, California.

Although the complete graphics capabilities are not expected to be completed until 1988, the new system will initially be promoted as a powerful server. It is expected to be priced from $70,000 to $130,000 (Wilke, 1988).

In 1984, Apollo had predicted that they would be a $600 million company by 1985, and built a large new manufacturing plant in Exeter, N.H. to support the new growth. However, Apollo did not reach this goal until 1988, which resulted in excess capacity which significantly impacted profit margins in 1985 through 1987. In 1988, there was still some excess capacity, but Apollo was starting to realize efficiencies from the new plant through increased volumes, increased automation, and reductions in plant personnel.

Like Sun, Apollo has relied on strategic alliances to support its growth. In 1987, Apollo's Solution Supplier Program nearly doubled its available software to almost 1500
application packages from more than 750 suppliers around the world (Apollo annual report, 1987). In addition, Apollo enlisted Alliant Computer to supply its workstation server products, which act as the central coordinating processors within a multi-system network. This alliance was deemphasized in recent years when their markets and range of products began to overlap.

Unlike other workstation companies, Apollo has not signed any strategic agreements with other major computer companies to support their future growth.

**Digital Equipment Corporation**

Digital (DEC) has long been a dominant force in technical markets within the overall computer industry with its $9.3 billion business of its tightly integrated VAX mini- and superminicomputer products. DEC entered the workstation industry in the mid 1980's with the introduction of its VAXstation line of desktop workstations. It surprised most observers by shipping the greatest volume of workstations in 1987: 40,000 VAXstations, which accounted for nearly one-third (31%) of the total 1987 workstation shipments. DEC's strategy has been to sell its workstations mainly to its existing VAX customers, many as replacements for VT-100 terminals which were connected to a central VAX mainframe. DEC is expected to become the new installed-base leader by the end of 1988, with a shipment rate of approximately 5000 VAXstations per month during 1988 (International Data Corp., March 3, 1988, p. 8.)

DEC offers a broad line of VAXstation workstations, ranging from its entry level

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19 Exhibit 6 shows workstation shipments for 1987 by vendor.
model priced around $5000 to a high-end offering priced around $40,000. DEC's low-end line starts with the VAXstation 2000, climbs through the VAXstation II/GPX, and tops out with the VAXstation 3200 (Robinson, 1988, p. 61). The high-end product rivals the comparable offerings of Sun, Apollo, and Silicon Graphics in MIPS performance benchmarks. Unlike other workstation vendors who have developed special configurations of their workstations to be used as network servers, DEC has chosen to promote its VAX 8000-series mainframes, priced at over $500,000, as its network servers.²⁰

One of DEC's strong points is that the VAXstation workstation architecture is consistent with the rest of DEC's VAX minicomputer line, allowing easy integration into an all-DEC networked environment, and offering one-stop shopping for its customers. Software is compatible across its broad computer line, from its workstations up to its largest VAX mainframes. As a result of keeping compatibility as its main priority, VAXstations are generally viewed as lagging behind competing products in performance and other features.

Since workstations have been targeted toward applications which previously ran on minicomputers, DEC has the most to lose with its entry into the workstation industry. High performance, low-price workstations compete directly with DEC's existing minicomputer products. However, its large installed base of technical users, who are primarily software developers and engineers, is one of DEC's biggest strengths. It has a large captive market of users who have built up a huge library of software applications that run under DEC's proprietary VMS operating system. The high switching costs associated with changing applications from VMS to other operating systems has given DEC the leverage to lock in its large installed base of users.

²⁰ A server acts as a network coordinator. DEC's server offering is priced about 8 times higher than Sun's offering in that product class.
One of DEC's weaknesses is that UNIX has become the favored operating system for technical applications, and many third-party software developers have written their new products for the UNIX operating environment. DEC received pressure to support UNIX from its software suppliers, who wrote primarily for the VMS environment, in addition to receiving pressure from its existing customer base. DEC succumbed to the pressure to support UNIX with its introduction of a version of UNIX it calls Ultrix. Yet there is still much debate as to how much support DEC is giving to Ultrix versus continuing to invest its resources into adding proprietary enhancements onto VMS (note McWilliams, 1987 and D.H. Brown, 1987). The library of VMS software application has been slow to migrate to Ultrix, and as of December, 1987, the Ultrix catalog only listed 16 CAD/CAM/CAE graphics packages.

DEC's past proprietary approach has limited its ability to win new customers for its workstations, and has caused some defections among VAX users to other vendors' UNIX-based systems. DEC's customers have mixed opinions about how DEC should approach UNIX. Some of their loyal VMS users feel they are able to do everything they need with VMS, while other potential customers swear they will not purchase DEC equipment as long as they are convinced that DEC has not thrown its full support behind UNIX. To date, Ultrix has been sold with 20% of the company's VAXstations, compared to 70% of all Apollo systems and about 90% of all Sun systems. This gap threatens the software availability for the VAX. Interestingly, market researcher Dataquest, Inc. estimates that 75% of Apollo and Sun workstations last year were installed in DEC VAX shops (McWilliams, p. 18), lending credibility to the theory of dissatisfaction amongst its existing customer base.

DEC, however, is not taking its poor price/performance position lightly. In order to
boost its competitiveness, it introduced the VAXstation 3200 and 3500 in September, 1987, which offered increased performance over earlier VAXstation models and was competitively priced at $19,000. In addition, it reduced the price of its low-end model to below $5000 in June 1987 (Leibowitz, November, 1987, p. 27).

DEC made a key strategic move in January, 1988 when it announced an agreement with Apple to jointly develop the networking interface between DEC's VAX systems and Apple's personal computers. This was thought of as being DEC's attempt to penetrate the low-end markets along with Apple's strong distribution networks, as well as an opportunity for Apple to access the large customer base of DEC.

Hewlett-Packard

Hewlett-Packard (HP) entered the computer industry in the 1970s with a broad line of multi-user minicomputer products, diversifying from its traditional business of scientific calculators and industrial test and measurement instruments for manufacturing environments. In the early 1980s, HP expanded its computer business, which was mainly for data-processing, factory and scientific purposes, into the more office-oriented personal computer arena when it introduced its IBM-compatible Intel 80286-based personal computer. In the mid-80s, HP added a competitive line of workstations, targeted at its existing scientific and technical customer base. Its workstation applications have been split equally among design automation, measurement and software development.

HP's workstation entries include two series of products, one family (HP 9000 Model
300 workstations) based on the Motorola 68000 family of microprocessors, and the higher-end (HP 9000 Model 800 systems) based on HP's own proprietary RISC processors (Robinson, 1988, p. 64). Its RISC philosophy is different than Sun's, in that HP chooses not to promote its own RISC design to the rest of the industry. While HP is one of the leading companies in workstation shipments, more than half of its low-end workstation products are installed as dedicated processors, having been shipped with only Basic or Pascal languages instead of an operating system. 21 Like other workstation vendors, HP has become a proponent of the UNIX operating system, shipping UNIX on over 75% of its 800 series systems during 1987 (Levine, 1988, p. 111).

HP's workstation strategy has been to leverage the loyalty of its existing account base by maintaining its excellent reputation for service and support and keeping a satisfactory price/performance ratio to prevent other workstation vendors from encroaching upon its existing client base.

Having entered the computer business as a large well-established firm built up around servicing the industrial sector, HP faced many new organizational challenges in developing its computer business for commercial as well as technical environments. When it first entered the computer field in the 1970s, it established a computer business sector in Sunnyvale, California, separate from its technical sector, to service the needs of its minicomputer and personal computer users. However, when it introduced its workstations

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21 Some analysts disagree on the extent of HP's workstation market share. Dataquest showed HP in third position in 1986 behind Sun and Apollo in total workstation revenues, while International Data Corporation lists them in 5th place for 1986. The difference is that IDC counts only HP Model 300 and 800 systems that are shipped with their HP-UX version of UNIX operating system.

The systems shipped without an operating system are typically installed in an industrial environment to control a certain manufacturing operation or process, while those shipped with an operating system have more ongoing user-interaction for development, engineering and office uses, and therefore IDC feels that the non operating system types are not really being used as "workstations".
in the mid 1980s, targeted initially for its technical and scientific customer base, it placed the workstation development and marketing groups within the technical sector in Fort Collins, Colorado. This remains one of HP’s biggest challenges as workstations evolve to more commercial applications and the function and features desired by both sectors become more similar.

**Silicon Graphics**

Silicon Graphics (SGI) has been a niche player in the workstation industry, with its high-end workstations targeted at applications requiring high-speed graphics.\(^{22}\) It has differentiated itself from the other workstation vendors with its superior graphics features and performance. In the last two years, SGI doubled its workstation revenues, and rose to become a strong second-tier player.\(^{23}\) Despite its highly niched position, it has earned a respectable number 5 ranking in overall 1987 revenues. It is considered to be the leader in the high-end graphics portion of the workstation industry (SGI, September, 1987, p. 1).

Like several other workstation vendors, SGI offers both 68020 and RISC-based workstations. The base prices for its systems range from about $20,000 to $80,000 (Weigner, November, 1987, p. 162).

SGI’s biggest competition in the past has been from Hewlett-Packard’s Model 350/SRX graphics workstation. It faces other strong competition from Sun, as well as Apollo, Stellar and Ardent, who announced new high-speed graphics workstations to be

\(^{22}\) SGI refers to this class of workstations as superworkstations, which have greater compute power and graphics performance than mid-range systems.

\(^{23}\) See Exhibit 5.
introduced in late 1988.

SGI is credited for creating some of the markets they serve. One good example is animation, in which they hold the largest market share of any workstation vendor. The other high-performance areas in which they compete are mechanical design automation, (their largest market), scientific modeling, visual simulation, which includes applications such as flight, medical imaging and radar display, industrial design, VLSI design, and manufacturing simulation, which includes CIM and robotics planning.

SGI has chosen to adhere to 3 important industry standards: UNIX, Ethernet, and Network File System. Yet to achieve the high-performance needs for graphics, it has developed its own proprietary set of VLSI chips for graphics and geometry processing. Contrary to Sun's approach, SGI has chosen to build these chips in-house rather than rely on outside chip manufacturers. SGI has attempted to support industry-standard software for established markets and has sponsored the development of new software to hasten the maturity of the market. Through its Geometry Partners Program, SGI promotes new software development and porting of existing software with more than 50 leading software vendors. SGI has more 3D graphics applications running on its high-end workstations than any other vendor (Silicon Graphics, 1987).

SGI's strategy has been to maintain superior graphics performance and expand its product line downward into the less expensive low to mid-range products. In a personal interview they stated that they recognize they must reorganize the company to address a broader line of products. Initially, with a narrow product line, they survived with a fairly flat organizational structure. However, with expansion into new markets, they must
reorganize so that the basic technology and software can be shared among many different products, yet service the varying needs of different market segments.

Silicon Graphics' strategy of branching into a broader product line may be a mistake for them at this time, since the new entrants on the high end, Ardent and Stellar, as well as new high-end systems from Apollo and Sun, are targeted directly at Silicon Graphics' primary markets. Until 1988, they virtually owned the high-end markets, and branching into other already crowded areas may be a near impossible move to pull off without sacrificing their primary business.

In order to fuel this new expansion, Silicon Graphics formed an alliance with Control Data Corporation early in 1988, in which CDC would purchase 20% of SGI. This alliance gave SGI the needed capital to expand, and CDC access into a new industry.

**IBM**

IBM entered the workstation industry in early 1986 with its RT-PC. Unlike Sun and Apollo, it did not base its systems on the popular Motorola 68020 microprocessor, and instead built a proprietary RISC microprocessor. Despite the marketing clout of its maker, the IBM RT PC only gained as high as a 4% market share during 1986 and 1987. After its slow start in 1986, IBM gained little momentum selling the RT configured as a single-user workstation in 1987. Fully two-thirds of RTs continue to be shipped as multiuser, commercial systems (International Data Corp., 1988). IBM offered its own version of UNIX, called AIX, as the main operating system, and adopted the industry windowing standard. However, its price/performance was not competitive with similar models from
the other leading vendors.

During 1987, IBM introduced its powerful new personal computer, the PS/2 Model 80, based on Intel's 80386 32-bit microprocessor. This has caused many buyers to doubt the long-term viability of the RT-PC. Although there is quite a bit of difference between the PS/2 and the RT-PC, this is not readily apparent in the eyes of the casual observer, who sees the PS/2 as having similar computing performance, graphics resolution, types of local area networks supported, windowing, and support for thousands of existing DOS programs. In reality, the PS/2 has a limited virtual operating system, and lower graphics performance. The bottom line on the RT-PC versus the PS/2 debate is that while the RT-PC may offer some performance advantages over the PS/2, the differences will be too indistinguishable to prevent the PS/2 from becoming IBM's primary technical workstation, especially once UNIX is fully implemented on the PS/2 (Burdick, 1988). As of early 1988, the PS/2 was still awaiting the full implementation of the OS/2 operating system from Microsoft to take full advantage of the advanced features of the 80386 processor.

IBM's manufacturing clout, their strong sales and marketing organization, and their large installed base of customers in the commercial sector presents a potent threat to the makers of other low-end workstations. Their biggest challenge is to encourage development of third-party software for the PS/2.

Symbolics

Symbolics has chosen to pursue a strategy of proprietary technology for a specific market niche. It has focused on the artificial intelligence market with its symbolic
processing architecture, tailored for rapid execution of LISP (List Processing Language), the most commonly used computer language for artificial intelligence and other advanced symbolic processing applications.

Their product strategy has been to provide a software development environment for LISP applications. Their target markets have included mainly research institutions, the government, and recently some interest from the financial sector. For example, American Express is involved in a major program to use Symbolics systems for doing instant customer credit checks.

They have recently made attempts to leverage their software base by providing a plug-in 80386 board, which will allow the software developer to develop software for the IBM-compatible (80386-base) machines.

Symbolics had very encouraging performance from 1981-1986, its sales growing to $114 million. But setbacks occurred both in sales results and management, and revenues dropped to $103 for 1987, with losses of $25 million.

The key issues for Symbolics's future are (a) will customers be willing to pay a premium for superior, yet proprietary, technology and performance, (b) can Symbolics compete with other high-end systems to deliver superior performance, and (c) should they alter their strategy to offer only software tools for other vendor's platforms? Since Symbolic's strengths appear to be in its software for artificial intelligence applications, it may make sense to get out of the business of supplying the hardware platform, and act as a VAR for the artificial intelligence market niche.
New Entrants - The High-End

Two new entrants on the high-end are Stellar Computer of Newton, MA and Ardent Computer of Sunnyvale, California, both founded in November, 1985, and both of which announced their new products in early 1988. Their products are targeted between the high-end offerings of existing workstation vendors and minisupercomputers, combining the features of both. These systems have been referred to as "graphics supercomputing workstations," with performances exceeding 20 MIPS. They are expected to be priced between $100,000 - $150,000 (Fitz Simon, 1988).

They have targeted a select group of scientists and engineers who need heavy-duty computing power and want the output displayed as sophisticated 3-D graphics. Key applications are expected to be those such as molecular modeling, computational fluid dynamics and computer animation. Typically these scientists rely on powerful number-crunching mainframes stuck in air-conditioned rooms. They compete with one another for time on the machines, input their data, and then wait, often overnight, for the computer to print out the results - on paper (Boston Globe, March, 1988).

They are both led by executives who are well-known in the industry. Stellar's founder and CEO, John William Poduska is a former founder of Prime Computer and Apollo. Ardent is led by Allen Michaels, former founder of Convergent Technologies, and assisted by Gordon Bell of Digital and Encore fame.

Their architecture approaches are very different. Stellar's machines consist of 45 proprietary application-specific integrated circuit microprocessors, fabricated by LSI
Logic. In contrast, Ardent's system is based on a RISC chip from MIPS Computer Systems in combination with a board set made by Silicon Graphics.

Industry analysts estimate that these systems will account for 10% of the $2.7 billion technical workstation market in the next couple of years (International Data Corporation, March, 1988).

Another new player is Intergraph, which rose to become the sixth largest vendor in 1987, after altering its strategy from a "total solutions" supplier of traditional turnkey CAD/CAM systems (i.e., a value-added reseller or systems integrator), to a manufacturer of graphics workstations. They have introduced a series of workstations based on the Fairchild (now Intergraph) Clipper processor chips, which have been price/performance pace setters in the mid-range markets.

Intergraph holds a promising position for several reasons. First, its workstation architecture reflects 15 years of experience in identifying and meeting the unique requirements of graphics users. Second, their Clipper-based workstations track the leading edge in hardware technology. Thirdly, these workstations embody existing software standards. Finally, third-party software is easily supported with a single software port executable on all workstations within their 16-member family (Robinson, February, 1988, p. 72).

New Entrants - The Low-End

The low-end entrants are the personal computer power houses, Apple, IBM, and
Compaq. International Data Corporation (IDC) classifies these systems traditionally known as personal computers as workstations if they are shipped with the UNIX operating system, which provides the multitasking environment characteristic of traditional workstations.

Prior to 1987, IDC defined a workstation as full 32-bit CPU, standalone, single-user capability, desktop or deskside configuration, engineering operating system, graphics (not just text) capability, 2 MB minimum main memory often expandable to 16MB, virtual memory, integer performance of at least 1 MIPS, and primarily used by a technical professional for technical applications (IDC, March, 1988). The key differences between personal computers and workstations is given in Exhibit 3, and were discussed earlier in the Workstation Definition section.

Compaq's Deskpro 386 was the first microcomputer from a major player to be powered by a full 32-bit microprocessor, when it was announced in late 1986. Six months later, IBM announced the PS/2 line, which included the Model 80, also powered by the Intel 80386 chip. By the end of 1987, there were many 80386 systems available from many different manufacturers.

Apple's new Macintosh II is a good entry level workstation, and is a strong alternative to the Sun-3/60 low-end systems. (However, at the time of this writing, it still remains to be seen how Sun's new 80386-based system, announced in April, 1988, will stack up against the Mac II.) The Mac II and the Sun-3/60 offer similar performance, but the Mac II is easier to use and more responsive to user input. However, the weakness of the Mac II is its operating system, which until it has the ability to support virtual memory, will be unable to handle complex simulations and design analyses. Apple is planning to offer
this with its UNIX-based A/UX operating system (Shebanow, 1988).

Other New Entrants

In March, 1988, Apple and Texas Instruments entered into a strategic alliance when they announced a new low-priced computer based on Apple's Macintosh II, to be used for artificial intelligence applications. For Apple, the new product, the microExplorer, is an opportunity for it to broaden the markets for its personal computers. For TI, which will supply its advanced microprocessor for artificial intelligence, called the Lisp\textsuperscript{24} chip, the venture offers access to markets not reached by its own Explorer machines and underscores the new willingness for TI to form alliances in technology areas where it is not strong. The product will be aimed at businesses and professionals, working with artificial intelligence software for tasks such as monitoring manufacturing processes or aiding medical diagnosis, which can not afford the more expensive Texas Instruments systems. The market for artificial intelligence applications is still so new that it is unclear how large the market actually is (Duke, 1988).

Foreign Competition

Until recently, the workstation industry has been dominated by domestic companies. However, its impressive growth has attracted the interest of the Japanese. NEC has already introduced workstations in the U.S. and Hitachi and Sony are expected to export their systems to the U.S. market soon (Leibowitz, November, 1987, p. 29).

\textsuperscript{24} Lisp stands for List Processing language. It is an object-oriented language, popular for use in artificial intelligence applications.
Sun claims it is not worried because the 12-18 month life cycle of the products is just too short for the Japanese to copy. Another factor is that, unlike the more commodity-like personal computers, technical markets require a much higher level of technical support and service, an issue which could put the Japanese at a disadvantage. However, NEC is attempting to counteract this disadvantage by targeting its sales to value-added resellers rather than selling directly to the end user.
CHAPTER 6

CONCLUSION

Strategic Issues Facing Sun

The strategic choices facing Sun, introduced in Chapter 2, are repeated here for convenience:

• Expand into a broad-based, general-purpose computer company along the lines of a Digital Equipment Corporation;

• Concentrate on high-end desktop graphics supercomputers like those manufactured by new entrants, Stellar and Ardent;

• Focus on a few market niches where Sun had been successful in the past, such as computer-aided software engineering and design automation;

• Focus on the potentially high-growth low-end workstation markets, primarily commercial applications, with products that compete with the new generation of personal computers offered by such strong forces as Apple, IBM, and Compaq.

Expansion into a broad-based computer company along the lines of DEC and HP, although not impossible, would take a decade or more to execute. This may well be a long-term goal of Sun, but there are more immediate problems to address, in order to stimulate growth for the 1990's. In my opinion, it would be a mistake for Sun to attempt to move too fast in this direction. There are many complex issues that must be addressed as growth into a large general-purpose computer company is planned. For example:

• Changes to the internal organizational structure to coordinate the common
needs of many different products.
  * Additional resources.
  * Definition of the new range of computer products.
  * Degree of common technology shared among the different products.
  * Degree of vertical integration.
  * Definition of what additional markets would be served.
  * Understanding of the needs of the buyers of these new markets.
  * New sales and distribution channels to service the new markets.
  * Understanding and anticipation of new trends in technology and in the industry in general.

Sun's growth into a multi-billion dollar company must be a controlled process, addressing each of the issues raised above. Sun is currently trying to answer many of these questions for its already large line of products and markets. Growth into a large computer company can happen through careful planning of its current business.

Concentration on high-end systems presents a couple of challenges for Sun:

  * Industry analysts estimate the total market size of the high-end systems not to be more than 10% of the entire workstation industry (International Data Corp., 1988).

  * Sun currently lacks the graphics capabilities that are important in these high-end markets.

  * There are a couple of serious new competitors in this high-end arena, especially Stellar and Ardent. In addition, Apollo plans to begin shipping its new high-end system in the fall of 1988.

The low estimated market size for high-end systems pertains to today's technology at today's prices. The high-end graphics workstations created the first markets they served with the introduction of sophisticated graphics and computational power. These markets
were not price-sensitive, and were mainly concerned with the sophisticated graphics and compute power. Just as with other computer systems, as technology improved and prices were reduced, the market size increased. It may happen that the systems which are now defined as high-end systems will encroach on the mid-range markets as prices come down. In addition, just as the original markets were initially created because of technology improvements, it is likely that new markets will also be created.

Sun's graphics capability is thought of as being inferior to systems offered by Silicon Graphics and Apollo. Sun would have to invest heavily in the development of its graphics hardware and software products. It would also have to understand the different needs of the buyers in these markets, which include solids modeling, electronics design, visual simulation, scientific modeling, animation, geophysical science, medical imaging, defense and artificial intelligence.

Sun has begun to address these new markets through its new business development group, within its corporate marketing division. However, Henry Snelling, manager of this group, feels that Sun has been limited in these new markets by its graphics capabilities, and would like to see Sun invest more resources into graphics development for these areas (Snelling, 1988).

However, on a more positive note, Sun has always had a good reputation for its price/performance leadership, and the computational power of its Sun-4 systems is impressive. Sun's size in relation to the high-end companies is an advantage. Sun continues to invest in new technology development at the rate of 13% of sales, a rate that may be hard for smaller companies to match. Sun's strong marketing and sales organization would provide a significant advantage over Silicon Graphics, Stellar, Ardent, and Apollo (to a
lesser extent). In addition, the alliance between Sun and AT&T provides the much-needed cash to fund development for growth into this high-end segment.

Another option Sun has is to focus on a few market niches such as computer-aided software engineering and design automation. These have been two of Sun's strongest markets, in addition to electronic publishing. Although this route is less risky than others and has a high possibility of resulting in Sun's dominance in these areas, it is likely to restrict Sun's overall growth potential if taken as its only direction. Examples of two companies that have stalled-out as a result of focusing on small market niches are Masscomp and Symbolics. Masscomp concentrated on real-time UNIX systems for data acquisition and control applications. Symbolics has concentrated on specialized systems for the artificial intelligence markets.

Sun's growth would be limited to the size and growth potential of these markets. The design automation market was about $1b in size in 1987, and is one of the more saturated markets. The 1987 market size for computer-aided software engineering, which was approximately $675 m in 1987, still has strong growth potential (Johnson, 1988).

The high growth markets of the future are expected to be in high and low-end markets. Growth on the high-end is anticipated to be in applications requiring strong graphics capabilities, such as scientific research and development, geo-scientific, imaging, and simulation, now that the graphics capabilities are available (Johnson, 1988). High growth is also expected in economic and financial modeling, with the introduction of powerful computing systems from new entrants Stellar and Ardent, as well as from Apollo's new high-end offering. The low-end markets are also expected to experience high growth, particularly in commercial markets, which include publishing, financial, banking,
insurance, and real estate.

The last option is for Sun to \textit{concentrate on the low-end markets}, primarily commercial, with products that compete with personal computer manufacturers such as Apple, IBM, and Compaq. This direction offers the greatest risk, with the highest potential return. Market researchers estimate that the low-end segment of the market, represented by systems costing $10,000 or less, will account for roughly half of all units shipped during 1988, and is expected to continue to be one of the high growth areas of the next five years (International Data Corporation, 1988).

In 1987, the competition on the low-end increased as Apple, Compaq, and IBM introduced products with performance characteristics similar to those of traditional technical workstations. In addition, workstations migrated into non-technical (i.e., commercial) applications.

To protect its position, Sun responded with its introduction of its 386i low-end workstation, which was a clear move into personal computer territory.

The risks that Sun faces on the low-end are:

- Intense competition from personal computer manufacturers which have high-volume, low-cost manufacturing operations.

- In addition, these PC manufacturers have extensive retail distribution networks, designed to reach the business and commercial users.

- This new 80386-based family expands the number of different architectures Sun has to support to three: the Intel 80386 based systems, the Motorola 68000 family based systems, and those based on its own SPARC architecture. With so
many different architectures, it becomes difficult to allocate resources to support current development as well as future research in related areas.

While UNIX is the common thread among all three, three architectures might be too much for Sun to support. If the new systems catch on in a big way, it could exacerbate the chip supply problem and cannibalize sales of its big-selling 3/60 workstation, which already faces lengthy production delays.

The disadvantage the personal computer manufacturers have over the workstation vendors is in the existing software to run under the UNIX environment. In Apple's case, all the current Mac applications have been written to run under Apple DOS. For Apple to be successful in the technical markets, it will have to convince software developers to write software for its new A/UX (UNIX) operating system. Since the number of Mac II units shipped with A/UX is likely to be much less than those shipped with Apple DOS, it will be difficult for Apple to convince existing software developers to port their applications to the UNIX environment. Therefore, a critical component of Apple's success in the UNIX environment will depend on its ability to attract existing UNIX applications (those for Sun and Apollo) to the Mac (Burdick, January, 1988).

Sun's advantages over the PC companies are:

- Sun has an established reputation in technical application areas. It understands the needs of the buyers and the technology in the low-end technical applications.

- Sun has a head start in establishing links with VARs which service the low-volume technical applications.

- Sun's technology is superior for the low-end technical markets, in terms of the graphics, networking, UNIX software, and extensive library of technical applications.
In summary, it appears that Sun has a technical advantage over the PC companies in the low-end technical markets, yet PC manufactures hold the edge in distribution to the commercial segments. However, it may be more difficult for the PC manufacturers to overcome the technical disadvantage than for Sun to overcome the distribution disadvantage. However, Sun and others must be on guard for what would happen if someone like Apple or Compaq were to join forces with a workstation company. With DEC's new alliance with Apple, one must wonder if this relationship could amount to more than just joint networking software development.

Although this thesis provides incomplete information for planning Sun's future strategy, my guess is that if Sun can leverage its technical advantages over PC manufacturers, its move into the low-end technical markets is its best option for successful future growth.

**Implications of Future Industry Evolution**

As the industry matures, there are many evolutionary factors which will shape the industry structure and the nature of competition. Some of these factors are:

- Changes in the market segments served as technology improves
- Adoption of standards
- New technology
- New entrants
- Changes in the relative position and threat of substitute products
- Penetration of customer groups
- Changes in the position of complementary products
Changes in the markets served

As price/performance continues to improve, we should expect that markets will continue to change. Just as the VAR channels have become an important new link between workstation companies and low volume technical markets, it is expected that retail channels will play an increasingly important role in the low-end commercial and business markets. Workstation companies must establish these channels in order to compete in the commercial markets with the personal computer manufacturers.

Adoption of standards

As more companies offer the same standards, Sun must consider where its competitive advantage will come from. Sun appears to be going after a price/performance leadership and a wide range of products as its primary means of differentiation. However, with entrance into so many new markets, both on the high-end and low-end, Sun runs the risk of spreading themselves too thin by trying to execute too many new tactics at once. The markets at each extreme differ significantly in the buyer’s needs, the hardware and software product technology, and the distribution channels.

New technology

As mentioned in chapter 3, an important consideration with workstation technology is in understanding the limits of the existing technology, and knowing when to make the shift to a newer technology. As recent evolution has caused a shift from the use of CISC to RISC architectures on high-end systems, workstation companies must properly anticipate when
to make the shift to parallel processing technology. By predicting when the limits of the RISC technology will be reached, companies can plan the shift of valuable resources onto the development of the new technology.

New entrants

Just as the success of Apollo and Sun attracted new large companies and niche players, one can expect that as the industry matures more new entrants will appear. New industries are characterized by a large amount of uncertainty about issues such as the size and existence of market segments, the optimal product configuration, the buyers' needs and how to best service them. The firms which enter new industries first have a high risk profile, and willing to live with a high degree of experimentation and uncertainty about the future.

Sun is a good example of a company with a high risk profile. It does not hesitate to introduce new products that will cannibalize and obsolete existing products. It was willing to gamble (so far successfully) on its adoption of an open systems approach. DEC, on the other hand, a later entrant, seems to display a more conservative risk profile. One example is its targeting of its existing customer base, and its reluctance to embrace the UNIX operating system over VMS to attract new customers and new software products from new (non-VMS) third-party software developers.

As an industry matures, there is a continual process by which uncertainties are resolved. Technologies are tested, markets are identified, and the industry size is more apparent. Along with this reduction of uncertainty may come imitation of successful
strategies and the abandonment of unsuccessful ones (Porter, 1980). This reduced risk may attract new types of entrants into the industry, just as happened with the entrance of DEC and HP.

The change in the relative position (and threat) of substitute products

What will be the next products that will steal market shares from the workstation vendors? One consideration is that the new mini-supercomputer technology, such as that offered by companies such as Alliant and Convex, may eventually come down in cost closer to that of the high-end workstations. If this happens, both Stellar and Ardent, in addition to the new high-end products from Sun and Apollo, are in a prime position to see this competition at their door step. We could see the same kind of blurring in distinction between the mini-supercomputers and high-end workstations that we are now seeing between the low-end workstations and personal computers.

An even more immediate threat, as mentioned earlier, is posed from the high-end personal computer products that will soon have UNIX, graphics, networking, and computation capabilities like that of the low-end workstations, and penetrate the more technical markets.

Penetration of the customer groups

High industry growth rates are characterized by increasing penetration, or sales to new customers rather than to repeat customers. However, once sales become more to repeat buyers than new ones, the next step is for the growth rate to begin to slow. Workstation
vendors must watch for this phenomena as a means of predicting when to alter product and
distribution strategies. The company who continues to service the repeat sales without an
alternate parallel plan for new products for new growth will find itself eventually left
behind.

Changes in the position of complementary products

Changes in the status of complementary products can have a profound impact of a
company's competitive position. Of particular importance in the workstation industry are
third-party software applications and chips. Already we have seen an increase in the
importance of these suppliers, as the availability of third-party software has become an
important competitive factor, and workstation vendors have paid much effort to attract these
software developers to their platforms by conforming to standards which give the developers
options for selling their products to other vendors, offering development discounts, and
marketing and sales assistance.

The U.S. chip suppliers have become an increasingly important factor, as shortage of
memory chips has become a problem for workstation companies in early 1988. The rise in
memory chip prices have caused Sun to raise its prices on workstations, and the shortages
have caused Sun's backlog for its most popular computers to increase to 120 days
(Schlender, 1988). Sun has had the right idea in its alliances with manufacturers of its
SPARC chip, however, none of the workstation vendors currently have much control over
the memory chip shortage, and margins on workstations have suffered as a result of the
higher premiums paid recently for the scare memory chips.

Workstation vendors must anticipate these kind of changes in order to gain a
competitive advantage. It is factors like these that make the need for strategic alliances extremely critical. I do not think that vertical integration into chip production by a workstation company such as Sun would be a smart move. There are too many other important areas of expertise that the workstation vendors need to concentrate on, such as nurturing of new distribution channels, workstation technology and manufacturing development, and product and market development.
EXHIBIT 1 - SUN'S WORKSTATION INSTALLED BASE

Source: Sun's VAR Program Bulletin
EXHIBIT 2
END OF YEAR REVENUE GROWTH LEADING WORKSTATION VENDORS
**EXHIBIT 3 - KEY DIFFERENCES BETWEEN WORKSTATIONS AND PERSONAL COMPUTERS**

**TYPE OF SINGLE-USER SYSTEM**

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>PERSONAL COMPUTER</th>
<th>WORKSTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Operating System</td>
<td>DOS, OS/2, Mac OS</td>
<td>UNIX, VMS, Aegis</td>
</tr>
<tr>
<td>Distribution channel</td>
<td>Primarily retail</td>
<td>Direct, OEM, VAR</td>
</tr>
<tr>
<td>Primary market focus</td>
<td>Commercial</td>
<td>Technical</td>
</tr>
</tbody>
</table>

**DISTINGUISHING PRODUCT CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Personal Computer</th>
<th>Workstation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary application</td>
<td>Text</td>
<td>Graphics</td>
</tr>
<tr>
<td>Integer performance (MIPS)</td>
<td>5.0 maximum</td>
<td>40 maximum</td>
</tr>
<tr>
<td>Typical display resolution</td>
<td>480 x 640</td>
<td>1024 x 1024</td>
</tr>
<tr>
<td>Graphics capability</td>
<td>2D only</td>
<td>3D available</td>
</tr>
<tr>
<td>Operating system</td>
<td>Single tasking</td>
<td>Multitasking</td>
</tr>
<tr>
<td>Examples</td>
<td>Compaq, HP Vectra, Apple with Mac OS</td>
<td>Apollo, Sun, Apple with A/UX OS</td>
</tr>
</tbody>
</table>

Source: International Data Corporation, 1988
EXHIBIT 4 - WORKSTATION MARKET FORECAST
BY TYPE OF PROCESSOR
WORLDWIDE REVENUES OF U.S. VENDORS, 1987-1992
($MILLION)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>$2320</td>
<td>2400</td>
<td>2700</td>
<td>2900</td>
<td>3000</td>
<td>3100</td>
<td>6.0 %</td>
</tr>
<tr>
<td>Mac II</td>
<td>$ 55</td>
<td>200</td>
<td>336</td>
<td>450</td>
<td>520</td>
<td>640</td>
<td>63.4 %</td>
</tr>
<tr>
<td>80386-based</td>
<td>$ 98</td>
<td>275</td>
<td>400</td>
<td>540</td>
<td>620</td>
<td>570</td>
<td>42.4 %</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$2473</strong></td>
<td><strong>2875</strong></td>
<td><strong>3436</strong></td>
<td><strong>3890</strong></td>
<td><strong>4140</strong></td>
<td><strong>4310</strong></td>
<td><strong>11.8 %</strong></td>
</tr>
</tbody>
</table>


---

25 Includes Motorola 680x0-based, proprietary (e.g., VAX) and RISC-based systems. Excludes 386-based system from Sun.

26 This category also includes the Mac II follow-on product(s).

27 Estimates shipments of Sun's 386-based product are included in this category.
EXHIBIT 5 - 1986 & 1987 TECHNICAL WORKSTATION REVENUES and MARKET SHARES FOR U.S.-BASED VENDORS

<table>
<thead>
<tr>
<th>RANK</th>
<th>VENDOR</th>
<th>1986 ($M)</th>
<th>% OF 1986 MRKT SHARE</th>
<th>1987 ($M)</th>
<th>% OF 1987 MRKT SHARE</th>
<th>RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Apollo Computer</td>
<td>391.7</td>
<td>33.1</td>
<td>553.6</td>
<td>20.0</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Sun Microsystems</td>
<td>341.2</td>
<td>28.8</td>
<td>754.4</td>
<td>27.3</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Symbolics</td>
<td>112.5</td>
<td>9.5</td>
<td>101.6</td>
<td>3.7</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>Digital (VAXstation)</td>
<td>102.7</td>
<td>8.7</td>
<td>689.0</td>
<td>24.9</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>HP (9000 Mod 300)</td>
<td>99.5</td>
<td>8.4</td>
<td>300.0</td>
<td>10.9</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Silicon Graphics</td>
<td>59.4</td>
<td>5.0</td>
<td>116.0</td>
<td>4.2</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>IBM (RT PC)</td>
<td>46.3</td>
<td>4.1</td>
<td>102.0</td>
<td>3.7</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Intergraph</td>
<td></td>
<td></td>
<td>98.7</td>
<td>3.6</td>
<td>8</td>
</tr>
<tr>
<td>------</td>
<td>-------------------</td>
<td>-----------</td>
<td>----------------------</td>
<td>-----------</td>
<td>----------------------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td>SUBTOTAL</td>
<td>1155.0</td>
<td>97.5</td>
<td>2715.3</td>
<td>98.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other(^{30})</td>
<td>30.0</td>
<td>2.5</td>
<td>46.6</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>1185.0</td>
<td>100.0</td>
<td>2761.9</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: International Data Corp., 1987, 1988

\(^{28}\) Revenues for the workstation market include the sale of workstations, servers, software tools and utilities, peripherals such as PC coprocessor boards and laser printers, service, and custom consulting fees.

\(^{29}\) The HP systems include only those shipped with an operating system. HP shipped a total of 28,500 Model 300s during the calendar 1986, but 75% of those offered Basic or Pascal in lieu of an operating system.

\(^{30}\) In 1986, no other company had greater than a .8% market share.
<table>
<thead>
<tr>
<th></th>
<th>VENDOR</th>
<th>'86 SHIPMENTS</th>
<th>'86 MRKT SHARE</th>
<th>'87 SHIPMENTS</th>
<th>'87 MRKT SHARE</th>
<th>'87 RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Apollo Computer</td>
<td>16000</td>
<td>35.3</td>
<td>24000</td>
<td>18.5</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Sun Microsystems</td>
<td>14000</td>
<td>30.9</td>
<td>34100</td>
<td>26.3</td>
<td>2</td>
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<tr>
<td>3</td>
<td>HP (9000 Mod 300)</td>
<td>7125</td>
<td>15.7</td>
<td>15000</td>
<td>11.6</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Digital (VAXstation)</td>
<td>3700</td>
<td>8.2</td>
<td>40100</td>
<td>31.0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Symbolics</td>
<td>1444</td>
<td>3.2</td>
<td>1125</td>
<td>0.9</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>IBM (RT PC)</td>
<td>1200</td>
<td>2.1</td>
<td>3400</td>
<td>2.6</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>Silicon Graphics</td>
<td>930</td>
<td>2.1</td>
<td>5750</td>
<td>4.4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Intergraph</td>
<td>4058</td>
<td>3.1</td>
<td>4058</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>----</td>
<td>---------------------</td>
<td>---------------</td>
<td>----------------</td>
<td>---------------</td>
<td>----------------</td>
<td>----------</td>
</tr>
<tr>
<td></td>
<td>SUBTOTAL</td>
<td>44399</td>
<td>97.9</td>
<td>127533</td>
<td>98.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other$^{32}$</td>
<td>948</td>
<td>2.1</td>
<td>1958</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>45347</td>
<td>100.0</td>
<td>129491</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: International Data Corp., 1987, 1988

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$^{31}$ These HP systems include only those shipped with an operating system. HP shipped a total of 28,500 Model 300s during the calendar 1986, but 75% of those offered Basic or Pascal in lieu of an operating system.

$^{32}$ In 1986, no other company had greater than a .8% market share.
EXHIBIT 7a - 1987 WORKSTATION MARKET
Source: Leibowitz, Nov., 1987
EXHIBIT 7b - SUN'S 1987 WORKSTATION MARKETS
Source: Sun Microsystems, Jan., 1988
## EXHIBIT 7c - TECHNICAL WORKSTATION MARKET
### BY PRIMARY APPLICATION AREA

<table>
<thead>
<tr>
<th>PRIMARY APPLICATION</th>
<th>TOTAL 1986 MARKET ($M)</th>
<th>% OF 1986 REVENUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software Engineering (CASE)</td>
<td>363.0</td>
<td>30.6</td>
</tr>
<tr>
<td>Design and Drafting (CAD)</td>
<td>300.9</td>
<td>25.4</td>
</tr>
<tr>
<td>Design Engineering &amp; Analysis (CAE)</td>
<td>158.5</td>
<td>13.4</td>
</tr>
<tr>
<td>Technical Management/Support (includes CAP)</td>
<td>97.1</td>
<td>8.2</td>
</tr>
<tr>
<td>Scientific Research &amp; R&amp;D</td>
<td>68.1</td>
<td>5.7</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
<td><strong>987.6</strong></td>
<td><strong>83.3</strong></td>
</tr>
<tr>
<td>Measurement and Control</td>
<td>53.8</td>
<td>4.5</td>
</tr>
<tr>
<td>Economic &amp; Financial Modeling</td>
<td>27.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Geo-Science &amp; Geo-Engineering (graphics)(^{33})</td>
<td>23.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Simulation (graphics)</td>
<td>19.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Defense (graphics)</td>
<td>13.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Animation (graphics)</td>
<td>13.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Biological &amp; Chemical Engineering (graphics)</td>
<td>11.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Industrial Process Analysis (graphics)</td>
<td>1.5</td>
<td>0.0</td>
</tr>
<tr>
<td>Imaging (graphics)</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Other</td>
<td>34.7</td>
<td>2.9</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1185.0</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Source: International Data Corporation, 1987

\(^{33}\) Includes some graphics-intensive operations
EXHIBIT 8 - SUN'S ORGANIZATION

Pres., CEO, Chairman McNealy, Co-Founder

VP Cust Srvc R. Lux

VP GM Sales J. Roebuck

VP Sales L. Hambly W. Marr S. McConnon

VP Info Res. M. Graves

VP Corp Res. C. Beveridge Exec. VP B. Lacroute

VP Finance CFO J. Graziano

Co-Founder VP R&D W. Joy Co-Founder VP Adv Dev A. Bechtolsheim VP/GM Intcntl D. Ohryn

VP/GM Europe D. Barbe VP Gen. Cncl M. Morris

VP Corp Mktg E. Zander VP/GM Wkstn Div B. Garrow

Vert Mkt Dev

Mktg Comm

3rd-party relations

Public relations

Cust. Mktg

VP Deskside Engr R. Cornell VP Desktop Engr H. Lee VP Mfg J. Bean

VP/GM Fed Sys C. Bartz VP/GM SW Prods E. Schmidt VP Dist. Sys L. Garlick

VP/GM Graphics B. Peuto VP/GM Educ Prods C. Wozniak

VP/GM E. Coast B. Folsom VP Adv Dev W. Rosing

Source: Company interview, April, 1988
EXHIBIT 9 - SUN MICROSYSTEMS SUMMARY CONSOLIDATED INCOME STATEMENTS

YEAR ENDED JUNE 30,

<table>
<thead>
<tr>
<th>(Dollars in 000's except per share)</th>
<th>1987</th>
<th>1986</th>
<th>1985</th>
<th>1984</th>
<th>1983</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Revenues</td>
<td>$537,537</td>
<td>$210,126</td>
<td>$115,249</td>
<td>$38,860</td>
<td>$8,657</td>
</tr>
<tr>
<td>Costs and expenses:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of sales</td>
<td>$272,722</td>
<td>$101,983</td>
<td>$61,697</td>
<td>$21,309</td>
<td>$4,486</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>$69,578</td>
<td>$31,041</td>
<td>$15,193</td>
<td>$4,813</td>
<td>$1,868</td>
</tr>
<tr>
<td>Selling, general and admin.</td>
<td>$126,933</td>
<td>$57,257</td>
<td>$24,103</td>
<td>$9,022</td>
<td>$1,715</td>
</tr>
<tr>
<td>Total costs &amp; exp.</td>
<td>$469,233</td>
<td>$190,281</td>
<td>$100,993</td>
<td>$35,144</td>
<td>$8,069</td>
</tr>
<tr>
<td>Operating income</td>
<td>$68,304</td>
<td>$19,845</td>
<td>$14,256</td>
<td>$3,716</td>
<td>$588</td>
</tr>
<tr>
<td>Interest income</td>
<td>$834</td>
<td>$369</td>
<td>($14)</td>
<td>$286</td>
<td>$136</td>
</tr>
<tr>
<td>Income before taxes</td>
<td>$69,138</td>
<td>$20,214</td>
<td>$14,242</td>
<td>$4,002</td>
<td>$724</td>
</tr>
<tr>
<td>Provision for taxes</td>
<td>$32,840</td>
<td>$9,025</td>
<td>$5,709</td>
<td>$1,344</td>
<td>$70</td>
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<tr>
<td>Net income</td>
<td>$36,298</td>
<td>$11,189</td>
<td>$8,533</td>
<td>$2,658</td>
<td>$654</td>
</tr>
<tr>
<td>Net income / share</td>
<td>$1.11</td>
<td>$0.42</td>
<td>$0.36</td>
<td>$0.13</td>
<td>$0.04</td>
</tr>
</tbody>
</table>

Source: 1987 Annual Report
EXHIBIT 10 - SUN MICROSYSTEMS SUMMARY CONSOLIDATED BALANCE SHEETS

YEAR ENDED JUNE 30,

<table>
<thead>
<tr>
<th>(Dollars in 000's)</th>
<th>1987</th>
<th>1986</th>
<th>1985</th>
<th>1984</th>
<th>1983</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSETS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Assets:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash &amp; temporary investments</td>
<td>$216,494</td>
<td>$49,681</td>
<td>$29,552</td>
<td>$3,513</td>
<td>$1,579</td>
</tr>
<tr>
<td>Accounts receivable</td>
<td>$98,277</td>
<td>$40,380</td>
<td>$16,464</td>
<td>$11,653</td>
<td>$2,515</td>
</tr>
<tr>
<td>Inventories</td>
<td>$66,145</td>
<td>$33,611</td>
<td>$15,726</td>
<td>$8,051</td>
<td>$1,205</td>
</tr>
<tr>
<td>Other current assets</td>
<td>$15,848</td>
<td>$3,835</td>
<td>$1,269</td>
<td>$511</td>
<td>$59</td>
</tr>
<tr>
<td>Total current assets</td>
<td>$396,764</td>
<td>$127,507</td>
<td>$63,011</td>
<td>$23,728</td>
<td>$5,358</td>
</tr>
<tr>
<td>Net property &amp; equip.</td>
<td>$99,870</td>
<td>$45,546</td>
<td>$16,434</td>
<td>$5,644</td>
<td>$2,014</td>
</tr>
<tr>
<td>Spare parts and other assets</td>
<td>$27,328</td>
<td>$9,329</td>
<td>$4,724</td>
<td>$1,820</td>
<td>$361</td>
</tr>
<tr>
<td></td>
<td>$523,962</td>
<td>$182,382</td>
<td>$84,169</td>
<td>$31,192</td>
<td>$7,733</td>
</tr>
</tbody>
</table>

LIABILITIES AND STOCKHOLDERS' EQUITY

Current liabilities:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Notes payable</td>
<td>$36,212</td>
<td>$14,960</td>
<td>$4,362</td>
<td>$900</td>
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<tr>
<td>Accounts payable</td>
<td>$62,995</td>
<td>$29,761</td>
<td>$8,619</td>
<td>$5,112</td>
<td>$1,571</td>
</tr>
<tr>
<td>Accrued liabilities</td>
<td>$31,183</td>
<td>$9,129</td>
<td>$3,928</td>
<td>$997</td>
<td>$383</td>
</tr>
<tr>
<td>Other current liabilities</td>
<td>$25,003</td>
<td>$13,545</td>
<td>$10,753</td>
<td>$1,852</td>
<td>$181</td>
</tr>
<tr>
<td>Total current liabilities</td>
<td>$155,393</td>
<td>$67,395</td>
<td>$27,662</td>
<td>$8,861</td>
<td>$2,135</td>
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<tr>
<td>Long-term debt</td>
<td>$127,444</td>
<td>$4,481</td>
<td>$6,514</td>
<td>$3,421</td>
<td>$749</td>
</tr>
<tr>
<td>Other liabilities</td>
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<td>$2,159</td>
<td>$1,615</td>
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<tr>
<td>Stockholders' equity</td>
<td>$240,734</td>
<td>$108,347</td>
<td>$48,378</td>
<td>$18,910</td>
<td>$4,849</td>
</tr>
<tr>
<td></td>
<td>$523,962</td>
<td>$182,382</td>
<td>$84,169</td>
<td>$31,192</td>
<td>$7,733</td>
</tr>
</tbody>
</table>

Source: 1987 Annual Report
LIST OF REFERENCES


Esdale, Paul, April, 1988. Apollo company interview.


CANDIDATE'S BIOGRAPHICAL NOTE

KATHY KESSEL-HUNTER

EDUCATION:
S. M., Management of Technology May, 1988
Massachusetts Institute of Technology
Sloan School of Management, Management of Technology Program
Thesis: A Strategic Analysis of the Technical Workstation Industry
Northeastern University 1977 - 1987
Graduate School of Engineering Part-time, Computer Sci., Economics
B.S., Mechanical Engineering December, 1975
University of New Hampshire Magna Cum Laude

EXPERIENCE:
AUTOMATIX, INC., Billerica, MA Robotic and Vision Systems
- Management of vision-guided robot development team.
- Marketing and sales assistance; proposal writing, trade show presentations.
- Project and manpower planning, scheduling, cost control, customer interface.
- Technology development: calibration, vision, user-interfaces, communications
- Development of product and applications software; debug, and documentation.

Software Development Engineer 1980 - 1984
- Specification of the Automatix RAIL language & system user-interface.
- Development of software tools and pkgs. (SPC, teach pendant, robot-guidance)
- Initiation of a software and documentation release control procedure.

1976 - 1980 TEXAS INSTRUMENTS, Attleboro, MA Materials & Electrical Products
Project Engineer 1978 - 1980
Coordinator of a pilot program to transfer TI's robot technology from the Dallas development group into production applications. Developed robot user language. Initiated and developed computerized labor reporting system for department.

Manufacturing Engineer 1976 - 1978
Engineering support for metals stamping & molding facilities. Identification of cost reduction programs, and implementation of computerized process controls.

PERSONAL:
Interests: tennis, reading, skiing, sailing, wind surfing, financial planning.
phone: 617-784-7524