

U.S. INFORMATION SERVICES  
CROSS-INDUSTRY MARKETS, 1986-1991  
ENGINEERING AND SCIENTIFIC SECTOR

MAY 1986

THE JOURNAL OF  
THE  
ROYAL ANTHROPOLOGICAL INSTITUTE  
OF GREAT BRITAIN AND IRELAND  
PUBLISHED BY THE  
CAMBRIDGE UNIVERSITY PRESS

U.S. INFORMATION SERVICE  
CROSS-INDUSTRY MARKETS, 1986-1991  
ENGINEERING AND SCIENTIFIC SECTOR

CONTENTS

	<u>Page</u>
I ISSUES, TRENDS, AND EVENTS .....	IV-ES-1
A. Introduction	IV-ES-1
B. CAD/CAM	IV-ES-3
C. CAE in Electronics Industry	IV-ES-6
D. Structural Analysis	IV-ES-9
E. Workstations	IV-ES-10
F. Silicon Compilers	IV-ES-12
II MARKET FORECASTS.....	IV-ES-15
III COMPETITIVE DEVELOPMENTS .....	IV-ES-23
A. Applicon	IV-ES-23
B. Auto-Trol	IV-ES-24
C. Computervision	IV-ES-25
D. Control Data Corporation	IV-ES-27
E. Daisy Systems	IV-ES-28
F. IBM	IV-ES-29
G. Intergraph	IV-ES-31
H. MacNeal Schwendler Corporation	IV-ES-32
I. Mentor Graphics	IV-ES-33
J. Tektronix	IV-ES-34
K. Valid Logic	IV-ES-36
IV NEW OPPORTUNITIES.....	IV-ES-39
A. CAD/CAM	IV-ES-39
B. CAE	IV-ES-40
C. Other	IV-ES-41
V CONCLUSIONS AND RECOMMENDATIONS .....	IV-ES-43
APPENDIX ES-A: FORECAST DATA BASE: ENGINEERING AND SCIENTIFIC SECTOR.....	IV-ES-45
APPENDIX ES-B: FORECAST RECONCILIATION .....	IV-ES-47



U.S. INFORMATION SERVICES  
CROSS-INDUSTRY MARKETS, 1986-1991  
ENGINEERING AND SCIENTIFIC SECTOR

EXHIBITS

		<u>Page</u>
II	-1 Engineering and Scientific Sector Information Services Markets, 1986-1991	IV-ES-16
	-2 Engineering and Scientific Sector Information Services Market By Delivery Mode, 1986-1991	IV-ES-18
	-3 Revenues of Leading Turnkey Vendors of CAD/CAE, 1985	IV-ES-19
A	-1 Engineering and Scientific Sector--Cross-Industry User Expenditure Forecasts, 1986-1991	IV-ES-46
B	-1 Engineering Sector--Data Base Reconciliation of Market Forecast By Delivery Mode	IV-ES-48



## I ISSUES, TRENDS, AND EVENTS

### A. INTRODUCTION

- CAD/CAM/CAE is the major component of the types of applications that are offered in the engineering and scientific market. For example, under CAD/CAM, along with design and drafting applications, are also included such applications as structural analysis and structural engineering. However, for purposes of analysis, a separate section is included for structural analysis applications. While the report focuses on the CAD/CAM/CAE segment of the market because it is the largest, most dynamic, and fastest growing, the forecasts also include scientific applications for such uses as biological research, statistical analysis, and linear programming.
- CAD/CAM includes a wide range of applications:
  - Mechanical design and drafting which includes finite element modeling and analysis, surface design, and solids modeling.
  - Electronic design which includes circuit analysis, schematic capture, schematic design-rule checking, and integrated circuit layout.
  - Architecture, engineering, and construction (AEC) which includes plant design, piping design and analysis, building design and management, mapping, and site engineering.



- Computer-aided manufacturing which includes robot program design and simulation, and numerical control programming.
- CAD can stand for either computer-aided drafting or computer-aided design.
  - Computer-aided drafting provides basic drawing entry and editing. Schematic capture, mechanical drawings, and map entry are examples of this type of activity.
  - Computer-aided design performs design rule checks on drawings that have been entered. The design rule checks performed include checking for typographical errors, simple design mistakes, and for incomplete drawings. Examples include checking for spacing for parts, electrical overloads, unspecified sizes of parts, etc.
- In addition to designing products, engineers must also analyze the designs to make sure the products will perform as required. Computer-aided engineering (CAE) programs were designed to fulfill this role.
- Sometimes the terms CAD and CAE are used interchangeably because they are both design automation tools. However, there are important differences between the two:
  - CAE systems are used at the "front end," where products are conceived. They are used by engineers to automate the analysis and simulation of the design. In analysis and simulation, a mathematical or software model of the design is created and tested under various conditions. The results of these tests show what a physical model would do under the same conditions.
  - On the other hand, CAD systems are used to draw and analyze physical structures. They are typically employed at the "tail end" of the



product development process where they are used to convert engineers' designs into production drawings.

- The engineering and scientific market is typified by work that spans many industry segments, yet is concentrated in manufacturing, both discrete and process.
- Approximately 17% of the total CAD/CAM/CAE turnkey systems is included in the engineering and scientific segment forecasts. The remainder is included in the discrete manufacturing, process manufacturing, utilities, transportation, federal government, and other sectors.
  - Likewise, the CAM portion is excluded from the analysis and forecasts in the engineering and scientific section. User expenditures for CAM sales are included in the discrete manufacturing industry sector.
  - Expenditures by architectural and engineering firms for applications that are designed specifically for that type of firm, as opposed to an application designed for engineers or architects in any type of firm, are included in the industry-specific services sector under architectural and engineering services.

#### B. CAD/CAM

- 1985 was one of the most turbulent years ever for the CAD/CAM industry. The turbulence is due in part to the massive influx of microcomputer-based products into what had previously been a mini and mainframe dominated market. PC-based systems have hurt sales of high-end systems priced at \$50,000-120,000 per workstation. This new competition has forced the traditional leading manufacturers to counter with micro products of their own, but they have had trouble maintaining revenues in this unfamiliar segment of the market.



- There are three major groups of CAD/CAM turnkey systems.
  - The first is a low-cost system that sells for less than \$25,000. These systems are typically dedicated to a single task such as semiconductor design. The IBM PC/AT is the primary workstation for these products. These systems are typically limited to drafting and two-dimensional (2D) design capability.
  - The second group of systems have more than one graphics workstation linked together in a cluster. Such systems begin at around \$100,000 and are suited to the needs of medium-sized firms with complex design needs.
  - The third group of CAD/CAM systems comprises the largest and most expensive equipment. These systems allow many designers to work on different portions of one project by using separate workstations that are connected to the central computer which updates and coordinates the whole design process. The high end of the market is growing at a slower rate than the other two groups.
- One significant impact of the rapid proliferation of low-cost workstation-based CAD and CAE systems is that the vendors can no longer afford the level of support and service that went with high profit margins associated with high-end systems. There is not enough margin in a \$20,000 system (unless sold in volume) to accommodate a lengthy sales call and a lot of follow-up support.
- In addition to the move toward PC-based systems, the major trends in the CAD/CAM industry are:
  - Move toward open architecture.



- Emergence of systems to integrate mechanical design, engineering, and shop floor manufacturing systems.
- Integration of data management and computing systems. An effective data base management environment is necessary for the integration of a multi-vendor information system.
- Communications across disparate workstations and computer systems from multiple vendors. In order to address these communication problems, CAD/CAM/CAE vendors are making major shifts in their workstation offerings toward systems based on emerging industry standards.
- Distributed solutions in a hierarchical setting. The premise of a hierarchy of computing systems is that data management and archiving functions are performed at the host level and the interactive data management and design applications at the workstation level. The transition in the industry is still in progress.
- Back-end processors at a departmental level.
- Movement toward solids modeling and 3D capabilities.
- Introduction of more intelligence through the incorporation of expert systems.
- Greater involvement of senior management in the decision to buy a system. The strategic importance of CAD/CAM has been recognized; thus, people in the company are required to approve the purchase which lengthens the sales cycle.
- There is a move toward component CAD/CAM systems because customers that already have computers do not want to buy a complete



CAD/CAM system that duplicates some of what they already own. Instead, they are likely to want separate CAD/CAM components such as software and graphics workstations that they can connect to their existing hardware.

### C. CAE IN ELECTRONICS INDUSTRY

- The need for CAE tools in electronic design resulted from the increasing complexity of large-scale integrated circuits and the electronic systems incorporating such components. This increasing design complexity has significantly lengthened the product development cycle while, at the same time, more competition in the electronics industry has shortened product life cycles.
  - The primary user benefits of CAD/CAM/CAE systems are in producing products less expensively and, more importantly, developing them faster to take advantage of market windows.
  - CAE is used to improve the quality of design by simulating operational performance and to reduce the turnaround time for various phases of electronics engineering, including defining overall system architecture, logic circuit layout, design-rule checking, and timing simulation.
  - This implies that there will have to be significant links between the design function and the production function, and post-production issues such as product test and field service. Engineers want the design to go smoothly from CAD to CAE and then to CAM in a fully integrated system.
- There are about 3,000 chip designers in the world compared with about 400,000 systems designers. The integrated circuit designers were the initial



purchasers of CAE tools. The trend is toward system design rather than chip design. CAE tools will be more gradually adopted by systems designers which will be accompanied by evolutionary changes in the characteristics of CAE tools and suppliers. Systems designers will require tools that are easier to learn and use and which address a broader range of electronic design applications. It takes a long time, even for a sophisticated IC designer, to learn how to use the current systems.

- A key issue facing CAE vendors now is data management, that is, the ability to move data through a particular vendor's system as well as the ability to transfer data from one vendor's system to another. However, because of the sheer volume of data and the assortment of formats used, data management presents a formidable challenge to the industry.
- Currently, three companies dominate the CAE tools marketplace: Mentor Graphics, Daisy Systems, and Valid Logic Systems. The market forces facing these three leading CAE vendors are:
  - Customers are demanding easier-to-use systems that cost less.
  - Startup companies are offering PC-based systems.
  - Established instrument, CAD/CAM, and computer companies are suddenly attracted to the CAE market.
- Vendors that have either entered or have announced their intention of entering the CAE market include:
  - Tektronix, a leading instrumentation company, who recently acquired CAE Systems, Inc. of Sunnyvale.
  - Hewlett-Packard, which has floundered in its attempts to develop CAE software, recently purchased a CAE software company—Cericon Inc. of Salt Lake City.



- The CAD/CAM companies, led by Computervision, Intergraph, General Electric's Calma subsidiary, and Schlumberger's Applicon division, have already begun encroaching on the CAE market.
- AT&T and IBM, with their own advanced internal CAE tools, could each be a major force in the market if they so chose.
- However, all has not gone well for these new entrants.
  - Companies like Hewlett-Packard and Tektronix have barely gained a foothold in CAE.
  - The established CAD vendors have had trouble moving into CAE as well. Both Computervision and Calma bought small CAE startups to help them move into chip design systems, but marketing and technical problems have hampered their product introductions.
- It takes a major investment of both time and resources to successfully penetrate this market. The software involved is very complex and, as H-P and Tektronix have discovered, more difficult and time consuming than anticipated. One cannot rush into the market with a CAE application.
  - In addition, an ever increasing number of product features are required to enter this market. Additional features that have been added recently to CAE systems include PCB layout, ATE (automatic test equipment) interfaces, silicon compilation, and standard cell layout.
  - The newer CAE products integrate the once independent functions of design, design verification, layout, and test generation, thereby easing the bottlenecks in the design-to-production process.



#### D. STRUCTURAL ANALYSIS

- Structural analysis and modeling is of interest to a diverse range of customer segments, including the aerospace, automotive, and civil engineering industries. In general, engineering analysis involves the detailed simulation of structural behavior under a variety of operating conditions.
- Typically, such analysis involves the use of "finite element modeling" (FEM) techniques for solutions. Finite element analysis, the most widely used of the structural engineering techniques, divides the structural unit being modeled into a discrete number of well-defined elements--the finite elements. These elements are assumed to be connected to each other in simple geometric shapes that individually lend themselves to analysis. The geometric shapes are then added together to form the essential structure of the object. Using this technique, the behavior of complex shapes, such as an airplane wing or an automobile fender, can be studied.
- The commonality and generic appeal of FEM techniques applied to diverse applications had led to the development of industry standard software packages, such as ANSYS, NASTRAN, PATRAN, and STRUDL.
  - The most popular FEM software is MacNeal-Schwendler Corporation's MSC/NASTRAN, a continuously enhanced version of the original NASA Structural Analysis program currently licensed for a monthly fee to over 300 customers in aerospace, defense, energy, construction, and consumer products industries. The full-scale program is available from most RCS vendors that support engineering and can be leased by a corporation for use on its own mainframe or minicomputer.
  - Dozens of other structural simulation packages are available either in the public domain or for a fee from third parties, generally designed to aid in problem solving applicable to specific disciplines of engineering analysis.



- The STRuctural Design Language (STRU DL) is an outgrowth of work done on computerized engineering techniques at MIT in the 1950s and 1960s. The early programs were in the public domain. Several software and RCS vendors have used this code as the basis of their own proprietary offerings. Proprietary STRUDLs offer greatly enhanced capability for analyzing complex structures under a wide variety of conditions. These packages feature automatic model generation, graphics model verification, automatic load generation, complete building code compliance, and member (element) redesign. McDonnell Douglas (MCD-ISG) offers a very popular and widely used version of STRUDL on its RCS service.
- In addition to the above, there are a number of widely available and highly regarded structural programs in use today, including:
  - ANSYS: developed and maintained by Swanson Analysis Systems, Inc. (Houston, PA).
  - EASE2: developed and maintained by Engineering Analysis Corporation (Torrance, CA).
  - MARC: developed and maintained by MARC Analysis Research Corporation (Palo Alto, CA).
  - STARDYNE: developed and maintained by Management Research Information (MRI) (San Jose, CA).

#### E. WORKSTATIONS

- The introduction of several significant new workstations created a large degree of change in a short amount of time. The personal computer proved



widely popular, followed by the introduction of DEC's MicroVAX II, Motorola 68020 chips, DEC's VAXStation II/GPX, and the IBM PC/RT.

- Currently, Apollo is the leading workstation vendor, followed by Sun Microsystems, with DEC and IBM coming on strong. In short order, IBM and DEC will establish themselves as the two leading hardware platform suppliers in technical computing. Sun and Apollo will remain strong in engineering departments.
- There will be four major CAD/CAM/CAE workstation platforms accepted over the next few years:
  - IBM PC family (PC/XT, PC/AT, and successors).
  - Unix workstations (Apollo, Sun Microsystems, etc.).
  - DEC MicroVAX family.
  - IBM workstation family (the RT and successors).
- Support for the first three of these hardware platforms is almost universal among CAD/CAM and CAE system suppliers, while support for IBM's new RT workstation should appear gradually (and reluctantly) because software and system developers already have their hands full either developing for, or converting to, other machines.
- The low-cost workstations will dominate this market in terms of units sold. With a PC, CAD/CAM users can perform about 70-80% of their basic CAD/CAM needs at 10% of the cost. Moreover, since many engineers already have their own PC, they believe that all they have to do is buy an inexpensive microcomputer software CAD/CAM package (and perhaps a few add-ons) and they are all set. Although this is true in some instances, the desire for increased performance and features will continue unabated.



- Today's workstation customers require links with existing computers (see discussion of integration in Chapter IV).
- The majority of engineers and scientists still do not have a workstation or personal computer. The biggest obstacle to getting these engineers to use a workstation and CAD/CAM applications is the initial cost involved.

#### **F. SILICON COMPILERS**

- One new technology with a great deal of promise that has so far failed to take off in the market is silicon compilers. A silicon compiler is a computer program that automatically designs a chip based on engineering descriptions of what the circuit should do. These compilers go beyond the capabilities offered by present CAE systems by actually doing the design of the chip. Despite much promise, the market for silicon compilers has not grown as quickly as expected.
- Silicon compilers began appearing in late 1984. Today, they are sold mainly by three small, private companies: Silicon Compilers Inc. (San Jose, CA); Seattle Silicon Technology (Bellevue, WA); and Silicon Design Labs (Liberty Corner, NJ).
- One established semiconductor company, LSI Logic, has recently entered the market with a silicon compiler based on a different concept. Rather than accepting the compromises in design that current products trying to automate the design of all types of chips are forced to make, LSI is developing a different compiler for each of the dozen or so major types of chips.



- The reasons this market has failed to take off at this point are:
  - The electronics companies, their primary customers, have been in a slump.
  - While silicon compilers can do the design job faster than an engineer, they still do not do as good a job. Computer-designed chips waste more space on the silicon, making such chips more expensive to manufacture.
  - However, silicon compilers have a bright future. Because chips are becoming so complex, engineers can no longer do the design without the aid of a computer. There must be a way for a designer to deal with all of the intricacies of a complex integrated circuit, and silicon compilers offer one of the few, if not only, available solutions.







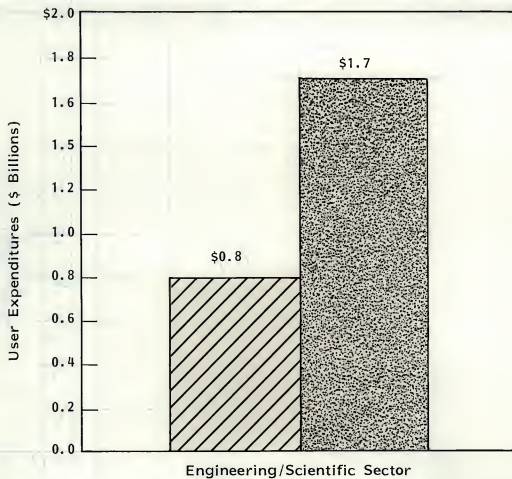
## II MARKET FORECASTS

- The four largest marketplaces for CAD systems are:
  - Mechanical design--this is the largest area, encompassing the aerospace and automobile industries.
  - Integrated and printed circuit board design--this includes primarily the electronics companies.
  - Civil engineering--this includes the construction industry. The primary use is for piping design and layout. Key users are oil and chemical companies and construction contractors that design and build refineries and chemical plants.
  - Mapping--this is used primarily by local and federal government agencies for municipal planning and public utility mapping. Natural resource firms are using CAD techniques for mapping seismic data on mineral deposits.
- The largest market for CAE is for electronics design, particularly for integrated circuit design.
- User expenditures for cross-industry engineering and scientific applications will grow 16% annually through 1991, increasing from \$812 million in 1986 to \$1.7 billion in 1991, as shown in Exhibit II-1.



EXHIBIT II-1

ENGINEERING AND SCIENTIFIC SECTOR  
INFORMATION SERVICES MARKETS, 1986-1991



Average Annual  
Growth Rate

16%

1986

1991

IV-ES-16

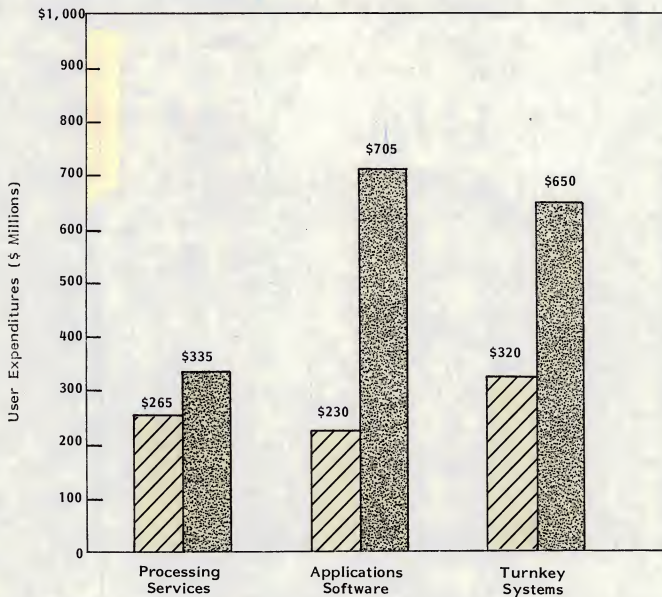


- One very promising area is remote computing services based on a supercomputer. Supercomputer processing services, such as Control Data Corporation's Cybernet service, provide the processing capabilities necessary for a number of applications such as wind tunnel simulation. This market should grow at a rate of 40% over the next two years.
- Forecasts for user expenditures by delivery mode are shown in Exhibit II-2. Application software sales will grow most rapidly at a rate of 25% as firms buy engineering/scientific software for their existing in-house computer systems.
- Appendix ES-A contains the forecast data base for each year, 1985-1991, by delivery mode.
- Exhibit II-3 lists the revenues of the leading turnkey CAD/CAM/CAE vendors. Vendors such as IBM, DEC, and Prime are excluded from this list because they sell hardware and software separately.
- The CAD/CAM industry is currently in a transition from the rapidly growing 1980-1985 period to an era of slower expansion. Expenditures outside the U.S., however, are expected to increase at a much faster rate (25% a year) than the U.S. market which will grow at only 16%.
- The reasons for the slowdown in growth include:
  - The initial period of rapid growth in the U.S. market has slowed as the "early adopter" phase has run its course and vendors face the more difficult task of selling to a new level of customers. The new customers want the CAD/CAM/CAE facility to be part of the overall computing facilities.



# EXHIBIT II-2

## ENGINEERING AND SCIENTIFIC SECTOR INFORMATION SERVICES MARKET BY DELIVERY MODE, 1986-1991



Average Annual  
Growth Rate

5%

25%

15%



1986



1991

Note: Some sectors included in the segment total are not broken out.

IV-ES-18



EXHIBIT II-3

REVENUES OF LEADING TURNKEY VENDORS  
OF CAD/CAE, 1985\*

VENDOR	REVENUES (\$ Millions)** WORLDWIDE	REVENUES (\$ Millions) U.S.
Intergraph	\$525	\$362
Computervision	441	185
Calma	210	157
McDonnell Douglas	150	112
Mentor Graphics	137	86
Daisy Systems	135	81
Control Data Corp.	117	88
Applicon	66	53
Auto-Trol	65	52
Valid Logic	56	36
Evans and Sutherland	41	37
Other	670	400
<b>Total</b>	<b>\$2.6 Billion</b>	<b>\$1.6 Billion</b>

\*Excludes computer manufacturers IBM, DEC, DG, PRIME, Hewlett-Packard, etc.

\*\*For industry-specific and cross-industry applications.



- The increased complexity and integration of systems has slowed the decision-making process. Many users now recognize the importance of design systems to their productivity and their ability to compete.
  - However, the integration of new CAD/CAM and CAE products with existing systems is critical to the user. In addition, these systems must also integrate with both planned and existing manufacturing systems and administrative systems. The drive to integrate, or at least to consider integration of multiple functions of the corporation, has pushed the purchase decision to higher levels of management and has caused the formation of purchasing committees, which in turn delays the decision-making process.
  - CAD/CAM systems have become capital expenditures; consequently, spending becomes more cyclical.
  - There has been a capital spending slowdown in almost all segments of manufacturing, but particularly in electronics companies.
  - Customers are now more discriminating and cautious in their spending.
  - The use of CAD/CAM/CAE is growing, but unit costs have come down dramatically in the past year so user expenditures will grow at a reduced rate.
- The most rapid growth within the CAD/CAM industry is taking place in the low-end turnkey systems where PC-based systems are proving to be an increasingly popular choice. Thus, although the shipment rate of workstations has increased significantly, user expenditures have not kept pace. The rapid rise of low-cost workstations in this industry has caused a decline in the growth rates from the 18% that was forecast last year, to 15%.



- Most of the increases in CAD/CAM/CAE will occur in the CAE sector. The total market size for CAE worldwide was \$450 in 1985. This segment of the market is forecasted to grow at an average annual growth rate of 25%.
  - The advent of low-cost entry level CAE workstations will expand the market significantly.
  - There is a very low penetration of the overall CAE market; consequently, there is a lot of room for growth.







### III COMPETITIVE DEVELOPMENTS

#### A. APPLICON

##### I. PRODUCTS/SERVICES

- Turnkey systems--their primary CAD/CAM products are the Series 4000 and the BRAVO! family of turnkey systems.

##### 2. MARKETS SERVED

- CAD/CAM/CAE for mechanical, electronics, and engineering applications.

##### 3. RECENT ACTIVITIES

- In July 1985, Applicon, a subsidiary of Schlumberger, was merged with Manufacturing Data Systems Inc. (MDSI), also a subsidiary of Schlumberger. They have added Unix versions of their application software to go along with their VAX/VMS offerings.

##### 4. FUTURE DIRECTION

- The very large scale integration (VLSI) product line previously marketed by Applicon is now offered by Electronic Design Automation (EDA). EDA is a new organization reporting to Factron, another division of Schlumberger's Computer-Aided Systems Group.



## **B. AUTO-TROL**

### **1. PRODUCTS/SERVICES**

- Turnkey systems.

### **2. MARKETS SERVED**

- CAD/CAM systems for the architectural, engineering, and construction (AEC), mechanical design and manufacturing, and technical publications industries. The AEC systems are used to prepare plans for office buildings, residential complexes, and industrial facilities. The plant design software is used to design new plants and to prepare the documentation for plant modifications. The mechanical design software is used to design and document mechanical parts and products.

### **3. COMPANY STRATEGY**

- Their corporate goal is to provide full function, distributed networked workstations with open systems architecture, and the highest quality software applications.

### **4. RECENT ACTIVITIES**

- In April 1985, Auto-trol acquired TRICAD, Inc. of Milpitas, CA. TRICAD marketed DEC VAX-based CAD systems primarily to the AEC market.
- In July 1985, Auto-trol introduced the Advanced Personal Workstation/15 (APW/15), an IBM PC/AT-based graphics system that provides full function capabilities for design, analysis, documentation, drafting, illustration, and support for general engineering programs.



- In 1985, the company introduced a variety of new packages including an integrated solids modeling system, a progressive die design system, and a kinematics interface package.
- Additional important new products that were introduced in 1985 include new releases of both their Series 5000 and 7000 software with greatly increased functionality and speed, and a host of industry-specific applications and communications supporting an array of protocols and system configurations.
- In fiscal 1985 the company experienced an operating loss and a decline in revenues.

### C. COMPUTERVISION

#### 1. PRODUCTS/SERVICES

- Turnkey systems and professional services. The company has developed several integrated lines of CAD/CAM systems marketed under the names CADDStation, CDS 3000, CDS 5000, Designer, Medusa, and Personal Systems. The CDS 4000 and Designer systems represent the largest portion of the company's installed customer base.

#### 2. MARKETS SERVED

- CAD/CAM for mechanical design and drafting, electronic design, architecture, design and engineering, and computer-integrated manufacturing. Their mainstay product is based on their proprietary CDS 4000 minicomputer. The computer runs a library of 400 software programs for design, test, and manufacture.



- The company has focused its marketing efforts on the following industry groups: automotive, aerospace, architectural, engineering and construction, electronics, and mechanical machinery.

### 3. COMPANY STRATEGY

- The company is now pioneering the development of product process automation which entails the integration and management of many product data bases to make possible their reutilization throughout the product development cycle.

### 4. RECENT ACTIVITIES

- During 1985, Computervision was in the process of moving from host-based systems to intelligent standalone networked workstations that will function in an increasingly open architecture. As a consequence of this wrenching transition in its product family, they have experienced a decline in revenues, a deterioration of their cash position, and a restructuring of the organization.
- In 1985, Computervision introduced a network designed to allow workstations to link up with their minicomputer systems.

### 5. FUTURE DIRECTION

- The company is in the middle of a three-year product transition period in which it is porting its software from proprietary systems to industry standard platforms. Computervision, once the leader in CAD/CAM, has fallen into third place behind IBM and Intergraph. The company was slow to move its large software library from minicomputers to workstations.



## D. CONTROL DATA CORPORATION

### 1. PRODUCTS/SERVICES

- Turnkey systems and remote computing services. They offer extensive CAD/CAM offerings and other engineering and specific applications.

### 2. MARKETS SERVED

- The Computer-Integrated Manufacturing division provides CAD/CAM/CAE solutions. The Scientific Information Services division, which combines the former CYBERNET and United Information Services divisions, offers remote computing services and software products for engineering and scientific applications. Applications are targeted to the electrical utility, electronic engineering, mechanical engineering, and government markets.

### 3. COMPANY STRATEGY

- They focus on integrated computer-aided engineering and manufacturing (ICEM). Through turnkey systems based on their Cyber mainframes, they target higher end users. They plan to offer integrated solutions since they view their integration capabilities as their strength.
- The recognition by the market of the importance of data management is a trend that Control Data is well positioned to capitalize on because of their traditional strength in data management.

### 4. RECENT ACTIVITIES

- They recently introduced CYBERNET Express, a line of seven software packages for IBM personal computers. The applications available include schematic design and analysis, finite element modeling, piping (for analysis



and design of piping systems and supports), and power systems (for design and analysis of commercial and industrial electrical distribution systems).

- They have just introduced a configuration management package that tracks the parts involved in the engineering process from design to manufacturing. Their system is unique in that it interacts directly with their CAD/CAM system.

#### 5. FUTURE DIRECTION

- They are moving from engineering applications into combining engineering and manufacturing for an integrated manufacturing approach.
- They have a strong commitment to this market. They are devoting senior management attention and considerable resources to this market.

### E. DAISY SYSTEMS

#### 1. PRODUCTS/SERVICES

- Turnkey systems.

#### 2. MARKETS SERVED

- Computer-aided engineering products for the electronics engineering process for design entry, verification, test development, and physical layout functions at the chip and system level.



### 3. RECENT ACTIVITIES

- During the second half of 1985, they introduced three significant new products: a PC/AT product, a workstation accelerator known as the Compute Engine, and a software package that facilitates the design of printed circuit boards. Daisy's most significant activities in 1985 were aimed at positioning the company to meet the market's growing demands for a complete CAE environment. Increasingly, the market has sought a building-block approach to the environment issue, offering customers the ability to tailor a CAE environment from a variety of fundamental elements.

### 4. FUTURE DIRECTION

- The key strategic issue facing Daisy continues to be the transition in products to general purpose computing platforms. The superb gross margins that Daisy has been able to command (75% on average) will decline as personal computer-based systems account for an increasing proportion of Daisy's revenue. Daisy has traditionally received its best gross margins at the high end where its CAE workstations are based on proprietary hardware.
- They have announced plans to begin offering software products on DEC VAX and IBM mainframe computers.

## F. IBM

### I. PRODUCTS/SERVICES

- Software products sold in combination with computer systems but not as fully integrated turnkey systems.



## 2. MARKETS SERVED

- The high-performance CADAM drafting systems and CATIA solid modeling systems have continued to gain market acceptance.

## 3. COMPANY STRATEGY

- IBM has the advantage that customers want to deal with a stable supplier and IBM is the company they turn to for stability. IBM has focused on factory automation as a key growth area and will focus on the integration of CAD and CAM.
- The company's strategy involves offering a range of workstations such as the PC/AT and the recently announced RT PC in an effort to capture the engineering data base developed by technical professionals. This is part of an overall strategy of linking workstations with host processors and linking engineering data bases with corporate data management, primarily through the DB2 data base management system.

## 4. RECENT ACTIVITIES

- They have continued to build their CAD/CAM/CAE product line with a steady stream of new products.

## 5. FUTURE DIRECTION

- They have become the leading vendor of computer systems worldwide for CAD/CAM.



## G. INTERGRAPH

### 1. PRODUCTS/SERVICES

- Turnkey systems and professional services.

### 2. MARKETS SERVED

- CAD/CAM systems with an emphasis on graphics systems. They offer DEC-based systems that support the creation, analysis, display, and maintenance of designs, drawings, maps, or other graphic representations. Historically, the company has derived the majority of its revenues from systems for land use and resource management, process and power design, energy exploration, and architectural and engineering design. In recent years, the company has developed systems addressing mechanical design and manufacturing, and electronics publishing.
- Their revenue was derived from companies in the discrete and process manufacturing, petrochemical, geophysical, utilities, architectural, and engineering industry sectors as well as state transportation and federal government agencies.

### 3. COMPANY STRATEGY

- Their corporate strategy is to provide an integrated, multi-discipline solution to their customer's graphics problems. In addition, they want to provide systems that coexist productively with other functions and processes in their customer's organizations through support of industry standards.



#### 4. RECENT ACTIVITIES

- Intergraph recently purchased Circuit Tools, Inc., a San Ramon, CA company that designed CSpice, a circuit simulation program and recently introduced a system based on the DEC MicroVAX II. They introduced new products for structural engineering, electronic publishing, and electrical wiring design. They also introduced a CAE system.

#### 5. FUTURE DIRECTION

- They are driving the concept of the distributed processing environment for design applications very aggressively in 1986, with a series of computing system and applications announcements planned through the course of the year.

### H. MACNEAL SCHWENDLER CORPORATION

#### 1. PRODUCTS/SERVICES

- They derive 100% of their revenues from leasing MSC/NASTRAN and related software products. MSC/NASTRAN is a descendant of NASTRAN, first released in 1970, a computer program owned by the U.S. government and leased to the public. At the beginning of 1985, MSC/NASTRAN was installed at approximately 25 service bureaus worldwide. Among the service bureaus offering MSC/NASTRAN are Cybernet (Control Data Corporation), Boeing Computer Services, McDonnell Douglas, and A.O. Smith.

#### 2. MARKET SERVED

- MSC/NASTRAN is used as a basic computer engineering tool to analyze structures and determine strength, safety, and performance characteristics.



- The aerospace industry accounted for a significant amount of MSC's revenue. Other markets they serve include the automotive, shipbuilding, industrial and office equipment, nuclear, petrochemical, and architectural and engineering sectors.

### 3. COMPANY STRATEGY

- The company leases rather than sells its software which ensures a continuing revenue stream.

### 4. RECENT ACTIVITIES

- In May 1985, an upgrade called MSC/pal2 was released. MSC/pal2 is a three-dimensional finite element software package for the IBM PC.

### 5. FUTURE DIRECTION

- MSC believes that microcomputers represent a new market for MSC/NASTRAN. In conjunction with MSC/pal, microcomputers will make available finite element modeling to small- and medium-sized companies with little or no prior experience in finite element technology.

## I. MENTOR GRAPHICS

### I. PRODUCTS/SERVICES

- Turnkey systems and software products.



## 2. MARKETS SERVED

- They offer CAE systems based on their IDEA Series of engineering workstations which are designed to help engineers capture, analyze, verify, layout, test, and document complex logic and circuit designs.
- The company's products are marketed primarily to the aerospace, semiconductor, computer, telecommunications, and consumer electronics industries.

## 3. COMPANY STRATEGY

- Their strategy has been to focus on companies with large concentrations of engineers. They focus on "key accounts," figuring that 80% of electronics engineers work for the 150 largest companies.

## 4. RECENT ACTIVITIES

- They have started to sell unbundled CAE software for the PC. In 1985, the company introduced a record number of new products, including the Hardware Modeling Library, the Compute Engine Accelerator, the Board Station workstation for printed circuit board design and layout, the Entry Station product for schematic entry using the IBM PC XT/AT, and QuickParts modeling techniques.

## J. TEKTRONIX

### I. PRODUCTS/SERVICES

- Turnkey systems and software products. Techtronix entered the CAE market in late 1984 and achieved approximately \$20 million in revenue in 1985.



## 2. MARKETS SERVED

- Tektronix has products based on each major CAE hardware platform: Apollo Computer Inc.'s Domain Systems, IBM's PC/AT, and Digital Equipment Corporation's MicroVAX line.

## 3. COMPANY STRATEGY

- Tektronix is attempting an ambitious plan to become the number one vendor in the CAE market, however, the company has run into a number of obstacles and has fallen short of its goals. They are trying to take advantage of their expertise in test and measurement and are emphasizing the link between design and test.

## 4. RECENT ACTIVITIES

- In March, the company acquired CAE Systems, Sunnyvale, CA, for \$75 million. CAE Systems did about \$13 million in 1985. CAE Systems has had a number of difficulties in its first year as a Tektronix operation, particularly with product delays and bugs. In August, Tektronix dropped its multimillion-dollar effort to build proprietary engineering workstations in favor of going with industry-standard workstations.

## 5. FUTURE DIRECTION

- Tektronix will continue to take advantage of its four-decade-old experience in the test equipment world. The major challenge they face is tying together its more than 2,000 instrument-type products into the CAE world. These instrument products include logic analyzers, microprocessor development systems, and semiconductor test systems.



## K. VALID LOGIC

### 1. PRODUCTS/SERVICES

- Turnkey systems which are integrated into the Valid Integrated Engineering System under the Unix operating system and the Ethernet local area network.

### 2. MARKETS SERVED

- CAE and CAD. Valid's CAE and CAD products can be used in designing both electronic systems and integrated circuits and include design tools for schematic capture, design verification, test development, and physical layout.

### 3. COMPANY STRATEGY

- They have focused on extensions to their product strategy in two key respects:
  - Positioning design tools on general purpose computing environments, most immediately the IBM PC/AT and the DEC MicroVAX II systems.
  - The other key thrust at the company continues to be extensions to the Realchip/Realfast line of proprietary hardware used in augmenting design simulation.

### 4. RECENT ACTIVITIES

- They introduced a variety of new products in 1985, including: Analog Designer, providing CAE to analog engineers; the Motorola 32-bit 68020 CPU was added to their product line; and made some additions to their application specific hardware line.



5. FUTURE DIRECTION

- They intend to introduce printed circuit board design tools for the MicroVAX II and further extensions to the performance and capacity of the Realchip, Realmodel, and Realfast lines.
- They have been working to improve their sales effort. Their sales staff is roughly half the size of Mentor's or Daisy's.







## IV NEW OPPORTUNITIES

### A. CAD/CAM

- There are three major areas of opportunity in the CAD/CAM market: three-dimensional capabilities, integration, and solids modeling.
- Three-dimensional modeling and design represents a significant opportunity. These capabilities are needed in the mechanical, electrical, and chemical fields. Applications include: three-dimensional mechanical design, fluid and air flow, and modeling of molecules in three dimensions.
- The next major opportunity in the market is the emergence of genuine integration of CAD and CAM, and in linkages between CAE and computer-aided testing, developments that promise to compress the process of design, test, and manufacture.
- Integration is important because it streamlines the product development cycle. A circuit board, for example, evolves from a schematic design into a layout of physical parts and is then rendered as an assembly drawing and transferred to manufacturing. At the same time, the board's mechanical housing must be designed and fitted. With an integrated data base, this activity becomes a single flow of information since all of these functions share a common data base. Thus, engineers at each step can work from the same model, speeding the communica-



tion of design progress and automatically ensuring part accuracy and compatibility.

- Costly R&D efforts will be required to succeed in developing and bringing such products to market.
- Solid modeling software is an emerging application that is expected to dominate design applications by the end of the decade. In the past, the computing power needed for solid modeling was often prohibitive, but as hardware prices declined and processing power increased, this allowed the capabilities of solid modeling to be available to more engineers. Solid modeling software enables designers to describe the volume and mass of mechanical parts on the computer—a considerable improvement over the edges and corners provided by other kinds of CAD software.

#### B. CAE

- The opportunities in the CAE market revolve around price, improved data management, and performance.
  - A drawback to CAE systems is price. What is needed are systems in the \$10,000-20,000 price range with the same performance and functionality as the systems that average about \$50,000. This will bring the systems into a price range that many more engineers can afford. There appears to be a threshold at about \$20,000 where large companies begin to think of buying a workstation for every engineer. Currently, engineering workstations are typically shared by a number of engineers.
  - One of the problems associated with CAE systems is the lack of sophisticated data management. Most CAE systems only have limited



facilities for relating information files. Once a hierarchical DBMS can be integrated into a CAE workstation, the designer will be relieved of much routine work, with a key benefit being the ability to do modular design.

- Another need by chip designers is for faster circuit simulation.

### C. OTHER

- The following are emerging research areas that will need software packages:
  - Biochemistry.
  - Combined chemical and structural engineering.
  - Cryogenic and space related research.
  - Graphics for biology.
  - Hydrology.
  - Linkage between automated design and machine tool control.
  - On-line simulation of biological and chemical processes.
  - Parametric design for a family of products.
  - Process synthesis.
  - Strategic Defense Initiative ("Star Wars").
  - Rock stability.



- In addition, other applications that are needed include:
  - Drilling simulation for underground modeling.
  - Improved laboratory management systems.
- Demand for computerized design and simulation tools will increase in biological and genetic engineering as new technical advances increase the complexity of these fields.



## V CONCLUSIONS AND RECOMMENDATIONS

- Rapid technological advances will continue to characterize the CAD/CAM/CAE industry and competition will continue to be intense.
- Communications are key to creating a productive system whether a customer is trying to share data among its various types of workstations, pass data to a remote location, or tie into a corporate data base.
- The winners in the turnkey market will be those vendors that offer products in the form of an open architecture with independent workstations ranging in power and capability that can all be hooked up to a common data base.
- In the future, current capabilities offered on workstations will be available on PCs. The implications of this are lower prices, greater unit sales, and potentially declining revenues for some vendors. However, the offering of greater capabilities on lower priced systems will serve to overcome a threshold level in the market by opening up the market to new users and new applications.
- To address the needs of the environment, a company should offer a hierarchy of solutions. A vendor should provide an entire spectrum of solutions that all work with a consistent user interface.
- Offering an inexpensive two-dimensional product on a PC will provide the vendor with the opportunity to sell the customer a more expensive three-dimensional product when the customer outgrows two-dimensional.



- The cost of entry into the market for sophisticated engineering programs such as NASTRAN is substantial and will limit the introduction of new competitive products.
- The CAD/CAM market will eventually develop into a data base battle, giving IBM the advantage over other CAD/CAM vendors. This will occur when the CAD capabilities become a commodity and the data base consequently takes on greater importance.



## APPENDIX ES-A: FORECAST DATA BASE: ENGINEERING AND SCIENTIFIC SECTOR

- This appendix contains the following forecast information, as shown in Exhibit ES-A-1.
  - Market size by delivery mode for each year, 1985-1991.
  - Market growth rates for 1985-1986.
  - Average annual growth rate (AAGR) for each delivery mode for the five-year period 1986-1991.



## EXHIBIT ES-A-1

ENGINEERING AND SCIENTIFIC SECTOR  
CROSS-INDUSTRY  
USER EXPENDITURE FORECASTS, 1986-1991

DELIVERY MODE	(\$M) 1985	85-86 GROWTH	(\$M) 1986	(\$M) 1987	(\$M) 1988	(\$M) 1989	(\$M) 1990	(\$M) 1991	AAGR 86-91
PROCESSING SERVICES	250	5%	263	276	289	304	319	335	5%
APPLICATION SOFTWARE									
MAINFRAME/MINI	150	24%	186	231	286	355	440	545	24%
MICRO	32	31%	42	55	72	94	123	162	31%
TOTAL APPLICATION SOFTWARE	182	25%	228	286	358	449	563	707	25%
TURNKEY SYSTEMS	280	15%	322	370	426	490	563	648	15%
SECTOR TOTAL	712	14%	812	931	1073	1242	1445	1690	16%

IV-ES-46



## APPENDIX ES-B: FORECAST RECONCILIATION

- This appendix contains the following information:
  - Exhibit ES-B-1 which indicates the changes made in this year's forecast as compared to last year's.
  - An explanation of any changes that were made to the forecasts.
- INPUT has made a significant adjustment in the size of the market for processing services. To avoid double counting, the cross-industry engineering and scientific processing services sold to the discrete manufacturing industry have been largely subtracted out. It was deemed that those revenues had also been counted in discrete manufacturing industry specific processing services. There is considerable overlap between the two sectors and it now is apparent that many applications that were previously classified as cross-industry engineering and scientific are specific to discrete manufacturing.
- INPUT has reduced the forecasted growth rate of the processing services market from 18% to 5%. The engineering community is increasingly bringing their computing work in-house. The increased performance and decreased cost of all computers, but primarily workstations and personal computers, has encouraged the acquisition and use of in-house computers. This process has dramatically cut into the use of outside processing services by engineers.



## EXHIBIT ES-B-1

**ENGINEERING SECTOR - DATA BASE RECONCILIATION  
OF MARKET FORECAST BY DELIVERY MODE**

DELIVERY MODE	1985 MARKET			1991 MARKET			85-90	86-91
	1985	1986	VARIANCE	1985	1986	VARIANCE	ANGR	ANGR
	FORECAST	REPORT	AS % OF	FORECAST	FORECAST	AS % OF	FORECAST	FORECAST
	(\$M)	(\$M)	'86 RPT	(\$M)	(\$M)	'86 FCST	IN '85 (%)	IN '86 (%)
PROCESSING SERVICES	915	250	266%	2490	335	643%	18%	5%
APPLICATION SOFTWARE								
MAINFRAME/MINI	150	150	0%	541	545	-1%	24%	24%
MICRO	32	32	0%	164	162	1%	31%	31%
TOTAL APPLICATION SOFTWARE	182	182	0%	705	707	0%	25%	25%
TURNKEY SYSTEMS	280	280	0%	767	648	18%	18%	15%
CROSS=INDUSTRY SEGMENT TOTAL	1377	712	93%	3962	1690	134%	19%	16%

