MECHANICAL ENGINEERING/33

CAD/CAM SYSTEMS

JUSTIFICATION
IMPLEMENTATION
PRODUCTIVITY MEASUREMENT

EDWARD J. PRESTON
GEORGE W. CRAWFORD
MARK E. COTICCHIA

CAD/CAM SYSTEMS
Justification, Implementation, Productivity Measurement

Edward J. Preston
Computervision Corporation
Edison, New Jersey

George W. Crawford
Mark E. Coticchia
Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

MARCEL DEKKER, INC   New York and Basel

Library of Congress Cataloging in Publication Data

Preston, Edward J., [date]
CAD/CAM systems. Justification, implementation,
productivity measurement

(Mechanical engineering ; 33)
Includes index.
1. CAD/CAM systems. I. Crawford, George W.
II. Coticchia, Mark E. III. Title. IV. CAD/CAM
systems. V. Series
TS155.6.P74 1984 670.42'7 84-17049
ISBN 0-8247-7257-1

MARCEL DEKKER, INC.
270 Madison Avenue, New York, New York 10016

Current printing (last digit)
10 9 8 7 6 5 4 3 2 1

PRINTED IN THE UNITED STATES OF AMERICA

The authors wish to thank their families and their companies for the support they gave throughout this project

Preface

In this age of technological explosion, we hear the term *breakthrough* so often that it has almost become meaningless. Yet, now and then, there is a development that one can truly label a breakthrough, for example, computer-aided design/computer-aided manufacturing (CAD/CAM). The Center for Productivity of the National Science Foundation said of this fast-emerging technology: "CAD/CAM has more potential to radically increase productivity than any development since electricity."

CAD/CAM allows one to perform many highly technical tasks essential to science and industry—and perform them far faster, more easily, more accurately, and more economically than by traditional methods. A computer-aided design and manufacturing system is one capital expenditure that could allow your business or organization to fully recover initial costs in less than a year—out of savings alone.

CAD/CAM systems speed many tedious steps in the normal concept-to-production cycle. For example, in engineering, construction, and manufacturing, up to 80% of all drawings are spin-offs from earlier designs. Imagine the potential time-savings with a system that provides almost instant access to original design and quick accurate editing or manipulation of that old design to produce a new one.

If there is one word that sums up the significance of CAD/CAM, it is *productivity*, a prime concern of both industries and nations. They all want to make use of their resources to offset the spiraling cost of materials and skilled personnel. With experienced designers and draftsmen at a premium, CAD/CAM offers a unique way to increase the productivity of this scarce and valuable resource.

Companies in every field of industry, from electronics to automobiles, from mapping to plant design, are using CAD/CAM to increase design and drafting throughput and trim product development time and costs. As you will see, the impact on the bottom line can be quite dramatic.

Yet, amazingly, a start-to-finish evaluation and selection of a CAD/CAM system can take up to 9 months to complete, even though the associated costs for companies in this mode can be staggering. This seemingly lengthy process can be attributed to two major issues. The first is the very competitiveness of the industry itself. New CAD/CAM companies, each with their own set of buzz words and acronyms to dazzle the prospect with, announce start-up almost monthly. It is often said that buying a system is a lot more difficult than selling one. The second can be identified as the customer "waiting for the better mousetrap to be built." (A very dangerous attitude, more on this in Chapters 1–6.)

No less than 15 areas of major concern must be satisfied before a suitable and palatable decision can be reached regarding vendor selection.

Price of system
Performance (software capability)
"Report cards" from surrounding users
Annual research and development expenditures
Regular new product announcements
A justifiable expenditure
Market share of vendor (sliding/gaining/static)
Proximity of postsale support
Evidence of system obsolesence
Turnkey versus third-party issues
Two- versus three-dimensional considerations
Benchmarking (Do I need to do this?)
Vendor's commitment to CAD/CAM only
System integration with other existing computers (communications)
Ease of implementation for engineering and manufacturing

This volume will address three of the most important above-mentioned areas.

This book is unique in that all efforts to date have focused on a single discipline and the ways in which a given software package would impact it (e.g., how the hardware and software of a given vendor have affected the overall printed circuit board design and drafting process). The handicap that besets the authors with this applications approach is that one must take a snapshot of current software capabilities while relating productivity gains that may be derived. Given that the CAD/CAM industry is truly software-driven and can change literally on a day-to-day basis, the information from an applications approach would be dated before a book could be published. So, specific feature/function/benefit studies will not be dealt with in any detail, but rather only in a cursory sense to make a statement clearer. We feel it is more useful to relate thoughts on broader-based topic areas, and in so doing, this book should attract three separate readership levels:

The *justification* process will be aimed at the company president who is concerned with return on investment and related subjects.

The *implementation* section will assist the CAD/CAM selection committee members with ideas on successful start-up procedures.

The *productivity measurement* portion will be targeted for potential users as well as existing CAD/CAM users and will be on ways to evaluate system productivity from a design/drafting standpoint.

Edward J. Preston

George W. Crawford

Mark E. Coticchia

CAD/CAM SYSTEMS

MECHANICAL ENGINEERING

A Series of Textbooks and Reference Books

1. Spring Designer's Handbook, *by Harold Carlson*
2. Computer-Aided Graphics and Design, *by Daniel L. Ryan*
3. Lubrication Fundamentals, *by J. George Wills*
4. Solar Engineering for Domestic Buildings, *by William A. Himmelman*
5. Applied Engineering Mechanics: Statics and Dynamics, *by G. Boothroyd and C. Poli*
6. Centrifugal Pump Clinic, *by Igor J. Karassik*
7. Computer-Aided Kinetics for Machine Design, *by Daniel L. Ryan*
8. Plastics Products Design Handbook, Part A: Materials and Components; Part B: Processes and Design for Processes, *edited by Edward Miller*
9. Turbomachinery: Basic Theory and Applications, *by Earl Logan, Jr.*
10. Vibrations of Shells and Plates, *by Werner Soedel*
11. Flat and Corrugated Diaphragm Design Handbook, *by Mario Di Giovanni*
12. Practical Stress Analysis in Engineering Design, *by Alexander Blake*
13. An Introduction to the Design and Behavior of Bolted Joints, *by John H. Bickford*
14. Optimal Engineering Design: Principles and Applications, *by James N. Siddall*
15. Spring Manufacturing Handbook, *by Harold Carlson*

16. Industrial Noise Control: Fundamentals and Applications, *edited by Lewis H. Bell*
17. Gears and Their Vibration: A Basic Approach to Understanding Gear Noise, *by J. Derek Smith*
18. Chains for Power Transmission and Material Handling: Design and Applications Handbook, *by the American Chain Association*
19. Corrosion and Corrosion Protection Handbook, *edited by Philip A. Schweitzer*
20. Gear Drive Systems: Design and Application, *by Peter Lynwander*
21. Controlling In-Plant Airborne Contaminants: Systems Design and Calculations, *by John D. Constance*
22. CAD/CAM Systems Planning and Implementation, *by Charles S. Knox*
23. Probabilistic Engineering Design: Principles and Applications, *by James N. Siddall*
24. Traction Drives: Selection and Application, *by Frederick W. Heilich III and Eugene E. Shube*
25. Finite Element Methods: An Introduction, *by Ronald L. Huston and Chris E. Passerello*
26. Mechanical Fastening of Plastics: An Engineering Handbook, *by Brayton Lincoln, Kenneth J. Gomes, and James F. Braden*
27. Lubrication in Practice, Second Edition, *edited by W. S. Robertson*
28. Principles of Automated Drafting, *by Daniel L. Ryan*
29. Practical Seal Design, *edited by Leonard J. Martini*
30. Engineering Documentation for CAD/CAM Applications, *by Charles S. Knox*
31. Design Dimensioning with Computer Graphics Applications, *by Jerome C. Lange*
32. Mechanism Analysis: Simplified Graphical and Analytical Techniques, *by Lyndon O. Barton*
33. CAD/CAM Systems: Justification, Implementation, Productivity Measurement, *by Edward J. Preston, George W. Crawford, and Mark E. Coticchia*
34. Steam Plant Calculations Manual, *by V. Ganapathy*
35. Design Assurance for Engineers and Managers, *by John A. Burgess*

OTHER VOLUMES IN PREPARATION

Contents

JUSTIFICATION

1

Getting Started

Once it has been determined that an effort should take place to examine the computer-aided design/computer-aided manufacturing (CAD/CAM) industry for eventual system selection, the first logical step is the formation of the CAD/CAM select committee. It is essential that *all* interests of the company be kept in mind when committee members are chosen. To do this correctly, your present *and* future product cycle should be as well-defined as possible. If you do not have a well thought out cycle, ask yourself two questions: (1) What is it you do? (2) How are you currently doing it? Be cognizant of your business plan one year out, three years out, and so on. This can be vital in helping in eliminating from consideration the CAD/CAM vendors who do not have the total capability necessary to do the job you need to have done. Some examples are discussed below.

If you have decided among other things, to eliminate outside service bureaus currently doing your engineering analysis finite-element modelling (FEM),finite-element analysis (FEA) you would not want to consider a low-end system with only two-dimensional (2-D) capabilities. This would narrow the choice of suppliers substantially. If your product is made up of both mechanical and electrical components, it would be in your best interest to examine only those systems that are multiapplicational *and* associative. This would also whittle down the list of potential vendors, in that some are purely limited to only one engineering discipline. Getting back to the product cycle, an example of a true engineering and manufacturing organization which will benefit from both sides of the CAD/CAM acronym appears in Chapter 4 (Fig. 7). Steps A-F of the illustration encompass the CAD capability, G-K refer to the CAM capability. The committee, therefore, should have representation from all iteration areas. This is not to suggest that a representative from each and every area be on the committee. Rather, the committee should include a person who has all the engineering information and interests, someone who has all the manufacturing interests, and so on who can represent collective groups within departments. In summary, each member should be a person who is sensitive to the inner workings and problems of all the major work areas. Typically, CAD/CAM committees have these recurring positions involved:

1. Engineering representative
   Design
   Drafting
   Analysis (FEM, etc.)
   Checking
2. Manufacturing representative
   Tool and fixture design and drafting
   Numerically controlled (NC) tape preparation
   Robotics
   Prototypes
   NC operations
3. Management of information services
   Communications to existing mainframe systems
   Communications to other CAD/CAM systems
   Analysis considerations
   Data storage
   Bill of material (BOM) considerations
4. Technical publications/illustrations
   Creation of nondimensioned drawings that refer directly to engineering drawings (very often a duplication of effort)
5. Facilities planning
   Group chartered with graphically illustrating growth/contraction within the company itself
6. Head of CAD/CAM committee
   Person chartered to disseminate all collected materials

A method often used to assist the committee for decision making is the vendor factor comparison chart. Because there are so many systems of comparable price with similarities in capability, prospects often benefit from a scheme that assesses these areas of importance and ultimately provides an overall numerical rating for each vendor. Let us take the list that was discussed in the preface, add upon it, and go through the exercise.

Vendor Factor Comparison

Category	Importance[a]	Vendor A Rating	Vendor A Point extension[b]	Vendor B Rating	Vendor B Point extension[b]
Delivery schedule	3	7	(21)	10	(30)
Vendor concern for us	9	6	(54)	4	(36)
Vendor support	9	10	(90)	4	(36)
Proximity of support	8	9	(72)	7	(56)
Future offering (R&D)	8	9	(72)	7	(56)
Lease commitment	6	10	(60)	6	(36)
Operating system	8	4	(32)	4	(32)
Data comm. to other devices	7	7	(49)	9	(63)
Data base associativity	10	6	(60)	4	(40)
Applications packages	7	10	(70)	5	(35)
Upward compatibility	10	7	(70)	6	(60)
Conversion risk	10	6	(60)	3	(30)
Dollars ($)	1	5	(5)	5	(5)
Data base admin. capability	6	10	(60)	4	(24)
System reliability	7	7	(49)	4	(28)
Environment requirements	2	6	(12)	3	(6)
Virtual machine	—	—	—	—	—
Obsolescence	5	7	(35)	4	(20)
Report cards from users	8	8	(64)	7	(56)
Justification assistance	6	10	(60)	2	(12)
Market share of vendor	8	5	(40)	3	(24)
Ease of use	7	9	(63)	8	(56)
Totals			(1039)		(727)

[a] Importance and rating factors were measured on a scale (1-10) low-1, high-10.
[b] Point extension = importance factor × rating factor. The evaluation team simply has to fill in the blanks and add the scores.