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Networking high-end CAD systems based on PC/MS-DOS platforms

Dagmar Antje Brinkmann
New Jersey Institute of Technology

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ABSTRACT

NETWORKING HIGH-END CAD SYSTEMS BASED ON PC/MS-DOS PLATFORMS

by

Dagmar Antje Brinkmann

The concept of today's technology has been dropped. Everything is now either obsolete or experimental. Yesterday's technology is appealing only because it is tried-and-true and prices are reduced for clearance. Tomorrow's technology is exciting, somewhat expensive and not well tested.

In the field of architecture, where most firms are medium or small, having limited resources, the high cost initially required for a CAD installation was generally impossible to meet not too many years ago.

From spreadsheets and CAD graphics to network file systems and distributed database management, the basic systems and application tools have matured to the point that the possibilities are now limited mainly by how creatively the architects can apply them.

CAD systems on the market today are not so different from the systems of the mid 70s, except they have gone from hardware costing a hundred thousand dollar to PC based systems, costing under ten thousand dollars.

Choices of hardware and software for CAD systems undergo continual changes in power and efficiency. There will come a

point where upgrading will create more a deficiency rather than an augmentation of capability efficiency and overall function. Thus it becomes a major problem for the prospect buyer.

NETWORKING HIGH-END CAD SYSTEMS BASED ON PC/MS-DOS PLATFORMS

by

Dagmar Antje Brinkmann

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New Jersey Institute of Technology
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APPROVAL PAGE

Networking High-End CAD Systems
Based on
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by
Dagmar Antje Brinkmann

Dr. David L. Hawk, Thesis Adviser
Professor of Architecture
School of Architecture, NJIT

Dr. Rose Dios, Committee Member
Associate Professor of Mathematics
Department of Mathematics, NJIT

Bharat Gami, Committee Member
Assistant Professor of Architecture
School of Architecture, NJIT

BIOGRAPHICAL SKETCH

Author: Dagmar Brinkmann

Degree: Master of Science in Architecture

Date: January, 1993

Undergraduate and Graduate Education:

- Master of Science in Architecture, New Jersey Institute of Technology, Newark, NJ, 1993

- Bachelor of Science in Architecture, New York Institute of Technology, New York, NY, 1985

Major: Architecture

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INTRODUCTION

A factor behind the rapid growth in computer-aided design is the emergence of low-cost personal computers. Hardware is becoming a low-priced, almost commodity item. Software, on the other hand, is becoming ever more complex.

Since accurate cost analyses must list all business areas impacted by computer technology, CAD, in a narrow sense, is simply a software program. If the same equipment that runs the CAD software can run software suitable for other business purposes, then it is fair to consider the capital cost of CAD as only the cost of the software itself. The hardware cost can be spread around by apportioning costs in all other areas where software such as word processors, database packages, and spreadsheets work to reduce cost. That is one reason PC platforms are so popular for CAD, even if they offer somewhat less capability than high-end systems.

The development of CAD is dated back to the early 1960s when researches at Massachusetts Institute of Technology (MIT) started work on the Sage system (CRT display and operating system). Due to the high cost of computers and peripheral devices, CAD was then considered a luxury.

In the 1980s, CAD developed towards interfacing standards, and powerful specialized hardware and software. The development of super-minicomputers in the late 1970s and

super-microcomputers in the early 1980s added a new dimension to CAD.

During 1989 it was CAD to database integration for automatic schedules and cost analysis, before that it was specialized modules for particular industries [AEC], 1990 has been the year of 3D CAD development, now there seems to be a lot of work on automatic macros and symbol templates.

Once an office makes the decision to buy a CAD system, it encounters the problem of what is the right choice for hardware and software. More than a dozen CAD programs have been developed for architecture (Appendix A). Since most firms buy only one CAD program and then must invest a great deal of time and effort learning it, they are pressured to make the right choice.

The content of the Thesis is to study the conditions and circumstances behind an appropriate choice of a PC-based CAD system, which will include the proper choice of hardware and software. This involves an analysis of the operating conditions of the design professions, with a focus on architectural design, and knowledge of the hardware and software capabilities available, or soon to be available, to meet the needs of these conditions.

CHAPTER 1

THE ROLE OF THE COMPUTER IN AN AEC OFFICE

The increasing use of computers in architectural firms is dramatically changing the historical concept of design profession which was based on providing clients with the service of the architect and charging for this expertise on an hourly basis.

CAD tends to catch architects' attention most because it is intriguing and versatile. Most architectural firms invest in CAD systems in the hope that automating the drafting of presentation and working drawings will buy them more time to conceptual design by traditional methods. CAD, in the overall sense, is simply a resource applied toward a goal. By listing the business goals of the architectural trade that are relevant to CAD, one can come up with a valid way to measure payback. CAD can reduce the cost of business through better design, faster and better documentation, and reduced operating cost.

But adding the CAD system to an architectural office is like acquiring a new staff member. The new member should have good credentials and be able to do the required job, and also be able to adapt to new challenges. But how will the new member handle the same tasks as any other staff member and how will it adjust to and apply the established office standards of practice? To give a CAD system humanized qualities and to attempt putting it to work as a rational,

artificially intelligent thinking system is a typical misconception made in the transition to efficient computer-aided design.

Unfortunately, it is not easy to calculate the benefits arising from CAD because a number of important factors must be taken in account. One must consider the organizational context in which CAD is placed and the particular task for which it is used. A CAD system should only be a productive tool for design and drafting, not a replacement for the normal functions. It is important to consider the skills of the designer or draftsperson operating CAD, and recognize that operators undergo a learning curve lasting up to one year. Management must be prepared to expect little during the initial phase of office automation and schedule activities accordingly. Training determines how productive a person can be with a given set of hardware and software tools. Poor training results in low productivity and can erase any benefits the company hopes to receive from its computing investment. Training is costly and time-consuming and it is disastrous if CAD operators leave the firm shortly after the training is completed. Too often in the architectural businesses people move on, through downsizing and the search for other economic opportunities. As these valued people depart, they often take with them a great deal of personal knowledge which is a net loss to the company.

Training, support, and service are not optional. One way or another, a company pays for all three. For example,

regardless of how skilled and supported an operator is, without proper service the computer system will drop to zero. Furthermore, even an equipment in perfect condition cannot help an unskilled, unqualified CAD operator.

A great way to maximize productivity is to eliminate manual work. Getting information into the system early in a form that can be reused later is important. The sooner data gets into the system, the more chances one will have to print it out later, and the more data there is, the higher the probability that it could be used again. If productivity is the avoidance of work, then most valuable information assets are going to come over a period of time. For example, when you put a piece of information in the machine, then take it back out in a drawing, it might cost two dollar; but if you take it out twice, it only costs one dollar. That's an immediate 100% productivity gain achieved by not having to put the piece of information into the machine a second time. It is also important that the firm builds a system that tracks, captures and records, archives and retrieves information used on a project. If it can be found again, it can be used again, which means zero input and higher productivity.

Basically a CAD system does not directly improve the management of design functions, but it can act as a catalyst for improvement in skills, training, organization, planing, and procedures. Good design is reflected in good products, the result of a well-managed design organization, in which

resources are used effectively. CAD is just a tool for designers to help them in visualizing and controlling designs. Unfortunately it is often a mismanaged tool. Where it is managed better, it might be more useful. Successful implementation of CAD is just as much a question of organization, people, and planning as it is of technology. It is not enough to have pretty pictures on the screen. Indeed, every architectural firm operates differently and must justify its own methods of expression. For most, accuracy is important, if not paramount.

A common misconception is that a computer aided design system alone will improve productivity. But CAD is essentially one component in an overall information management system. The two aspects that really make a CAD system productive are its capability to integration with other systems and the customization which is permitted either in-house or by use of third party software. Can commands be run from an ASCII file? Can external programming language be used to modify the program or drawing model (i.e. "C" binding)? Can macros/menu commands be optimized for speed? Are macros/menu commands compilable to run at the same speed as system commands? Can the programming language run in interpretive mode?

A firm's strategic technology plan should look like a performance specification, not a checklist of hardware and software features. The key to using CAD systems productively is its integrated use for all project phases. Those working

with the computer need to know more than how to operate a specific CAD package.

It is necessary that architects put their hands on the computer. The utilization of the computer's capabilities is apprehended through use, as it is possible to read and hear about design, but in order to learn how to design, it is necessary to engage in designing. Architects are the ones who know how to deal with architecture. They must get involved in the development of systems, if they aspire that these systems may gradually become more familiar to them. They cannot depend on computing specialists to solve their architectural problems.

Depending on the size of the office, the information systems coordinator can be supported by a business applications manager who is responsible for business application software. Technical support should be provided by a systems manager who is familiar with the hardware, the operating system, and the networking software.

Management has to establish or redefine existing standards to conform to the use of a network. With a network there comes the ability to enforce and manage the way each task is stored and made accessible to all the users. In order to prevent 'garbage in, garbage out', the firm has to have a set of rules and methods for each group of users. An example of such rules range from login procedures, menus, common files (blocks), to the drawing numbering scheme and the subsequent directory placement of such files.

While larger firms have hired full-time computer specialists who do nothing but manage the network of CAD workstations, computers, word processors, and other peripheral hardware and software, most smaller firms have given the job of system manager to one of their existing technical staff as a part-time function in addition to his or her regular duties. The system manager can greatly improve computer equipment productivity and minimize system problems by taking care of the following criteria:

1. Maintaining the firm's computer equipment

2. Allocating hardware and software to the users in the office

3. Renting computer equipment when needed to satisfy short-term peak load

4. Ensuring that all computer usage is logged and charged to the proper project or overhead account

5. Ordering supplies in the quantities and frequency that ensures the best prices and availability

6. Keeping up with the latest developments in computer hardware and software

7. Recommending to management when additional purchases are required

8. Coordinating training and providing ongoing user support

The first thing any firm will have to do is evaluate its needs for automation and justify the costs. The firm has to develop a clear vision of its business strategy and needs to

have an understanding of the role CAD plays in that strategy. It needs to focus on a goal and a way to achieve it. Otherwise it could happen that the firm retrospectively claims that at the pre-implementation stage, important issues such as skills and training were not incorporated into investment proposals, a managerial failing which could result in creating problems. Priority of applications will be determined by the office's business vision. Design-oriented firms may pursue high-quality visualization, multi-media presentation or cyberspace applications. Service-type firms may concentrate on project scheduling, resource allocation and cost estimating application. Different architectural firms have interest and concentrate in different areas - Design/Build, Development Building, Model Building and 3D Design, Contract Administration, Custom Detailing, Interiors, Energy Conscious Design etc.. in addition to working on different building types.

To manage the most productive acquisition of a CAD system, some preliminary planning must be accomplished. This planning should take the form of a thorough consideration of how a computer-aided design system would be applied at each of the major stages in a project.

Information that explodes and is available to be reused is an important element in an effective business strategy. Getting information into the system early in a form that can be reused later is important. The more data there is, the higher the probability that one will be able to use it

again. Communication among A/E professionals using CAD systems is very important. Translation of a CAD drawing from one system to another is becoming a requirement on projects done with CAD.

CAD stations in general are very reliable, but failures do occur. It is essential that office management develops contingency plans to deal with equipment failures because certain kinds of machine failure can lead to loss of stored data. The loss of a disk may result in the loss of a great deal of data. Even though most CAD systems provide an automatic backup of individual files, it is necessary to backup the entire system periodically. Disciplined routines by the system manager can ensure that adequate backup measures are used.

How can an architectural practice begin to research for high returns on technology investment? The first step is to shift the firm's focus, as it plans computer investments, from the evaluation of specific products to an analysis of how computer technology can be used to assist the firm in achieving its longer-term goals. A firm's strategic technology plan should look like a performance specification, not a checklist of hardware and software features. And the principals must commit to the plan because there will be a period of investment and absorption before returns are realized.

Very often, the technology of computers, advanced instrumentation, data base techniques, and software are all

ignored by the management with a claim of ignorance of technology. The net effect is that the machinery is no longer the limitation to advancing efficiency, productivity and throughput. The human being using the technology and making the technology better or more applicable is most assuredly the limiting factor.

Often the CAD system works well, but the overall picture is not improved due to the lack of change in the management of the process. However, it is not a good idea to try different approaches on a given project. Instead, a process has to be established, then it has to be executed on a project, and finally effectiveness has to be evaluated. The same principle applies to setting up graphic standards for CAD. First, standards have to be set up and management has to insist on strict adherence to those standards. Then after couple of jobs, the standards have to be evaluated and appropriate changes should be made until specific standards evolve for CAD graphics. These must include how one approaches the CAD system as well as the finished product. If management does not insist on strict adherence to standards, when one designer gets sick, another designer will not be able to complete that particular work.

The years ahead will continue to require enhanced focus on how to improve productivity. Computer-aided design and drafting and computers can be of great help. They can significantly change a firm's work methods and can require totally new approaches to producing drawings. Management

must be aware of these changes or productivity will actually be diminished. While some applications can produce dramatic efficiencies, it requires careful management and skilled operators to make an overall improvement in productivity.

Profitability and productivity depend far more on management skill and organization than on the use of a CAD system. CAD is a tool that is currently being used by a large percentage of design firms. The interim period of establishing a CAD system will be a time of lower profits and productivity. Hardware must be purchased, software obtained or written, staff trained and reorganized, and management processes developed.

Productivity gains promised by vendors are overstated. The management has to learn how to properly bill for CAD use. Failure to determine and negotiate proper charging methods will result in lower profitability if the alternative use of labor could have been billed at a greater rate or in greater quantities.

CHAPTER 2

CAD SOFTWARE

The first CAD products consisted of specialized application software bundled with mainframe or minicomputer hardware to form "turnkey" systems which were designed to support multiple users in a timesharing environment. The market continued to develop with stand-alone CAD workstations becoming available in 1983. Today, CAD software systems, including high-end and low-end systems, are widely used on desktop computers and workstations. CAD systems are all in a state of continual development. Each manufacturer looks at their CAD system as the ultimate single tool. Thus, with update after update, they add modules for all sorts of purposes.

During the 1980s, the CAD market became dominated by two vendors. At the high end was Intergraph, which sold high-powered, high-priced equipment designed to run on large CPUs and perform very sophisticated functions. At the low end was Autodesk's AutoCAD, which sold relatively inexpensive and which could run on personal computers. During the late 1980s, the differences in both costs and capabilities between these standards narrowed dramatically.

From the beginning of the computer age of the A/E profession, computers have been used extensively for highly repetitious, computation-intensive tasks such as structural analysis, HVAC load calculations and energy analysis. Such

tasks, however, as important as they are, comprise a small portion of the effort required to complete a design project. The magnitude of documentation associated with a project has to be considered: rolls of drawing, hundreds, if not thousands, of pages of specifications, not to mention correspondence, team communications, schedules, budgets, time and expense records, just to mention few of them. To manage this mountain of information and managing information is the essence of CAD integration.

The information in an integrated system is organized in a logical way and demonstrates a centralized behavior with consistent and non redundant data. Once multiple users share the data the issue becomes administrative rather than technological. Data must be handled with care by each user, since data corruption affects everyone. Data should not be repeated in separate areas. There is a tendency to create and save data without thinking of other users.

The current state of technological development already makes it possible for departmental groupings to be broken down. On a CAD system, it is no longer necessary for the designer to be near other designers in order to share resources. The designer/detailer does not need to be close to records of company standards and procedures; all can be made available directly upon the system.

For most of the next decade the biggest bang for the A/E's computing buck will be in project integration and management. To state the issue with a slightly different

emphasis, if we commit a piece of information to the computer, we must get more out of it than a graphic symbol on a drawing or a paragraph of text in a specification document. If we draw a detail which includes a steel lintel, brick, mortar and copper flashing, the specifications for lintels, brick, mortar and flashing should be flagged for inclusion in the project-or place markers inserted if the exact details have not been established. If we place a lavatory on the drawing, not only should its specification tag along, but also its hot and cold water and waste connections. Far-reaching, long-term, blue-sky ideas? Perhaps, but remember that five years is a geological era in the computing business. The computer industry has given us the basics: workstations, graphical user interfaces, network operating systems. During the next few years the great strides in computing systems will be in areas that will contribute significantly to A/E project integration, namely: integrated graphics/database/text data structures and object-oriented database.

Useful object-oriented behaviors for a specification document include:

- A specification section could be thought of as an object made up of article objects, which in turn are made up of paragraph objects, and so on.

- If we refer to one of these text objects (e.g., to include a portion of the master specification in a project), we should get the entire object, including any

lower level objects that are part of it, without consciously thinking about where a block of text begins and ends.

- The formatting particulars of a paragraph, such as its numbering, indent and typeface, should be inherited from the document of which the paragraph is a part. When a paragraph is copied to another document, it should automatically inherit the formatting of the new document.

Selecting a CAD system is both easy and difficult. It is easy because there are many good systems, but difficult because finding the best one among the good ones is time-consuming. But the difference between good and best can be an order of magnitude of design and drafting productivity, so it is worth the effort.

It is important to know that there is no perfect CAD package on the market. Each package has particular strengths and weaknesses due to the general marketing orientation of a package by the software company.

Prior making a decision of purchasing a system, the management of the architectural firm should evaluate its needs for automation and justify the costs. The management should consider devising a grading system that takes into account several criteria:

- functional and technical offerings
- connectivity
- price
- intangible benefits

Most CAD programs even though geared to architecture, still require significant training and for occasional users, the relearning of a lot of complex commands. CAD has profound effects on the process of creating, visualizing, and presenting architectural design.

The most dramatic difference in the ability of CAD programs is how well they work in 3D as opposed to 2D. It is important to recognize that not one program does, or could, excel in all these different areas. For instance, a program designed, from the outset, as a 3D CAD system would differ greatly in one started out as a production drawing tool. Most 3D CAD packages (Appendix B) are designed as schematic modeling design tools, or they are designed as presentation or rendering programs, neither is truly appropriate for producing 2D production document drawings. Similarly, a good 2D CAD package (Appendix C) keeps track of entities such as dimensions, notes, titles, detail symbols etc. that have no place in a 3D model.

Once the firm selects the category of software that makes sense for its organization it can actually begin the evaluation process. While many people do a thorough job of comparing various programs on feature by feature basis by watching demos, talking to users, and reading the product reviews, most will stop short of considering the long term potential of a system. When contemplating a hardware purchase most buyers rarely consider expansion capabilities as a criteria for software evaluation. By its very nature,

software is an inherently dynamic product and thus should be the easiest to change. The purchase of a CAD program is not a one time matter because usually from every 12 to 18 months software manufactures will release new versions of their programs. These upgraded versions are available to all existing users for a nominal upgrade fee. The true long term potential and value of the CAD software will be based upon how well the software developer can maintain or exceed his product's current competitive standing in the industry over time.

What this boils down to is that a superior product today may not always hold that title in the future. In fact, the brief history of this industry has shown that some of the leading products can stop dead in their tracks due to the financial problems of their companies. Here factors such as the product's long term change in market share, and the stability of the manufacturer will pay a role. Principal factors effecting competition in the personal computer CAD market are:

- *INTEGRATION*

Does a CAD package have to rely on added components for extra cost to a generic drawing program to get architectural features (ACAD, AEC) or is the architectural part integral (DataCAD)? For example, even though ACAD is currently on Release 12, the AEC module has not been updated since ACAD 2.5. Also, a program designed from the beginning with

architects in mind will inherently be easier to use, more intuitive, and offer more for architects, than a generic drawing package with an architectural module attached.

Integrated systems should allow project development from strategic planning up to space planning and facilities management, including all the intermediate stages, with different features taking part in the whole process in an orderly and interacting manner:

-store, search and retrieve existing data

-visualize design concepts

-analyze and evaluate planning and design information

-develop and illustrates design details

-specify the process of building

-estimate costs and quantities

-schedule, monitor and control construction

-file, store and recall specific data

- *COMPATIBILITY*

One of the most important things to look for in a CAD package is that the system is compatible with the firms consulting engineers and with the local plotting services.

- *PERFORMANCE* *(that means speed)*

The importance of speed depends on which approach is taken. The speed of a program will determine how readily it is accepted in an organization.

- *EASE OF USE*

It is important to find out how long it really takes to become versatile in a package (not from a dealer). The CAD software should be intuitive and simple and should not require significant training.

- *EXTENDED FILENAMES*

Since DOS limits drawing names to eight characters, an extended filename capability is very important. This capability can be used to further identify drawing numbers, revisions, projects, dates, and the creator, which greatly simplifies the drawing retrieval process.

- *HARD COPY OUTPUT*

Most CAD software let the user output drawings to printers or plotters or both, but it is essential to select the system that will support the CAD software. For software that have network support, compatibility with the network hard copy devices is required.

- *SUPPORT AND USER GROUPS*

Support is extremely important, not only in providing training and continuity through updates, but in increasing industry awareness and encouraging third party support of the program.

- *AVAILABILITY OF THIRD PARTY APPLICATIONS SOFTWARE*

To keep the CAD system productive is to seek out and use the resources of the manufactures and vendors of the hardware and software systems. If the local vendor of the potential CAD system does not have local or easily accessible consultants, another system which does should be considered.

When evaluating CAD systems, more than the above mentioned factors come into play. As the CAD's evolution in the AEC industry continues, the question of whether it can ultimately pull its weight will depend on how well it can be integrated into an overall strategic business plan.

Furthermore, in comparing the prices of CAD programs, one could easily fall in a trap overlooking the support offered by the vendors. Some vendors charge up to $1,200 a year for technical support. Some start the fee at time of purchase, others provide free aid during a warranty period.

The CAD package is whatever software product automates drafting functions. There are many such packages on the market, both general purpose and industry specific. The general purpose products with the greatest market share are Autodesk's AutoCAD and Intergraph's Microstation (Table 2). Each different CAD package meets a unique mix of market needs; one, especially an industry-specific product, may meet a company's individual needs exactly.

The CAD marketplace consists of several dozen competing niche products (Table 1). The products differ fundamentally

and those differences are quite subtle and difficult to comprehend (Table 2). How is the current or prospective CAD user supposed to make intelligent choices about which system to use?

	A	CE	C	E	FM	M
AutoCAD (Rel. 12)	X	X	X	X	X	X
CADvance (ver 4.0)	X	X	X		X	
DataCAD (ver 4.0)	X		X			
Drawbase (ver 107)	X				X	
MegaModel (ver 3.01)			X			
Microstation (ver 4.0)	X	X	X	X	X	X
MountainTop (ver 3.2)		X	X			X
PowerDraw (ver 3.0)	X	X	X			X
SilverScreen (ver 2.0)	X		X			
VersaCAD 386 (rev 6.0)	X	X				X

Table 1 CAD Market Analysis:
Architecture (A) Civil Engineering (CE) Construction (C) Electrical Engineering (E)
Mechanical Engineering (M) Facilities Management (FM)

TASKS   **SOFTWARE**

TASKS	ACAD	CADVance	MicroStation	VCAD
Animation	+	N	+	+
Architectural design	Y	Y	Y	Y
Architectural modeling	Y	Y	Y	Y
Building Code Analysis	N	+	+	N
Construction documents	Y	Y	+	+
Cost estimation	Y	+	+	Y
Design development	Y	N	+	Y
Document management	+	+	+	+
Drafting	Y	Y	Y	Y
Drawing management	+	+	+	+
Duct design	+	+	+	+
Facility management	+	+	+	Y
Flowcharting	Y	+	+	N
Interference checking	+	N	+	N
Interior design	Y	Y	Y	N
HVAC system analysis	+	N	+	N
HVAC system design	+	N	+	+
Landscape design	+	+	+	+
Lighting analysis	+	N	+	N
Lighting design	+	+	+	N
Lighting simulation	+	N	+	N
Manual digitizing	Y	Y	+	N
Mass property analysis	Y	N	+	Y
Network management	+	N	+	N
Piping	+	+	+	+
Rendering, presentation	Y	Y	Y	N
Schematic design	Y	Y	Y	Y
Site planning	Y	Y	+	N
Sketching	Y	N	+	N
Space management	+	+	+	Y
Specifications	Y	+	+	N
Steel design	+	+	+	N
Steel detailing	+	+	+	N
Structural analysis	+	+	+	N
Structural design	+	+	+	N
Text editing	+	Y	Y	N
Utilities mapping	+	+	Y	N
Can commands run from an ASCII text file	Y	Y	Y	Y
Can external programming language be used to modify the program or drawing model	Y	N	Y	Y
Can macros/menu commands be optimized for speed	N	Y	Y	Y
Are macros/menu commands compileable to run at the same speed as system commands	Y	N	Y	Y
Can programming language run in interpretive mode	Y	Y	Y	N

Table 2 TASKS
Y   task is part of CAD software package
+   task is available in an add-on package from a third-party vendor

When evaluating the base CAD software packages one will immediately find an incredible range of prices for products. Unfortunately the prospective buyer usually is not aware of the evolutionary improvements in CAD software and hardware. There are two basic categories :

- high-end packages (Appendix A)
- low-end packages. (Appendix B)

The high-end is defined by products costing $3000 or more per workstation. This category includes many of the more widely recognized names in the industry such as Intergraph's MicroStation product and Autodesk's AutoCAD product. These products also hold the largest market share for CAD systems sold in the industry; which implies that since most of the other consultants (and clients) in the architectural field are already using these products there exists a substantial pool of employees trained in the operation of these systems. This single factor alone can substantially lower costs for training over the lifetime of the system and potentially make it easier to coordinate with other consultants.

Selecting a CAD system is more complex than it was when it first appeared on the market. The task is more complex because the CAD system is no longer a gadget to replace a drawing board but instead the embodiment of a technology that the organization must assimilate. Selecting a CAD system means selecting not just the CAD program but also the

operating system software, network software, and hardware - essentially it means redesigning the design environment.

Software must be found or created to automate the chosen tasks. Simply buying software just to get the job done is not enough. It is essential to find a software package that meets the needs of an organization and its tasks.

So how should one go about choosing the software needed to build a successful CAD system? Such software falls into four broad categories: the CAD package itself, the underlying operating system, third-party software, and additional software.

It is best to choose to automate a task first, for example drafting and then to choose the software and hardware needed to support that choice afterward.

The underlying operating system is the software that lets the CAD package work with the hardware and other software that will eventually be purchased to build a complete computer system. Depending on the CAD package, there may only be one operating system that works with it. On the other hand as with both AutoCAD and MicroStation, there may be multitude of operating systems to choose from.

Whatever CAD package is purchased, one can assume that three to five years from now you will be using a different package- either an update on updates that makes what you use now look like a different program, or you will gravitate to a better CAD package, possibly even on a different platform.

2.1 CHOICES OF CAD SOFTWARE

2.1.1. AUTOCAD

For many who use AutoCAD, it is more than just a computer program. Offices once filled with drafting tables and T squares are now occupied by rows of personal computer design stations. And AutoCad is the program running on more than 70% of those stations.

Incorporated in April 1982, Autodesk's AutoCAD software package quickly became the software of choice for low-end design work. Over the years, the company has continuously upgraded the software to take advantage of the more powerful IBM-type desktop computers, with recent versions being extremely sophisticated. The firm's early lead and its influence over its distribution channel allow it to dominate the CAD software market. Autodesk distributes its products through a VAR network, which reduces selling expenses. AutoCAD has gained popularity in part because it supports the development of third-party software that run on top of AutoCAD.

Today, Autodesk is the world's leading supplier of computer-aided design software with a market share of over 70% and growing. According to H.C. Allison et al Alex. Brown & Sons, INC, the market for CAD software is growing more than 20% annually. In 1986 Autodesk added a complete programming language, AutoLISP, which further enhanced AutoCad's customization capabilities. With AutoLISP, users could add new commands to the program-to delete all drawing

could add new commands to the program-to delete all drawing entities of a particular type or automatically save a drawing after a specified interval, for example-thus tailoring the package to fit their individual needs.

The product is now in Release 12, with a new version introduced every 18-24 months. It takes the dealer channel and user base about 12 months to absorb a new release. Some of the features added to Release 12 include enhanced programmability for customizing AutoCAD's use and the ability to use AutoCAD on a network giving designers access to each other's work. This latter feature is important in large-scale operations such as construction projects that involve teams of people working on different aspects of the design and where each designer's work will impact that of the next designer.

Working with AutoCAD Release 12, the production drafter gains speed and plotting enhancements, modelers get true solids-modeling capabilities that outperform the old 3-dimensional tools; everybody gets many new management tools and a better interface. With Release 12, AutoCAD offers direct network support for the first time. A new plotting feature, called "paper space" gives multiple plotting views.

In addition to enhancing AutoCAD itself through upgrades, Autodesk has released a number of complementary products that either work with AutoCAD or leverage the company's investment in graphical software. These include software to create a solid image from the AutoCAD design,

and shading to make a photo-realistic image and animate the drawing.

AutoCAD Release 12 is operating in the RISC environment which from the user's point of view is probably the most significant release of Autocad ever because it includes more than 170 new features that provide answers to just about every customer request of the past two to three years including:

- A new built-in 32-bit display lists which permits pans and zooms without regens, so that the CAD operator can spend time editing the drawing instead of waiting for regens.

- Release 12 and Release 11 drawings are forward and backward compatible.

- Locked layers feature prevents accidental modification of drawing data.

- AutoCAD SQL Extension (ASE) allows the operator to access data in standard database management systems via SQL. ASE provides commands for manipulating external nongraphic data and linking it to graphic entities in AutoCAD drawings.

- No Main Menu! One can enter directly into AutoCAD drawing editor, where one can perform configuration operation, as well as work on the current drawing.

- Database-specific drivers link AutoCAD and external nongraphic databases, such as dbase, Paradox, Oracle and others.

- Release 12 allows to import TIFF, GIF and PCX raster images into the current drawing.
- One can polt without leaving the drawing editor and without loosing the UNDO file.
- Network users can view and plot AutoCAD drawings without using server authorization.
- One can plot AutoCAD drawings as bit malp files in PCF, TIFF and TGA formats. The drawings can automatically be faxed to a subcontractor or client.

Autodesk showed a very early version of AutoCAD Release 11 under Microsoft Windows. That product is slated for delivery in the first half of fiscal 1993. The challenge with Windows version will be very similar to the current 286 effort: in all probability, AutoCAD will not perform as well under Windows as it does without Windows. But key customers have indicated that the Windows version is a necessity, especially since AutoCAD is used for much more than drafting and architectural design.

With 88% of revenue from AutoCAD last year, the company continues to look for new business opportunities to diversify the revenue base. AutoCAD's first major effort is well underway: its move into multimedia. Autodesk's multimedia business will likely get a boost this year from Animator Pro, which was introduced in late April 1991. Animator, the low-end product, has a user base approaching 40,000; Autodesk 3D Studio, the high-end product which

shipped in October 1990, already has about 2,500 users. Animator Pro fits in between the two product lines.

Autodesk's growth trend continued during fiscal year 1991, with net revenues increasing 33 percent over the previous year. This growth was primarily attributable to the continued market acceptance of the flagship, AutoCAD, both domestically and abroad. AutoCad's success has been influenced by a general expansion of the personal computer CAD software market, which has stimulated both new orders as well as sales of product updates.

Autodesk develops and markets computer-aided design, engineering and animation software products. The Company's primary software packages are used on PCs and workstations. AutoCAD, the Company's premier drafting offering, contributes over 90% of the firm's revenues. Autodesk's success can be attributed primarily to its business model, which exploited a market segmentation opportunity in the early 1980s by offering production-drafting software on low-cost PCs. The firm's early lead in this segment and its influence over its distribution channel allow it to dominate this product category. The add-in offerings allow AutoCAD to penetrate the market more deeply than would have been possible as a simple production drafting system. The firm also offers products in the multimedia, molecular modeling, and data management markets as well, but these offerings are still a trivial portion of the firm's revenues.

2.1.2 MICROSTATION

Intergraph Corporation is one of the largest design software vendors in the industry, supporting the Mechanical, AEC, Electronic, and Mapping/Global Information Systems (GIS) markets. Until early 1991, Intergraph offered its software only on its own proprietary hardware platforms. This strategy limited the Company's growth potential because it restricted customer choice. With the late-1990 acquisition of the bankrupt Dasix Corporation's assets, Intergraph began offering its Electronic products on Sun Microsystem's workstations. Shortly thereafter the firm announced it was moving its Mechanical offerings to Sun as well. Intergraph has developed an extremely strong franchise in Mapping/GIS.

Intergraph's MicroStation PC has been on the market only for the past five years and is one of the few PC CAD packages to challenge AutoCAD's supremacy. One reason for its rise might be the rapid pace of enhancements.

The move from MicroStation Version 2 to Version 3 at least doubled the program's capabilities, and now with Version 4, those capabilities have increased by a factor ten. The package's new graphical user interface (GUI) is a slick implementation of OSF/Motif and was designed for speed. Its dialog box is a complete file management system and has the capability of fast opening, creating, deleting, and renaming design files and all libraries. Furthermore, the system works with DOS as well. MicroStation PC is

particularly flexible for two main reasons: its interface and the range of tools available for it.

The graphical user interface is designed for speeding up the design process and therefor contributes to productivity. MicroStation has over 900 command combinations, called tools, which the user can use by pointing and clicking on dialog boxes and icons. For customization Intergraph has added the MicroStation Development Language (MDL) which gives the user control over and access to MicroStation commands from the inside. MicroStation provides links to Oracle or dBase to provide almost limitless database capabilities within the program.

Microstation PC 4.0 CAD Software package is a DOS extender-based CAD program that runs on Intel Corp 80386-based microcomputers. It supports Novell Inc, NerBIOS, Transmission Control Protocol/Internet Protocol (TCP/IP), Sun Microsystems Inc's Network File System and Apple LocalTalk-compatible networks. The program suffers from a lack of project management capabilities, and its documentation has little information regarding installation on a network file server. Drawing access is well-controlled; other users can reference a drawing while one user edits it, but only one user can edit at a time. The program ships with a hardware-protection device, which fits into the parallel printer port of the workstation.

2.1.3 CADVANCE

CADvance Version 4.01 from IsiCAD is a solid, reliable computer-aided design package that offers outstanding network features. It includes a wide variety of typical 2-dimensional drawing commands, and it provides unexpected symbol features as well as extensive attribute capabilities. Work can be linked to any dbase-compatible database for access to the data from within the drawing. CADVance includes fairly wide range of drawing tools. Dimension styles and hatching features are strong. CADVance includes almost all of the necessary editing tools. One can edit such object parameters as color, line style, and weight. In programming ability, CADVance includes both a simple macro capability that replays keystrokes and command picks and a programming language for more complex macro creation. Since it lacks the flexibility of most high-end CAD programs, CADVance is considered a solid but not outstanding product. However, it is the best possible networking CAD package.

2.1.4 VERSACAD

VersaCAD 386 from Cmputervision is a fully-programmable, interactive CAD software package, designed for the 80386 processor while still fully compatible with its predecessors. The product functions as a 2-D drafting system with a full array of features comparable to other microcomputer-based CAD packages. As a 3-D modeler, it has some limitations but is nonetheless a workable system.

VersaCAD/386's clumsy user interface, its separation of its 2-D and 3-D modules and its limited surfacing capabilities are problems VersaCAD has to solve. Because it demands a substantial budget for hardware and software, VersaCAD may be suited only for large companies that use the same system for a variety of platforms and applications.

2.2 AEC MARKET GROWTH

For most of the next decade the biggest bang for the A/E's computing buck will be in project integration and information management. So, if one commits a piece of information to the computer, more than a graphic symbol on a drawing or a paragraph of text in a specification document should be accomplished.

AEC market growth rates over the past nine years have reflected a violent market shift from bundled systems to software-only, from minicomputer and mainframe systems to workstations and PCs, and from direct sales to VAR distribution. According to an industry report by H.C. Allison of Alex INC. the AEC software growth rate has recently approximated 20% and it is estimated that the growth will decline steadily until a new modeling approach is applied to this market.

The primary engine of progress in all computing markets is the declining price/performance ratio. The cost of computing declines roughly 30% per year, halving the cost of computing every two years. Every six and one-half years this produces a tenfold. This trend has spanned roughly 40 years, although there is some evidence to suggest a recent acceleration.

To summarize, a new software design offering that elevates the design environment to a higher level of abstraction is a critical event from an application point of view and therefore, from an investment point of view.

Product is not the only source of differentiation, however, and application software is not the only beneficiary of the price/performance bonanza. In the 1980s for example, graphic user interfaces, bit-mapped graphics, new distribution channels and personal computers, the UNIX operating system, and portable software also consumed large portions of the price/performance improvement.

The business model a design software firm employs is as critical to its success as the products it sells. Several of the industry's leading firms are differentiated not by product lines, but by business models that exploit a market opportunity. The optimal business model for a design software market evolves through several stages as the market matures. The importance of this evolution is that transitions present opportunity, and that the lessons can be applied to other segments or future cycles. The critical business model issues are:

- degree of hardware involvement
- product integration/data sharing strategies
- market segmentation and distribution.

The design software industry is a software business, but hardware is often part of a vendor's product offering. Some firms have a natural hardware product that participates directly in the value-added-like an accelerator. Other firms are merely involved in hardware without adding value. There are several degrees of hardware involvement, and each is optimal at one point in the market's evolution, but

eventually becomes inferior. Because hardware is sometimes necessary, investors should not automatically shun companies involved with hardware but they should be cognizant of the risks and of how to gauge the time at which a firm must change strategy or loss competitive advantage.

The role of hardware in the design software industry follows a pattern: initially it is a necessity, later it is a millstone. In the early stages of a design market's evolution, bundling hardware and software is often critical to a firm's initial success. As the market matures, the hardware involvement should be reduced, but this requires major adjustments to the firm's business model. Because the switching costs from a hardware-intensive business model to a lesser-involved state are high, vendors frequently either fail to survive the transition, or defer it until they have lost competitive momentum.

Autodesk's AutoCAD,a low-cost PC-based alternative to minicomputer-based drafting systems, exploited a market segmentation and distribution opportunity when it was introduced in early the 1980s. As design software markets mature, market segmentation usually occurs. According to an industry report by H.C. Allison of Alex INC. the new products follow an 80/20 rule: 80% of the functionality for 20% of the price. In an unsegmented marketplace, design software vendors concentrate exclusively on the needs of premium customers. Premium performance adds cost and complexity, unnecessary for mid- and low-end users, and

creates the opportunity for market segmentation. Thus segmentation is the only way to achieve full penetration in most design markets, but several conditions must be met for it to occur:

- lower cost distribution: lower prices require a different form of distribution. A VAR channel, retail channel, or other alternative to direct selling must be developed;

- ease of use: the new product must have lower support requirements to match the ability of channel and the user;

- a relatively mature design software industry segment in which competing vendors focus exclusively on premium customers.

The AEC design software market is dominated by AutoCAD and a handful of production drafting offerings. These offerings are used to model drawings as opposed to buildings, bridges, roads and factories. Offerings that model the final product and permit forms of analysis tend to be in-house or niche-market offerings.

While penetration of the production drafting market continues, it is clear that at some point there may be a market opportunity for more advanced AEC offerings that model projects at a higher level of abstraction. In contrast to the Mechanical and Electronic design software markets,

the AEC market has been impeded in this respect for several reasons:

(1) The final product of the AEC design process is a drawing. In the Electronic market the final design is frequently a computer file used in manufacturing techniques.

(2) The AEC design process is fragmented over a variety of design, engineering, and construction firms. This inhibits coordinated use of computer-based techniques for lack of standardization.

(3) The AEC industry is fragmented by local regulations and local manufacturing techniques.

(4) Time-to-market urgency and competitive leverage of superior design are far lower in AEC than either the Electronic or Mechanical industries. As a result, design software demand in the AEC market is biased toward cost-saving and presentation efforts.

CHAPTER 3

CAD HARDWARE

After purchasing the CAD software the next step is to buy the appropriate hardware products to build a complete computer system. What makes this step so hard is not knowing what products are needed or how to choose from among the bewildering array of options. There are over 400 separate hardware choices involved in assembling a complete production CAD system. Every complete system is composed of five hardware categories: Computing, storage, input, output, and communications.

In finding out how good a CAD system is, potential buyers are influenced by what vendors say and by how well the vendors and their dealers represent the product. The potential buyer and user of a CAD system should not be intimidated by computers, but should think of them as a potential advantage that should be studied carefully before buying.

Furthermore, the prospective buyer has to be cautious about purchasing a "leading edge" computer. For those who can afford the latest and greatest available it may be difficult to understand why these machines may not always be the best choice. Many of the new technology introductions have been plagued by bugs discovered in the earliest releases of the products. When only considering the IBM-PC compatible line this phenomena has been responsible for hard

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disk crashes on the original IBM-PC/AT, nonfunctional 32-bit instructions in the Intel 80386 microprocessors, and problems in the floating point unit of the 80486 chip. Learning from the past it is essential that new computer technology should undergo extensive user testing before it matures and stabilizes.

3.1 PC INDUSTRY

3.1.1 THE EVOLUTION OF THE PERSONAL COMPUTER

Computing or calculating by machine began in the middle east with the use of pegs or stones in trays or channels. The Babylonians developed the idea of stone or bead counters into the modern abacus- modern in the sense that the abacus is still in use today and in the hands of an experienced operator can calculate results faster than a computer.

In the early days of computing, in the 1960s, those lucky enough to have access to computers were allowed to share the resources of a centralized mainframe. The access was limited and expensive. Resources were scare and had to be maximized. All jobs ran on the computer remotely, in batch mode-i.e. one program at a time. A user submitted his or her job and then waited for results, sometimes as long as a couple of days. Computers were not interactive; therefore if the user had to modify the data or the program, the process was repeated. Delays were expected. The early mainframes at the time barely had the power of the early generation of IBM PCs, and without all of the easy-to-use software now available. Nevertheless, users' expectations were low and benefits of using the mainframe far exceeded its frustrations.

Minicomputers were invented in the late 1950s, commercialized in the 1960s, and became widespread in the 1970s. The minicomputer had three primary advantages over mainframes, although the minicomputer augmented rather than

mainframes, although the minicomputer augmented rather than replaced the mainframe by creating incremental demand for computers. First, although minicomputers were less powerful than the mainframes, their costs were significantly less expensive, making it possible for many more companies and universities to afford them. Second, minicomputers did not need the support services dedicated to mainframes so they became ideal for smaller groups of individuals or small businesses. Finally, minicomputers allowed interactive communications, simply meaning that the user spoke directly with the computer through a terminal wired into the central processing unit.

Minicomputers had to be shared, but because of their interactive nature users did not have to wait to see the results of their efforts. As a result, minicomputers became ideal for engineers and software development, while mainframes remained in the corporate data center.

The personal computer industry exploded on the scene during the 1980s and is changing dramatically in the early 1990s. Users now are familiar with these ubiquitous devices, as total new distribution networks have been established.

Personal computers got their name from the fact, for the first time, individuals did not have to share the computer resources with anyone else, at least at the same time. Although the initial PCs did not offer much performance compared to its larger competitors, not having to share the resource was a major breakthrough in the evolution of

computers. In addition, each computer could be customized to each user's needs with specific software and hardware, making the PC an almost universal tool. PCs were inexpensive compared with mainframe and minicomputers so that almost everyone could afford one. With the introduction of such popular programs as spreadsheet, database, accounting and computer-aided design software and word-processing software, using a PC produced substantial gains in productivity for individuals. As PCs became more powerful and workstations became affordable, completely new applications, such as desktop publishing, were developed. Unit volumes accelerated and annual revenues for the PC industry exceeded those of both the mainframe and the minicomputer industries by the end of the 1980s. By the end of the decade, the penetration of PCs was relatively high and unit sales came primarily from a replacement cycle as new software programs forced users to upgrade their hardware investment.

In many respects, computer hardware and software have become unbundled, allowing customers to purchase software applications separate from hardware decisions. Open systems will force this trend even more thoroughly as one vendor's hardware becomes interchangeable with another's.

The PC industry is currently undergoing substantial changes that have raised investor and end-user concerns about the industry. Traditional PC hardware leaders are faltering due to price competition and a restructuring of their distribution channels. IBM PC-compatible vendors, such

as AST, DELL, Packard Bell and Gateway 2000 are taking share from IBM and Compaq due to their lower prices and more efficient distribution channels. PC prices are collapsing, creating challenges for traditional PC vendors, IBM and Compaq.

PC unit growth is one of the primary drivers of demand for PC software. The PC industry has recently hit snags with weakening demand and aggressive prices in the United States and Europe. The most interesting question now is, do lower PC prices drive higher unit growth, particularly with lower-priced 386 and 486 PCs? Or do users just accept the lower prices as a windfall gift from the industry? What major developments lie just over the horizon?

Perhaps the most important is the development of the optical computer. To understand the potential impact of this technology, compare it to the stages of microcomputer development during the 1980s:

	1984	1987	1990	1992	199x
	80286	80386	80486	80586	optical
Mhz	6	25	33		
MB	2	10	10		
FPC	287	387	integrated		
MB (HD)	60	300	650		
$	10K	20K	3K		

Table 3 MICROCOMPUTER TREND

One of the most interesting aspects of the current wave of computing is that this generation of microprocessor-based systems, PCs and workstations, is as powerful as the current-generation minicomputers. And for the first time in the history of the computer industry, the next-generation microprocessor-based computers are projected to be more powerful than future minicomputers, and it is probable than within the next several years computer vendors will produce microprocessor-based systems with greater performance than the then-based systems to technology, many people expect microprocessor-based systems to eventually replace all other computer architectures in the future.

The increased power of optical computers will be so great that it is difficult to speculate on their impact on CAD, but one thing is most certain: when fully developed, optical computers will render all previous technologies obsolete.

Computer hardware is becoming more of a commodity, creating even greater opportunities for the networking and software vendors as hardware continues to deliver ever-increasing price/performance.

After first selecting the desired software, then and only then should one choose the hardware that will support the software requirements. A computer system that is being acquired by a design and drafting office should provide multifunctional use. For it to be able to accomplish only CAD functions would not be the most efficient use of

investment. Purchasing the hardware first may cause unnecessary setup time and even require purchase of extra software interface programs in order to properly operate the desired CAD system. Prior making a choice the office management should determine the software necessary to fulfill their different office tasks such as word processing, spreadsheet, file and database manager, high-end or low-end CAD software, rendering etc.....

A CAD workstation should be used exclusively for architectural design and the generation of drawing documents. Any processing of alphanumeric data, such as word processing or spreadsheet applications, should be done on less expensive equipment.

The main component that is necessary to create a CAD system is the development and implementation of standard procedures for communication interface and information transfer among the people involved with the operation. Two key areas of communication interface and information transfer are essential to the CAD system's effectiveness between the designer and the CAD operator and among the CAD operators themselves.

Deciding which CPU to buy is not the only important decision in purchasing CAD systems. The CPU usually accounts for less than half the total cost of a typical system, the remainder being for monitors, software, plotters and other peripherals. It is the purchase of these peripherals that

can drive up the costs of an inexpensive CPU to the point that the investment will never pay for itself.

3.1.2 THE EVOLUTION OF NETWORKING

The 1990's will see a dramatic rise of the personal computer in the connected environment. PCs in local area networks (LAN) will be able to accomplish nearly everything that has been associated with mainframes at a fraction of cost and with far greater flexibility for the user. If employees are shuttling floppy disks around in an effort to generate reports using current data from multiple sources on their computers, then the department is a serious candidate for a LAN. The reasons for establishing a LAN fall into two categories:

- delivering office services
- program and data sharing.

3.2 COMPONENTS OF A LOCAL AREA NETWORK

There are six basic components of a LAN. Four of these components are hardware related, the other software related. These components are:

3.2.1 WORKSTATION

Local Area Networks use Distributed Processing. Each workstation is a PC and does it's own processing. The network is used for storage and retrieval of programs and data. When a program is run at a workstation it is first retrieved from a file server's hard drive, transferred over the network cable and loaded into the workstation's memory. The program runs at the workstation not the file server. Because networks use distributed processing adding more workstations doesn't slow the network down and since each station loads DOS using a workstation on a network is the same as using a stand alone PC. By adding a network card existing PCs can be connected to the network. Operators already trained to use a PC will not have to be retrained to use the network.

Because programs run at the workstation (distributed processing) each workstation should be tailored to the tasks it will perform. For example, a 286 would be well suited for word processing, but desktop publishing or CAD/CAM would perform significantly better on a 386 or even better on a 486.

3.2.2 FILE SERVER

The most important choice to be made when setting up a network is the server. The file server is the central component of a LAN. It is usually a fast PC with extra disk space and dedicated to running the network operating software. The file server becomes the hub of the network, routing all communication and printing requests and acting as the central storage vault. A fast server will benefit everyone on the network. Skimping on the server will make everyone on the network suffer. Every network must have one or more servers. Each server has a hard disk and optional printers that can be shared by workstations on the network.

3.2.3 NETWORK INTERFACE CARDS

Every workstation and server on a network must have a network interface card (NIC). NICs are connected with cables to form a Local Area Network. The NIC is responsible for sending and retrieving programs and data fromthe server. There are different types of NICs (Ethernet, Arcet, Token Ring). Which type of NIC is best for a particular office depends mostly on office layout. The cabling system, performance, and cost vary with the type of NIC chosen.

3.2.4. CABLES

LANs can use four types of cable:

- *SHIELDED TWISTED PAIR*

Twisted pair cable uses two stranded copper wires that are separately insulated and twisted together. The twisted pair is protected by an outer layer of insulation called a jacket.

ADVANTAGES OF SHIELDED TWISTED PAIR CABLE:

- well-understood technology
- minimal skill to connect devices
- quick and easy installation
- minimal emanation of electrical or magnetic signals
- some immunity to interferences, cross talk, lightning and corrosion

- *COAXIAL*

Coaxial cable is composed of a copper wire surrounded by a stranded shield that acts as the ground. The conductor and the ground are separated by a thick insulating material, with the entire cable protected by an outside insulating jacket.

Coaxial cable comes in a wide variety and thicknesses. Thicker coax cable carries signals longer distances than thinner cable, but thicker cable is more expensive and less flexible. In installations where cable must be pulled through existing cable trays, conduits with limited space, or around tight corners, thinner cable must be used.

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ADVANTAGES OF COAXIAL CABLE:

- supports two different transmission systems: broadband and baseband
- transmits voice, video, and data
- easy installation
- well-understood technology
- wide availability through pre-existing installations

• *FIBER OPTIC*

Fiber optic cable is used for very high speed, high capacity communication applications, particularly when freedom from noise and electrical interference is important.

Fiber optic cable consists of a very fine fiber made from two types of glass, one for the core, the other for the outer layer. The two glasses have different indexes for refraction. This combination prevents light entering one end of the fiber from passing through the fiber's outer surface. The fiber itself is encased in a protective sheath to lend structural integrity.

ADVANTAGES OF FIBER OPTIC CABLE:

- High-speed applications
- does not emanate electrical or magnetic signals
- immune to interference, cross-talk, lightning and corrosion

- potentially less expensive medium than coaxial or
  CATV cable
- Can propagate a signal without boosting over a
  longer distance than copper wire
  - cannot be tapped, so most useful in point to
    point topologies

- *UNSHIELDED TWISTED PAIR*

Telephone cables are unshielded twisted-pair cables and so can be used with very minor modifications.
ADVANTAGES OF UNSHIELDED TWISTED-PAIR CABLE:

- well-understood technology
- minimal skill required to connect devices
- quick and easy installation
- low cost cabling

3.2.5 THE NETWORK OPERATING SYSTEM

The type of PC that can be used for a server depends on the LAN operating system chosen. Novell Netware 286 V2.2 requires a 286, 386 or 486 server. Netware 386 will only run on a 386 or 486 server. Novell Netware 386 is significantly faster than Netware 286 in large networks.

The primary software application within the networking sector is the network operating system, the application program that controls the entire workings of the network. This market is dominated by Novell with its netware system products.

Network applications will allow corporations to increase the productivity of individual workers through better communications with the rest of the organization, as well as increase the productivity of groups of workers. Eventually, as the entire company is networked, new applications should emerge that will increase the productivity of the whole organization through better communication and more efficient resource sharing.

Novell is the leading franchise in the PC-based local area network market, with a 55% market share. Novell's next nearest competitor is the jointly developed IBM-Microsoft LAN Server/LAN Manager product with an estimated 15% market share. Novell's great attraction can be attributed to a number of factors. Technical support is available through resellers and consultants around the world. Because Novell is already used at so many sites, it is the natural choice for CAD managers who want to integrate CAD-software on PCs. Many managers are learning that the product that has been supporting their PC-based CAD stations can provide the same support to their Macintosh and Unix clients as well. Novell NetWare bridges the gap between operating systems, providing not only file-serving but plot spooling and security as well.

Plan to involve two for 10-20/hours/week for a maximum of three months to thoroughly learn and customize (setup) systems. Think through, with a paid consultant or trainer,

your file management system (i.e. file naming, sharing files, etc.)

3.2.6 NETWORK PERIPHERAL (PRINTERS, DISKS AND TAPE DRIVES)

One of the costliest components of any CAD system is the plotter. A quality high-speed plotter can cost as much as several PC-based CAD systems. Most CAD operators left to their own devices will want to plot every drawing change no matter how small. To permit this would require a high-speed plotter for virtually every CAD station, a financial impossibility.

When choosing a plotter, the entire cycle of plotting should be considered, that is, from the time all work on the computer is done to the time all hard copies have been generated, including such tedious tasks such as trimming the plotted drawings.

Not too long ago there was a limited choice of printers and plotters available on the market. Today, choosing an output device is a complex task. Hundreds of devices such as Black and White Laser Printers, Thermal Printers, Printer/Plotters, Electrostatic Plotters, Pen Plotters, Ink Plotters, Black and White/Color Thermal Plotters, Raster Plotters, Laser Plotters and Pen/Pencil Plotters are utilizing a half-dozen technologies from dozens of manufactures offer thousands of varied and tantalizing features and options.

manufactures offer thousands of varied and tantalizing features and options.

Networks are a complex field for both users and investors. The reason is the architecture of the network. At the simplest level, there are two basic designs to a PC network. The first is *peer-to-peer network*, each PC is connected to each other. No single PC controls or manages the printing or storage of data. The second, and more complex, network is called a *client/server based network*. The underlying characteristic of a client/server based network is that one PC is dedicated to providing print or storage services to other PCs on the network.

The difference between a mainframe environment and a PC LAN is that a mainframe does all the processing work on a single machine. With a LAN, once the server sends the requested programs from its central hard disk to the PC workstation, all the processing of that program is done at the user's end on the PC.

As the installed base of PCs reached a critical mass in the mid 1980s, corporations began to interconnect them as a way to communicate and share expensive resources such as laser printers and large disk storage. These work groups improved the productivity of individual workers and lead the first wave of computer networking. By most estimates, the number of PCs has reached 60 million units in use worldwide, most of which are for business applications. It is estimated that there are roughly 1 million networks installed.

The networking of PCs and workstations within a department or small work group such as users can share print and file resources as well as communicate with each other. The key to work group computing is the need to communicate and share information between users. PCs and workstations have become so powerful that without communications the machines would be nothing but islands of computation.

Networking can take advantage of the aggressive price-performance trends expected over the next few years from microprocessor-based computers versus significantly slower improvements expected from their older minicomputer and mainframe ancestors.

To reap the full benefits that a network can provide, it is very important to keep in mind what a network really is, a tool to better organize the way data is stored and the way users work on all networked computers.

CHAPTER 4

NETWORKING CAD SYSTEMS BASED ON

PC/MS-DOS-PLATFORMS
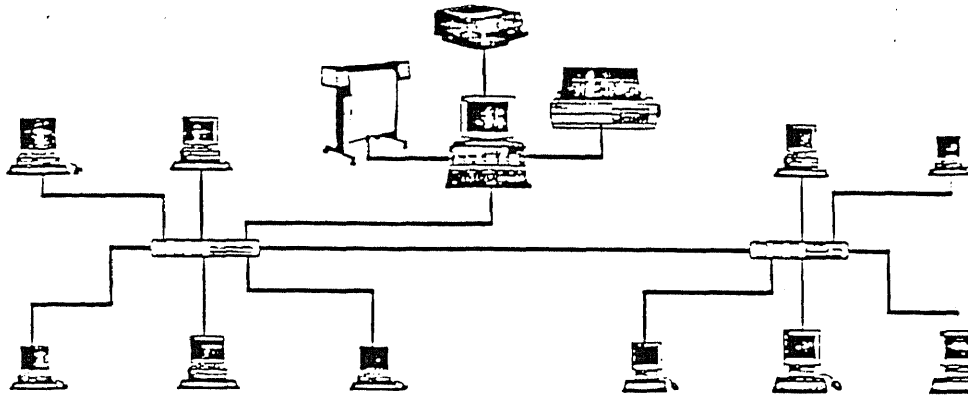
4.1 NETWORK SYSTEMS

CAD networks have existed alone for years. Since CAD was frequently the most resource-intensive computer application, the network solution that works best was the one that worked best for CAD, even with other business applications in place at the same location. Often, CAD networks were installed in addition to other business networks, using incompatible standards and duplicating resources.

Is there a need to integrate CAD into the business computing environment? If so, what steps should be taken for the best integration? Managers today are discovering two good reasons to bring CAD into network. First, they have discovered a wealth of project delivery information that exists outside of CAD computers; a single network would provide convenient access to it. Second, the technology required to use standard wiring and connectivity schemes that accommodate both CAD and business applications is well-developed.

It is not difficult to see why a team approach to computer resources is a business advantage. Overlay system drafting is a good analogy to CAD networking-several drafters can use a copy of a single base building drawing while each draws a discipline's unique information on the overlay sheet. The analogy can be taken a step further by visualizing a specifier, a secretary, a project manager, a cost estimator, and a designer all standing over the same desk, using the same set of documents, and updating them

continuously. This analogy seems ridiculous for manual methods but not for computer networks.

Since a network lets many users access the same document, there is no need to duplicate information or maintain several versions of a document at different computers. Central file servers provide the most efficient storage and backup of important information, relieving the user from the task of managing files and backups. Since CAD files are often quite large, sharing files can save money just by reducing storage requirements of the hardware.

As a minimum, an office network should be designed to be a medium for communication between people, machines, and documents, as well as a conduit for sending files to a central storage facility. Most network software is capable of this kind of basic communication.

A central network is usually thought of as a large mainframe computer with keyboard/monitor-style terminals connected to it. Dumb terminals are seldom used in CAD systems because sophisticated CAD graphics computations require too much processing from a central host. Diskless workstations with large amounts of RAM can be used to enforce central file storage procedures, as long as the workstation has enough memory to contain both the CAD application and the data files and has an adequate CPU to handle graphics. Diskless workstations may not work with CAD applications like MicroStation that use virtual memory (the use of hard disk space supplement RAM).

4.1.1 DISTRIBUTED NETWORKS

Distributed networks do the bulk of the actual computing at the workstation level. The term distributed computing is self-descriptive, because in the ideal sense processing tasks are distributed more or less equally among intelligent workstations on the network. Intelligent workstations such as personal computers, with their own CPU, RAM, and hard disks, are generally most appropriate for modern CAD networks, because CAD application software and associated data files can be stored on a local hard disk rather than having to be downloaded from the server, large graphics files can be handled locally using the workstation's own hard disk and processor, and the central file storage computer is relieved of processing tasks required by CAD applications. The network runs much quicker since only data files rather than data and applications cross the network to get to each workstation.

Generally it is most efficient to run CAD software from an intelligent workstation rather than as a multi-user network application, because in a distributed environment, the addition of workstations has a minimal effect, increasing network response time only in proportion to file requests. As each new workstation is added to a centralized network, response time increases proportionately to each new processing demand, in addition to file requests.

A more advanced version of the distributed computing model permits tasks that are particularly CPU-intensive,

A more advanced version of the distributed computing model permits tasks that are particularly CPU-intensive, such as photo realistic rendering, to be shared among multiple computers on the network.

Even though LANs do both distributed and central processing, they are considered distributed networks, because the PC workstations on the LAN do all of the actual manipulation of documents; the central equipment is used for file storage, servicing file-related activities, and sharing peripherals like printers and plotters.

Some of the network software packages most commonly used in PC LAN arrangements today are Novell's NetWare, Microsoft's LAN Manager, Apple's AppleShare, and Banyan Vines.

4.1.2 PEER-TO-PEER NETWORKS

Peer-to-peer networks allow any workstation to connect to any other on the network and use its resources (disk storage and processing) as if it were connected locally to that workstation. A peer-to-peer network does not have to have a central file server, because each workstation, or node, can share its disk space with any other. The whole network becomes an electronic commune, access to which is granted by the workstation user. This scheme is potentially the most flexible but trades off flexibility for difficulties in security, data integrity, and network management.

The peer-to-peer network requires that the workstation have the capability to run more than one process or program at once (multitasking). This capability can be built into the operating system of the workstation, as in Unix, OS/2, and Macintosh computers, or can be added to it with programs like TOPS for DOS PCs.

In distributed and peer-to-peer networks, data conflicts can be critical. This problem results when two or more users work on a copy of the same file. When the file is sent back to common storage, one of the files is overwritten and work is lost, or else tedious culling of file changes has to be performed.

Two methods of dealing with distributed data conflicts can be seen in most CAD networks. The first is where an electronic check-in and check-out accounting system is installed. If a user wishes to access a file, the original copy of the file is locked so it cannot be accessed by anyone else, and a copy of the file is sent across the network to the user to work on at a local workstation. When the editing session is finished, the edited version is sent back across the network to replace the locked original, where it is once again marked "available".

The second method is more easily implemented. The user always works on an original file residing on the network file server. The network locks the file to limit access when busy; the file is released when the user exits or accesses a different file.

Choosing between these two schemes depends on the difficulty of implementation and the network traffic implications of each. For CAD applications that move information to and from the disk during an editing session, the check-in/check-out method often works best, since a local workstation drive is usually accessed much quicker than a network drive.

It is difficult to tell which network file access scheme to implement until each is tested. Use a network benchmark at peak load. The benchmark should include the transfer of a large file across the network and several types of time-consuming editing operations. It would help to know which of these operations require disk access as opposed to memory access, to get a variety of criteria. Also, the benchmark should be as close to real-world use as is practical and closely conforming to the individual business needs. The time to complete the benchmark has to be averaged when all workstations are in place.

4.1.3 CLIENT-SERVER NETWORKS

Client-server networks combine features of distributed networks and central networks. The concept is that the client, or workstation, processes only the data relevant to its own task, and the server, or central computer, processes enough of the data stored there to give the client only what it needs. This improves network efficiency by reducing the

amount of data sent over the network and by sharing processing tasks.

A typical client-server application is an SQL (structural query language) database. When a traditional database is run on a file server network, the entire database must be sent to the workstation to be processed, because the file server is only designed to handle file access and storage. In a client-server database, SQL allows the workstation to send a message to the file server where the data is kept, specifying how the data should be sorted and searched, and what data should be returned. The file server then searches the entire database and sorts and returns a subset of the information over the network to the workstation. The workstation can then further process this smaller piece of data. For example, IsiCAD's CADvance for work groups application uses Novell NetWare loadable modules to give work group members remote access to an SQL database engine on a central servers at once over a network, each can return its own data subset that matches the search criteria, and the workstation can assemble it as if it came from a single source.

4.2 BENEFITS OF NETWORKING CAD SYSTEMS

In the near future, compound documents consisting of CAD graphics, text, data, and other information created by different software packages will exist as dynamic entities on the network, growing and evolving as members of a workgroup add and change information. An open document will be updated live with changes in the source documents, responding to messages sent across the network that a change in another of the sister documents has taken place.

There are promising new network programs available today that give a glimpse of what networking will be a few years from now. Add-on software that enables CAD drawings to be marked up and commented with a light pen is available for managers to use without full production knowledge of the CAD application.

In a network environment, it is unrealistic to expect every user to learn and use exactly the same application for a particular task. Since people have individual work strengths and preferences, and each type of software has strengths and weaknesses, it seems to be a better network solution to define standards for files, rather than standards for programs to manipulate files. Most CAD applications have not been designed to read another's binary (native) file format, and therefore vendors have developed standard file interchange formats such as DXF and IGES. Unfortunately, unlike business applications, there is usually significant loss of information or translation error

when exchanging files using these formats. So it is desirable to use a single manufacturer's CAD file format as the network file standard to preserve file integrity.

Many companies enforce this by allowing only one type of CAD software to be used. A better solution is to permit the use of translation-compatible CAD software from other manufacturers but require deliverable files to be in a single format. In this way, a company can use AutoCAD and Microstation, for example, to create files for a project, and all the deliverable will be consistent in format. Neither type of work need be turned away because of mismatched CAD standards. It is important for all CAD users to be familiar ahead of time with standard procedures used to create compatible files, so problems with later translation can be avoided. Also, translation should always be in one direction only, to avoid compounding errors.

In the near future, compound documents consisting of CAD graphics, text, data, and other information created by different software packages will exist as dynamic entities on the network, growing and evolving as members of a workgroup add and change information. An open document will be updated "live" with changes in source documents, responding to messages sent across the network that a change in another of the sister documents has taken place.

This new software capability amplifies the need for effective networks. Add-on software that enables CAD drawings to be marked up and commented with a light pen is

available for managers to use without full production knowledge of the CAD application.

Microcomputer-based CAD programs are increasingly being used in network architectures. Networking provides for better control backups, and standard drawings, symbols and details can be shared on a network. A designer working on the electrical systems for a new building may need to see where another designer has put the heating ducts or the plumbing. Software meant for networks also helps control this situation. Security controls can let one designer see another's work but not alter it. And by keeping CAD drawings in a central location, users can more easily track updates and make sure nobody is working with old drawings.

Communications between CAD systems in a network are currently based upon the principles of requesting , sending and receiving files. This may be initiated to acquire a program in order to process some data locally, or to send the data in file form to be processed remotely.

There are also benefits in links between CAD stations. A designer working on the electrical system for a new building may need to see where another designer has put the heating ducts or the plumbing. Software meant for networks also helps control this situation-security controls can let one designer see another's work but not alter it. And by keeping CAD drawings in a central location, users can more easily track updates and make sure nobody is working with odd drawings. Tasks that demand a lot of processor power, such

as hidden line removal can be turned over to a central server to avoid tying up a designer's workstation.

An architectural office with unconnected PCs depends on the dreaded sneaker network. Often it is a challenge to figure out who is working on a drawing, and in the worst case two or more people realize that they are working on a different version of the same drawing. As disks are passed from desk to desk, they may be misplaced, file names can be mysteriously mangled, and chaos reigns.

While a networked CAD system may not solve all problems, but it certainly can make life a lot easier. It enables the firm to keep a single copy of each drawing on a central computer, called a server, and to control access to it. Only one person at a time can work on it, but others can view it as a "reference file", and use it as an underlay for their own work.

The network software, which is ideally invisible to users, automatically handles plotting and printing for the entire firm, queuing up requests as they arrive.

A well-planned CAD network has another benefit, too. It enables a project team to divide a project into parts based on, for example, spaces, floor levels, or disciplines, and then share these parts with relative ease.

CHAPTER 5

A METHODICAL APPROACH TO BUYING HARDWARE

When purchasing workstations, the buyer should not underestimate the power and memory storage needed. It is adviseable to spend a few extra dollars because the user will find many third-party applications he/she wants, and as drawing capabilities and comforts increase, so will the drawing file size, and need for additional space.

Mail order clones can be a very good buy but one has to make sure that there will be fast service if needed. Do they have local carry-in service? What are the cost of onsite service and extended warranties? What warranty covers the product? Will the onsite service company provide diagnostic services or must the buyer work out a diagnosis by phone with the manufacturer's support people? What is the vendor's return and refund policy? Is there a restocking charge? Is there a discount or change in price when dealing by check or charge card? How long has the vendor be in business?

Still more technical. What speeds are available on the CPU? How many free slots are available on the internal motherboard for expansion with future upgrade circuits? How much memory is installed on the motherboard? How big is the hard drive? Are the internal components industry standard? Who are the manufacturers? Is DOS included or an extra purchase? What version of DOS? What display monitor and card is included? How is the keyboard? (Appendix E)

Placing a computer on every designer's desk is all well and good, but it hardly addresses the real issues of design in the '90s. A network is an essential part of the solution, with a node on every desk, including the desks of top management.

To reap the full benefits that a network can provide, it is important to know what kind of network platform to get. Prior purchasing the network system the office management should be able to answer the following questions:

- Is multi-tasking capability important? (Will staff use more than one software package simultaneously?)

- Will all stations be active simultaneously?

- Are cabling distances between stations less than 100 feet? (100 ft is the recommended maximum distance for coaxial 'LAN' cable)

- Is file integrity important? (File integrity means that only one user can work on a file at a time)

- Does office's budget allow for a dedicated file server? (Allow $15K to $20K extra)

- What kind of network operating software package should be purchased? (According to recent sales figures, Novell

NetWare accounts for about 60 percent of all new network operating sales. Novell's great attraction can be attributed to a number of factors. The product is stable in even the most demanding environment. Although Novell was developed as a PC networking product, the most recent versions and add-on packages provide connectivity to Apples, NFS-compatible UNIX workstations, and even VAX mainframes.)

CHAPTER 6

CONCLUSION

In computing, there is no such thing as "today's technology". Everything is either obsolete or experimental. Yesterday's technology is appealing because it is tried-and-true and prices are reduced for clearance. Tomorrow's technology is expensive and not always fully tested.

As Personal computers become more powerful, supermini-computers are becoming cheaper. The impressive advances now taking place in network technology enable the interconnection of Personal Computers, workstations, dedicated CAD systems and mainframes, in a scheme where the use of each component is optimized.

The market for AEC/CAD, despite the worldwide recession and the real estate bust in the USA, is quite healthy. According to Dataquest's forecasts, for instance, the architectural component of the AEC/CAD market - as opposed to civil engineering, process plant design, or facilities management CAD - will grow more than 15 percent per year between now and 1996. The total AEC/CAD market will grow from $2.4 billion in 1991 to close to $5 billion by 1996.

Because of falling system prices, it is predicted that the penetration of AEC/CAD in terms of seats-will grow even faster, from just less than 500,000 seats today to more than 1.3 million seats in 1996.

Users buy solutions, not just "neat " technology. Individuals need computer systems to solve problems; they are not interested in buying new technology for the sake of owning the latest technological breakthrough. As a result, next-generation software applications are more important at this stage of the industry's development to future hardware purchases than the advances in hardware development.

Despite gains in hardware, software still can leave something to be desired. An often complaint about software is the lack of programs that can create strong ties between graphic and non-graphic information. Before CAD can be really productive , CAD must be able to provide not only graphics but information about volume, square footage of materials, costing and scheduling information.

CAD and computer technology is no longer an option but a requirement forced by the market. The competitive edge is no longer gained by just using or implementing CAD but by fully integrating it with other automation technologies to extract the maximum benefit from that synergy of employees and computing tools.

A common misconception is that a computer aided design system alone will bring about improved productivity. But CAD is essentially one component in an overall information management system. The two aspects that really make a CAD system productive are its capability to integration with other systems such as database and spreadsheet programs, desktop publishing software, scheduling software etc.. Those

working with the CAD system need to know more then how to work a specific CAD software package. They should be familiar with importing and exporting data and with moving from one operating system to another.

As an architectural company grows in its knowledge and implementation of CAD and computer technology, the entire organizational structure will begin to change, becoming more efficient, streamlined, and flexible. The equation for a successful CAD system implementation starts with a clear understanding of the computer's intended role in a particular office and converges to a solution after an intelligent evaluation of the office's options for hardware, software, and support services.

Computer use requires changes in the way work is done. If the firm is unwilling to change and is efficient in the use of traditional methods, CAD may not be necessary. Too, if the staff does not understand proper use of the computer, the investment may not be efficient.

A CAD system should not be used to design parts just because it is the modern thing to do. The successful transfer of ideas from a concept in the mind to its appearance on paper is perhaps the biggest challenge to architectural expression.

The design profession is still in the process of assimilating CAD technology. Senior managers in most architectural firms are faced with the responsibility for deciding what to buy, but most don't have the technical

knowledge to make these decisions. Adding to the confusion are the hardware and software vendors who want to sell the most costly solutions to the firm's CAD problems.

In many ways, buying computer products is different from buying anything else. For one, it often seems that everything in a computer system depends on everything else. The monitor depends on the graphics adapter. The graphics adapter depends on the bus. The bus varies from one computer system to another. The computer depends on the software and the software depends on the tasks to be automated. The tasks that need to be automated may dictate which video monitor is needed-and on and on it goes.

Management has to keep in mind that the capital value of the hardware will probably be gone in three years-perhaps less, depending on the flexibility, upgradability, and expandability of the hardware. The firm's data is the most valuable network component. The network tools should be designed to eliminate data re-entering and to maximize data use and reuse. As long as one has a reasonably expandable system, one doesn't spend any more on hardware capability than one can use immediately, since it will probably cost much less to add the same capability when needed. Software development lags behind hardware development, so one shouldn't expect to even get maximum use out of what one does have until the software capability catches up. If investing in future capability, buy expandability and flexibility rather than unused capacity.

Look for unique and inventive ways to use existing applications. Many ordinary applications can become much more powerful when used on a network, often by adding an interface software utility or by upgrading to a new version. One aspect of networks that will become increasingly important is the ability of workstations to share processing tasks. Resource optimization is a method of distributing the processing power of several workstations across a network, avoiding the waste of CPU time that would otherwise be idle. Most standalone computers spend the vast majority of the available processing time waiting for the next key to be pressed.

Placing a computer on every designer's desk is all well and good, but it hardly addresses the real issues of design in the '90s. A network is an essential part of the solution, with a node on every desk, including the desks of top management. And even that's not the entire solution. Coordinating the design effort is the crux of the matter, and that requires procedures, planning, and communication.

The office should try not to buy hardware or software that is not need needed. Computers can be worse than drugs in their ability to spend sums on the latest/fastest/best, even if that expense buys only a 10% improvement in productivity.

Hardware and software represent only the tangible cost. The cost of commitment of time to learn the system and become proficient could be overwhelming. Also, keeping the

quality of CAD operations high, is not something to be achieved once, but it is an ongoing effort where there is no final destination.

APPENDIX A

COMPANY LISTING OF HIGH-END CAD PRODUCTS

Arris
Sigma Design INC
1601 Trapelo Road
Waltham, MA 02154

Aries Concept Station
Aries Technology, INC.
600 Suffolk Street
Lowell, MA 01854
Tel. 508-453-5310

AutoCAD
AUTODESK, INC.
2320 Marinship Way
Sausalito, CA 94965
Tel. 800-445-5415

Cadkey
Cadkey INC.
440 Oakland Street
Manchester, CT 06040
Tel 203-647-0220

CADvance
ISICAD, INC
1920 West Corporate Way
P.O. Box 61022
Anaheim, CA 92803-6122
Tel. 714-533-8910

DataCAD
CADKEY, INC.
440 Oakland Street
Manchester, CT 06040

Drawbase
CADWORKS, INCORPORATED
(formerly SKOK SYSTEMS, INC)
222 Third Street, Suite 1320
Cambridge, MA 02142

MegaModel
MEGACADD
66 Marion Street, Suite 301
Seattle, WA 98104
Tel 206-623-6245

Microstation
INTERGRAPH CORPORATION
Huntsville, Alabama 35894-0001
Tel 800-345-4856

MountainTop
ACCUGRAPH CORPORATION
5822 Cromo Drive
El Paso, TX 79912
Tel 915-581-1171

Personal Designer
Computervision
100 Crosby Drive
Bedford, MA 01730
Tel 800-248-7728

PowerDraw
ENGINEERED SOFTWARE
P.O. Box 18344
615 Guilford-Jamestown Road
Greensboro, NC 27419
Tel 919-299-4843

SilverScreen
SCHROFF DEVELOPMENT CORPORATION
5424 Martway
Mission, Kansas 66205
Tel 913-262-2664

VersaCAD 386
COMPUTERVISION, A PRIME COMPANY
100 Crosby Drive
Bedford, MA 01730
Tel 617-275-1800

APPENDIX B

3-D SOFTWARE PACKAGES

Cadmax 3D...........
Vector Automation
Village of Cross Keys
Suite 250
Baltimore, MD 21210
Tel 301-433-4200

DesignCAD 3D
American Small Business Computer INC
327 S. Mill Street
Pryor, OK 74361
Tel 918-825-4844

Design Graphix
Engineering Systems Corporation
3636 S. Sherwood Forest Blvd
Suite 400
Baton Rouge, LA 70816

MegaModel...........
MEGACADD
66 Marion Street, Suite 301
Seattle, WA 98104
Tel 206-623-6245

SilverScreen........
Schroff Development Corporation
5424 Martway
Mission, Kansas 66205
Tel 913-262-2664

APPENDIX C

2-D SOFTWARE PACKAGES

DesignCAD 2D
American Small Business Computer INC
327 S. Mill Street
Pryor, OK 74361
Tel 918-825-4844

DGS-2000
Data Automation
7966 Arjons Drive
Suite A108
San Diego, CA 92126
Tel 619-693-4070

Snap
Forthought
P.O. Box 31
Sunset, CA 29685
Tel 803-878-7484

MegaDRAFT......
MEGACADD
66 Marion Street, Suite 301
Seattle, WA 98104
Tel 206-623-6245

PointLine CADD.
Point Line Graphics INC.
8309 Greenway Road
Middleton, WI 53562
Tel 608-831-0077

APPENDIX D

LOW-END CAD PACKAGES

Cadkey
Cadkey INC.
440 Oakland Street
Manchester, CT 06040
Tel 203-647-0220

DataCAD
Cadkey INC.
440 Oakland Street
Manchester, CT 06040
Tel 203-647-0220

Personal Designer
Computervision
100 Crosby Drive
Bedford, MA 01730
Tel 617-275-1800

PowerDraw
Engineered Software
P.O. Box 18344
615 Guilford-Jamestown Road
Greensboro, NC 27419
Tel 919-299-4843

APPENDIX E

Questionaire sent to 105 different computer dealers nationwide to obtain the following information about 486DX and 386DX PCs

HARD DISK	
Manufacturer	
Disk capacity	
Interface	
Hard disk seek time	
CPU performance index	
Controller location	
Controller manufacturer	
Integrated floppy/ hard disk controller	
Drive bays	
Hard disk options	
FLOPPY DISK	
Type	
Manufacturer	
MOTHERBOARD MEMORY	
installed RAM	
maximum installable RAM	
RAM packaging (& rated speed)	
Chip size	
ADD-IN MEMORY BOARD	
installed RAM/Max RAM	
RAM packaging (& rated speed)	
Chip size	
PROCESSOR RAM CACHE	
Cache controller	
installed RAM	
Maximum installable RAM	
RAM packaging (& rated speed)	
Chip size	

TESTED CONFIGURATION

standard configuration hard disk

Case Type

Dimensions (HWD, in inches)

Motherboard manufacturer

Chip set manufacturer

System RAM arrangement

Wait states

EXPANSION BUS

FREE SLOTS AFTER HARD/FLOPPY DISK DRIVES, VIDEO, ONE PARALLEL AND TWO SERIAL PORTS ARE INSTALLED :

free 32-bit slots

free 16-bit slots

free 8-bit slots

Ports originate on motherboard

VIDEO

Display circuity location

Interface

Manufacturer

Chip set manufacturer

MONITOR

FCC certification class

Dimensions (HWD in inch)

Tilt and swivel base

SIGNAL COMPATIBILITY
    1,024 x 768 noninterlaced

    VGA (800 x 600)

    VGA (640 x 480)

    MCGA

    EGA

    CGA

    MDA

OPERATIONAL FEATURES
    maximum noninterlaced
    resolution (pixels)

    Video bandwidth (MHz)

    Vertical scanning frequency
    range(Hz)

    Horizontal scanning frequency

ANALOG D-SUB CONNECTOR:
  9-pin mini

    15-pin mini

    15-pin standard

ANALOG BNC COAXIAL CONNECTORS:
  3-wire synch on green

    4-wire external composite synch

    5-wire external composite synch

CONTROLS
  Brightness

    Contrast

    Color matching

    Horizontal position

    Horizontal size

    Vertical size

    Pincushioning

    Barrel distortion

    Overscan

    Underscan

    Degaussing

    120-/240-volt switching

KEYBOARD

Manufacturer

Number of keys

Number of function keys

Keyboard cable length (inches)

SOFTWARE INCLUDED

DOS (version number)

Microsoft Windows (version number)

OTHER

MISCELLANEOUS

Coprocessor supported

Physical features:

  Power supply (watts)

  Number of device connectors

  Keyboard lock

  Case lock

  Power-on switch

  Reset switch

SERVICE POLICIES

Warranty on parts (dealer or manufacturer)

Warranty on labor

Service (on-site, dealer, manufacturer,

service center)

FCC certification class

PAYMENT

Is there a credit card surcharge?

What is your complete return policy?

Are there any restocking fees? If yes, how much)?

APPENDIX F

LIST OF COMPANIES CARRYING 486DX AND 386DX PCS

Companies who complied with the following:
* free technical support
* volume discount
* overnight shipping
* minimum 1 year warranty policy
* minimum of 30 days money back guarantee
* no restocking fee

1. Altec Technology Corp
   18555 East Gale Ave
   City of Industry, CA 91748
   Fax 818-912-8048
   Tel 800-255-9971

2. American Computer Express
   2303B Industrial Blvd
   Sarasota, Fl 34234
   Fax 813-359-1325
   Tel 800-533-4604

3. ANS Computer System
   231 West 29th St. Rm 201
   New York, NY 10001
   Fax 212-239-4312
   Tel 212-239-4463

4. ARES Microdevelopment
   24762 Crestview Court
   Farmington Hills, MI 48018
   Fax 313-473-4450
   Tel 800-322-3200

5. Binary Technology
   17120 Dallas Pkwy
   Dallas, TX 75248
   Fax 214-248-1571
   Tel 800-776-7990

6. Blue Dolphin Computers
   1010 Morse Ave., Suite 9
   Sunnyvale, CA 94089
   Fax 408-734-8719
   Tel 800-345-0633

7.   Centrix Computer
     15316 East Valley Blvd
     Industry, CA 91746
     Fax 818-330-9618
     Tel 800-888-9988

8.   CompuCity
     258 South 5th Ave
     City of Industry, CA 91746
     Fax 818-333-0477
     Tel 800-659-8868

9.   CSS Laboratories
     1641 McGaw Ave
     Irvine, CA 92714
     Fax 714-852-0410
     Tel 800-966-2771

10. EiSYS
     500 Bernardo Ave
     Mountain View, CA 94043
     Fax 415-964-4428
     Tel 800-743-6938

11. Gateway 2000
     610 Gateway Dr.
     PO Box 2000
     North Sioux City, SD 57049
     Fax 605-232-2023
     Tel 800-523-2000

12. Insight Computers
     1912 West Fourth St.
     Tempe, AZ 85281
     Fax 602-829-9193
     Tel 800-776-7600

13. Iverson Computer Corp.
     PO Box 6250
     McLean, VA 22106 6250
     Fax 703-883-0722
     Tel 800-444-7290

14. Main Street Computer
     1656 Main St.
     Sarasota, FL 34236
     Fax 813-355-5841
     Tel 800-456-6246

15. Micro Generation
    300 McGaw Dr
    Edison, NJ 08837
    Fax 908-225-8999
    Tel 800-872-2841

16. Microlab
    23976 Freeway Park Dr
    Farmington Hills, MI 48024
    Fax 313-474-7291
    Tel 800-677-7900

17. Santron Computer
    1510 Noriega St
    San Francisco, CA 14122
    Fax
    Tel 800-748-6355

18. Standard Computer Corp
    12803 Schabarum Ave
    Irwindale, CA 91706
    Fax 818-337-2626
    Tel 800-662-6111

19. Swan Technologies
    3075 Research Dr
    State College, PA 16801
    Fax 814-237-4450
    Tel 800-468-9044

20. Ultra-Comp
    11988 Dorsett Rd.
    Maryland Heights, MO 63043
    Fax 314-991-0437
    Tel 800-435-2266

21. Zeos International
    530 Fifth Ave NW
    St. Paul, MN 55112
    Fax 612-633-1325
    Tel 800-423-5891

APPENDIX G

PRODUCTS FOR NETWORKING

LANtastic Network Operating System:
This is a peer-to-peer network
system that allows any machine to
be a server, workstation or both.
It features multiple levels of
security, disk caching, electronic
mail , voice mail, laptop, and
modem options. It also supports DOS
3.1 file and record locking. It
opens up to 5100 files per server.
It is available with LANtastic
2Mbps or LANtastic Ethernet
adaptors; also in a
serial/parallel/modem version; and
in a version that runs on selected
third party adaptor cards.

10CAD EDMS:
10CAD EDMS upgrades ordinary
networks to support CAD/CAM
applications. It manages all
AutoCAD products, drawings, and
plotters. Features include an
engineering database with extensive
project and drawing look-ups,
modifiable field names, remote
spooling,etc. The product supports
eight plotters on a single
workstation (serial and parallel).

LiveLinks AutoCAD/Frame 10.0/2.0:
This software links AutoCAD to
FramerMaker on Sun Microsystems
workstations and network servers.
It lets a user interactively pull
up a drawing, edit it using
AutoCAD, then position and update a
drawing in the Frame document.

VINES:
VINES is LAN operating system that
supports Ethernet, 3COM, Interlan,
token ring, and other well-known
boards. Unlimited users are
supported; features include systems
administrator programs, print

spooling, electronic mail, remote access, support for IBM mainframe connection, and a bridge to other LANs.

Plot Station:
This plotter/printer networking system centralizes and automates plot production in Intergraph CAD networks. It supports HP-GL and PostScript graphics file formats and produces plots over networks from AutoCAD, CADKEY, MCS Anvil, and more and runs on a 286, 386, or 486 PC or compatible.

LAN-D/S Documentation Software Release 1c5:
An AutoCAD application software package for data communications and LAN documentation. LAN-D/S documents cabling, outlets, computers/terminals, concentrators, patch panels, etc. LAN-D/S produces outlet, computer devices, and phone schedules.

Operation Manager:
The latest version of Operations Manager, this network CAD file management software includes support for MS-DOS Windows environments, an industry-standardized graphical user interface for CGA/EGA/VGA, and an Oracle/SQL database. It is compatible with AutoCAD, CADKEY, and other CAD packages and Novell and VINES networking software.

The SuperNet Series:
The SuperNet Series conects up to 128 PCs on an Ethernet and Token ring network concuuently and is compatible with UNIX, MS-DOS, NetBIOS, and TCP/IP. Based on an 80386 microprocessor, The SuperNet Series can connect 3270 terminals, PCs, ASCII terminal, and minicomputers to mainframes.

NetWare Open Systems:
Novell's series of products include file, print,communications, and database services, and hardware

that can run on multiple platforms.
Protocol independence lets users
access these services on the
hardware connections and transport
protocol of their choice.
Compatible with DOS, OS/2, or
Macintosh environments.

APPENDIX H
1. PRICE/PERFORMANCE ANALYSIS

OBSERVATIONS	T1	T2	T3	T4
1 Animation	0	1(-)	0	0
2 Architectural design	1	1	1	1
3 Architectural modeling	1	1	1	1
4 Building Code Analysis	1(-)	0	0	N
5 Construction documents	1	1	0	0
6 Cost estimation	1	0	0	1
7 Design development	1	1(-)	0	1
8 Document management	0	0	0	0
9 Drafting	1	1	1	1
10 Drawing management	0	0	0	0
11 Duct design	0	0	0	0
12 Facility management	0	0	0	1
13 Flowcharting	1	0	0	1(-)
14 Interference checking	0	1(-)	0	1(-)
15 Interior design	1	1	1	1(-)
16 HVAC system analysis	0	1(-)	0	1(-)
17 HVAC system design	0	1(-)	0	0
18 Landscape design	0	0	0	0
19 Lighting analysis	0	1(-)	0	1(-)
20 Lighting design	0	0	0	1(-)
21 Lighting simulation	0	1(-)	0	1(-)
22 Manual digitizing	1	1	0	1(-)
23 Mass property analysis	1	1(-)	0	1
24 Network management	0	1(-)	0	1(-)
25 Piping	0	0	0	0
26 Rendering, presentation	1	1	1	1(-)
27 Schematic design	1	1	1	1
28 Site planning	1	1	0	1(-)
29 Sketching	1	1(-)	0	1(-)
30 Space management	0	0	0	1
31 Specifications	1	0	0	1(-)
32 Steel design	0	0	0	1(-)
33 Steel detailing	0	0	0	1(-)
34 Structural analysis	0	0	0	1(-)
35 Structural design	0	0	0	1(-)
36 Text editing	0	1	1	1(-)
37 Utilities mapping	0	0	1	1(-)
38 Can commands run from an				
39 ASCII text file	1	1	1	1
40 Can external programming language be used to modify the program or drawing model	1	1(-)	1	1
41 Can macros/menu commands be optimized for speed	1(-)	1	1	1
42 Are macros/menu commands compileable to run at the same speed as system commands	1	1(-)	1	1

1   task included in generic package
0   task available with purchase of third-party package
1(-) task not available

ANALYSIS OF VARIANCE FOR A COMPLETELY RANDOMIZED DESIGN:

Number of treatments = 4   (Software packages: AutoCAD,
                                     CADVance, Microstation, VersaCAD)
Maximum Number of observations = 42   (Tasks)

ANALYSIS OF VARIANCE TABLE				
Source of variation	Degrees of freedom	Sum of Squares	Mean Square	F
Treatments	3	9.304	3.101	6.314
Error	164	80.548	0.491	
Total	167	89.851		

The F value of 6.314 with 3 and 164 degrees of freedom
would be cause for rejection of the Null Hypothesis at an
Alpha level of 0.00005

SUMMARY OF POPULATION STATISTICS						
Treatment	Obs.	Mean	Std. Dev.	Minimum	Maximum	TJ's
1	42	0.405	0.091	-1.000	1.000	0.268
2	42	0.024	0.120	-1.000	1.000	-0.113
3	42	0.310	0.072		1.000	0.173
4	42	-0.190	0.137	-1.000	1.000	-0.327
Total	168	0.137				

COST UPGRADE ANALYSIS:
T1 = AutoCAD
T2 = CADVance
T3 = Microstation
T4 = VersaCAD

AGGREGATE COST = INITIAL COST + (#0) COST FACTOR +
(#-1) LIMITATION FACTOR

IC = initial cost
C = cost factor
L = limitation factor

T1 3750 + (21) C + (02) L
T2 3495 + (17) C + (12) L
T3 3450 + (29) C + (00) L
T4 3495 + (08) C + (21) L

2.AUTODESK'S NET INCOME

The number of data pairs is 5

Input the value of alpha to be used in setting
confidence intervals ?   .05

The selected value of alpha is .05
The t statistic is = 3.1799

Independent Variable (x)	Dependent Variable (y)
1	11620
2	20541
3	32695
4	46378
5	56755

Correlation Coefficient = +0.998

Minimum (x) =   1.000   Maximum (x) =   5.000
Minimum (y) =   11620.000   Maximum (y) = 56755.000

Mean of x =   3.000   Mean of y = 33597.801

F Statistic for Hypothesis test of Beta 1 = 0
F = 694.32 with 1 and 3 Degrees of Freedom

This F Statistic would be significant at an
Alpha Level of 0.000

Model: Y = B0 + B1 * X

Sum of squares for regression (SSR) = 1.348083E+09
Sum of squares for error (SSE) =   5824768
Total Sum of Squares (SST) = 1.353908E+09

Unconditional variance of 'Y'   S (Y) = 6.769541E+08
Conditional Error Variance S(Y/X) = 1941590

Estimate of B0 = -1234.300   Variance = %2135748.200
Estimate of B1 = 11610.700   Variance = 194158.938

Correlation between B0 and B1 = -.905
   95% confidence limits on B0 and B1

Probability (-5881.47 < B0 < 3412.87) =95%
Probability (10209.53 < B1 < 13011.88) =95%

AUTODESK'S ESTIMATED NET INCOME FOR 1992 AND 1993:
y= -1234.300 + 11610.700 (6) = $ 68429.9   for 1992
y= -1234.300 + 11610.700 (7) = $ 80040.6   for 1993

3. AUTODESK'S ESTIMATED SALES

The number of data pairs is 5

Input the value of alpha to be used in setting
confidence intervals ? .05

The selected value of alpha is .05
The t statistic is = 3.1799

Independent Variable (x)	Dependent Variable (y)
1	52382
2	79257
3	117302
4	178591
5	237850

Correlation Coefficient = +0.987

Minimum (x) =   1.000   Maximum (x) =   5.000
Minimum (y) = 52382.000   Maximum (y) =%237850.000

Mean of x = 3.000   Mean of y = %133076.406

F Statistic for Hypothesis test of Beta 1 = 0
F = 112.33 with 1 and 3 Degrees of Freedom

This F Statistic would be significant at an
Alpha Level of 0.001

Model: Y = B0 + B1 * X

Sum of squares for regression (SSR) = 2.211539+10
Sum of squares for error (SSE) = 5.906453E+08
Total Sum of Squares (SST) = 2.270603E+10

Unconditional variance of 'Y'   S (Y) = 1.135302E+10
Conditional Error Variance S(Y/X) = 1.968817E+08

Estimate of B0 = -8004.600   Variance = %216569920.000
Estimate of B1 = 47027.000   Variance = % 19688174.000

Correlation between B0 and B1 = -.905
    95% confidence limits on B0 and B1

Probability (%-54801.01 < B0 < 38791.81) =95%
Probability (32917.35 < B1 < 61136.65) =95%

AUTODESK'S ESTIMATED SALES FOR 1992 AND 1993:

y= -8004.600 + 47027 (6) = $ 274157.4   for 1992
y= -8004.600 + 47027 (7) = $ 321184.4   for 1993

4. INTERGRAPH'S ESTIMATED SALES:

The number of data pairs is 5

Input the value of alpha to be used in setting
confidence intervals ? .05

The selected value of alpha is .05
The t statistic is = 3.1799

Independent Variable (x)	Dependent Variable (y)
1	641083
2	800160
3	860062
4	1044617
5	1195378

Correlation Coefficient = +0.991

Minimum (x) =   1.000   Maximum (x) =   5.000
Minimum (y) = %641083.000   Maximum (y) =%908260.000

Mean of x = 3.000   Mean of y = %908260.000

F Statistic for Hypothesis test of Beta 1 = 0
F = 164.02 with 1 and 3 Degrees of Freedom

This F Statistic would be significant at an
Alpha Level of 0.001

Model: Y = B0 + B1 * X

Sum of squares for regression (SSR) = 1.830736E+11
Sum of squares for error (SSE) = 3.348546E+09
Total Sum of Squares (SST) = 1.864222E+11

Unconditional variance of 'Y'   S (Y) = 9.321108E+10
Conditional Error Variance S(Y/X) = 1.116182E+09

Estimate of B0 = 502345.910   Variance = %1227800060.000
Estimate of B1 = 135304.703   Variance = %111618192.000

Correlation between B0 and B1 = -.905
   95% confidence limits on B0 and B1

Probability (%390922.28 < B0 < %613769.50) =95%
Probability (%101709.22 < B1 < %168900.19) =95%

INTERGRAPH'S ESTIMATED SALES FOR 1992 AND 1993:

y= 502345.910 + 135304.703 (6) = $ 1314174.1 for 1992
y= 502345.910 + 135304.703 (7) = $ 1449478.8 for 1993

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5. INTERGRAPH'S ESTIMATED NET INCOME:

The number of data pairs is 5

Input the value of alpha to be used in setting
confidence intervals ?   .05

The selected value of alpha is .05
The t statistic is = 3.1799

Independent Variable (x)	Dependent Variable (y)
1	69876
2	87986
3	79502
4	62557
5	71108

Correlation Coefficient = -0.372

Minimum (x) =   1.000   Maximum (x) =   5.000
Minimum (y) = %62557.000   Maximum (y) =% 87986.000

Mean of x = 3.000   Mean of y = %74205.797

F Statistic for Hypothesis test of Beta 1 = 0
F = 0.48 with 1 and 3 Degrees of Freedom

This F Statistic would be significant at an
Alpha Level of 0.541

Model: Y = B0 + B1 * X

Sum of squares for regression (SSR) = 5.273912E+07
Sum of squares for error (SSE) = 3.292426E+08
Total Sum of Squares (SST) = 3.819817E+08

Unconditional variance of 'Y'   S (Y) = 1.909909E+08
Conditional Error Variance S(Y/X) = 1.097475E+08

Estimate of B0 = 81095.297   Variance = %120722280.000
Estimate of B1 = -2296.500   Variance = %10974753.000

Correlation between B0 and B1 = -.905
   95% confidence limits on B0 and B1

Probability (46156.56 < B0 < %116034.03) =95%
Probability (%-12830.92 < B1 < 8237.92) =95%

The line is not good for this model!
Use $y=b_0+b_1x+b_2x^2+b_3x^3$

Multivariable Model:

SET	X1	X2	X3	Y
1	1.000	1.000.........1.000		6.99E+04
2	2.000	4.000	8.000	8.80E+04
3	3.000	9.000	27.000	7.95E+04
4	4.000	16.000	64.000	6.26E+04
5	5.000.......25.000		125.000	7.11E+04

	Means of Variables	Std. Dev. of Variables
X1	3.000	1.581
X2	11.000	9.670
X3	45.000	50.966
Y	7.42E+04	9772.177

The Variance - Covariance matrix of the input variables

VAR	X1	X2	X3	Y
X1	2.500	15.000	76.000	-5741.250
X2	15.000	93.500	487.500	-4.13E+04
X3	76.000	487.500	2597.500	-2.21E+05
Y	-5741.250	-4.13E+04	-2.21E+05	+9.55E+07

Simple Correlation Coefficients

VAR	X1	X2	X3	Y
X1	1.000	0.981	0.943	-0.372
X2	0.981	1.000	0.989	-0.438
X3	0.943	0.989	1.000	1.000
Y	-0.372	-0.438	-0.444	1.000

Variables	Minimum	Maximum	Range
X1	1.000	5.000	4.000
X2	1.000	25.000	24.000
X3	1.000	125.000	124.000
Y	6.26E+04	8.80E+04	2.54E+04

Correlation matrix for regression coefficients

Coe	B0	B1	B2	B3		
Bo	1.000	-0.975	0.937	-0.900		
B1	-0.975	+1.000	-0.989	0.967		
B2	0.937	-0.989	1.000	-0.994		
B3	-0.900	0.967	-0.994	1.000		
Coe	Value	Std. Dev.	t	Prob>t	Std. Coeff.	
B0	-5628.359	9263.878	-0.608	0.676	0.0000	
B1	1.12E+05	1.21E+04	9.247	0.035	18.1181	
B2	-4.10E+04	4494.543	-9.131	0.965	-40.6108	
B3	4341.322	496.253	8.748	0.037	22.6417	

Multiple Correlation Coefficient R-Squared = .990716

F Statistic = 35.57066 with 3 and 1 Degrees of freedom

Probability (x < f) by chance = .128727

Standard Deviation of error = 1883.172

Variance of error = 3546336 with 1 Degrees of freedom

Error sum of squares = 3546336

Total sum of Squares = 3.819817E+08

INTERGRAPH'S ESTIMATED NET INCOME FOR 1992 AND 1993:

$Y=-5628.359+11200(6)-41000(6)^2+4341.322(6)^3$ for 1992

$y=-5628.359+11200(7)-41000(7)^2+4341.322(7)^3$ for 1993

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