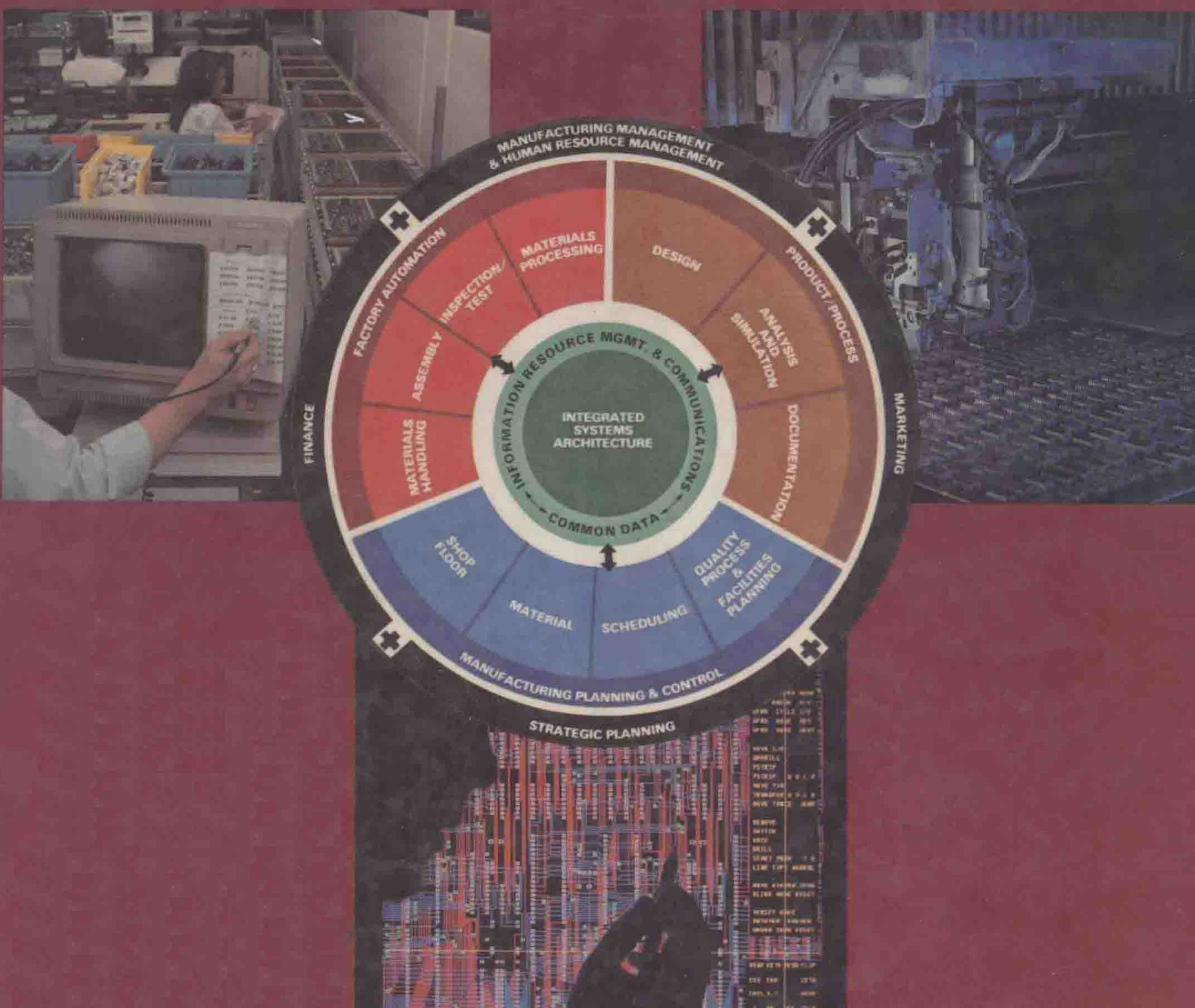
FUNDAMENTALS OF CIM TECHNOLOGY



DAVID L. GOETSCH

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AUTOMATION IN DESIGN, DRAFTING, AND MANUFACTURING

DELMAR PUBLISHERS INC.®

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PREFACE

FUNDAMENTALS OF CIM TECHNOLOGY was written in response to the need for an easy-to-understand but comprehensive, up-to-date text on automation in design, drafting, and manufacturing. There are several books available for fourth-year engineering and graduate students. However, there is little available to meet the specific needs of students in postsecondary vocational schools, community colleges, and technical schools; nor is there a book which meets the special needs of the Baccalaureate student in technology.

WHO IS THIS BOOK FOR?

FUNDAMENTALS OF CIM TECHNOLOGY can be a useful text for a variety of categories of postsecondary students, including:

- Manufacturing technology students
- Industrial technology students
- Engineering technology students
- Drafting and design students
- Machinist students
- Technology education students
- Industrial arts education students
- Vocational teacher education students

Practitioners in design, drafting, and manufacturing who need technical updating in the areas of CAD, CAM, and CIM may also find this book useful.

SPECIAL FEATURES OF THE BOOK

FUNDAMENTALS OF CIM TECHNOLOGY has several special features that enhance its usefulness as a learning aid. The most important of these are:

1. The book is written in simple language making the technical concepts dealt with easier to understand.
2. Several chapters begin with "real-life" vignettes.
3. The book is heavily illustrated with a broad range of drawings and photographs which complement the text.
4. The applicable levels of math are covered in appropriate chapters.
5. Each chapter contains a summary, review questions, and problems.
6. The book contains a comprehensive glossary of CAD/CAM/CIM terms for reference.
7. The book contains a comprehensive index for easy access to specific material.

FUNDAMENTALS OF CIM TECHNOLOGY begins with an introduction that puts the many buzzwords associated with these concepts into perspective. Chapter 1 gives an in-depth explanation of the computer. This is important because the computer is at the heart of all CAD/CAM/CIM developments. Chapter 2 explains how the computer is actually used in CAD/CAM/CIM settings and what types of computers are used.

Chapters 3 through 7 are the technical chapters. Each is a mini-book covering a major CAD/CAM/CIM concept such as CADD, CNC, Robotics, group technology, and CIM/FMS. Chapter 8 is an in-depth treatment of CAD/CAM/CIM, management. This is an important chapter because many of the CAD/CAM/CIM students of today will be the CAD/CAM/CIM managers of tomorrow. Chapter 9 covers several other CAD/CAM/CIM concepts that are important, but less known than those presented in Chapters 3 through 7. Chapter 10 is a look at the future of CAD/CAM/CIM.

FUNDAMENTALS OF CIM TECHNOLOGY was purposely designed to have both broad appeal and usefulness. I hope this book meets the needs of a broad and varied audience in a language that is easy to understand.

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INTRODUCTION

Manufacturing firms in this country and abroad are working toward the implementation of computer integrated manufacturing (CIM) in an effort to be competitive in the national and world markets now and in the future. Many have already automated some of their traditional manufacturing functions and processes by implementing computer-aided design and drafting (CADD), computer numerical control (CNC), robotics, and group technology. The next step is to integrate these and the various other processes used to convert raw materials into finished products. The result will be computer integrated manufacturing.

In order to understand CIM, one must examine the entire spectrum of development in manufacturing to see where it fits in with what has preceded it and what will come after it. Manufacturing has evolved over the years through several distinct phases. Each of these phases falls along a continuum. At one end of the continuum are man's earliest attempts at manufacturing. At the other end, one finds the completely automated manufacturing plant. In between lie the various stages of development which have occurred and will continue to occur until the goal of the automated factory is realized at some point in the future.

The earliest stage in the development of manufacturing can be called the MANUAL PHASE. In this phase, people used their hands and simple, crude implements to produce the products they needed to live. These products were such things as tools, weapons, furniture, and so on. In spite of the crudeness which characterized early manufacturing, there was one important advantage that was lost in the later stages of development and is only now, after hundreds of years, beginning to resurface. That advantage is called INTEGRATION.

The earliest manufacturing processes were completely integrated because one person did it all. An early craftsman designed a product in his mind and performed all of the processes required to produce it. Because the craftsman's mind and hands were connected, there was continuous and immediate feedback as he moved through the various processes in the making of the product. Because they were controlled by his mind, his hands would produce the product he saw in his mind. Such control, coordination, and continuous feedback are known as integration. Not since the days of the early craftsman has there been total integration.

The next stage in the development of manufacturing can be called the MECHANIZATION PHASE. It was brought about by the industrial revolution. In this phase, manufacturing tools and processes became mechanized and specialization became the norm. All of the various manufacturing processes were divided into categories such as casting, forging, turning, milling, drilling, and cutting; manufacturing workers became specialists in one of these areas.

Specialization resulted in the elimination of integration and the separation of design from manufacturing. It also created the need for drafting, since one person would now design a product and several other specialists would manufacture it. Drawings became the vehicle for communication between design and manufacturing. Specialization also created a need for quality control, since each specialist saw only his small part of the overall production process and performed only his specialized task.

The mechanization phase had the advantage of being able to accomplish mass production, to produce interchangeable parts, and to produce many more products faster. However, it lacked the old advantage of integration.

The current phase in the development of manufacturing is called the AUTOMATION PHASE. There have been several important milestones in this stage. In 1975, mass production was automated through the use of transfer lines. In 1976, batch production was automated through the use of flexible manufacturing systems (FMS). In 1979, wide-scale automation of design and drafting through CADD began. In 1985, the beginnings of integration or CIM began to appear. The goal of this phase is to have a completely automated manufacturing plant that operates with only a minimum of human involvement. Progress is being made in this regard, but the realization of this dream is still somewhere in the future. The wholly automated factory will combine the advantages of both the manual and mechanization phases. It will be capable of mass production, and it will be fast. It will also be completely integrated.

The most important development with regard to automation in manufacturing has been the computer. This device, coupled with other technological developments in machines and in materials handling, will eventually become the catalyst in bringing about the completely automated factory. Progress toward CIM has added a number of new terms to the language of manfacturing. For many people, these buzzwords are confusing and difficult to put into an understandable frame of reference. Doing so is necessary if one is to understand CIM.

THE BUZZWORDS AND WHAT THEY MEAN

CAD/CAM has become a frequently used buzzword in the world of design and manufacturing. So have several others including CADD, CNC, FMS, Robotics, and CIM. Before undertaking an in-depth study of CIM, one should sort these terms out and understand what they mean and how they relate to one another. (Additional buzzwords include AMH, MP & CS, CAE, APP, APPS, MRP, AI, ASR, and CAPP. These and many others have been listed in the glossary.)

What is CAD/CAM?

CAD/CAM is a broad term under which all of the other terms fall. CAD, by itself, means *computer-aided design*. Computer-aided design is a concept which encompasses any use of the computer to enhance or aid in the design process. Computers have several features that make them valuable aids to designers. These include calculation, analysis, review, modeling, and testing capabilities.

CAM, by itself, means *computer-aided manufacturing*. Computer-aided manufacturing is a concept which encompasses any use of the computer to enhance or aid in any manufacturing process. The two best-known uses of the computer to aid in manufacturing are CNC (computer numerical control) and Robotics. Almost any type of machine used in manufacturing—lathes, mills, drills, saws, punches, shears, and so on—can be computer controlled. Industrial robots are also computer controlled.

In addition to the CAM concepts of CNC and Robotics, there are other less known CAM concepts. These include computer-aided production scheduling, computer-aided quality control, computer-aided purchasing, and computer-aided sales. All of these concepts are dealt with in this book.

Using the terms CAD and CAM together (CAD/CAM) is an attempt to show the close relationship of these concepts in a manufacturing setting. It also symbolizes a goal of the automation phase of development. That goal is the elimination of the wall between design and manufacturing that was put up by specialization during the mechanization phase. When true CAD/CAM exists, there will be instant and continuous communication between design and manufacturing systems. Such communication will be electronic rather than through hard copy such as drawings.

Such communication will be accomplished over NETWORKS. Networks are the communication channels which connect design systems to other design systems, manufacturing systems to other manufacturing systems, design systems to manufacturing systems, and design/manufacturing systems to systems in other components such as sales, purchasing, shipping and receiving, contracts and bids, estimating, and accounting.

At this point in the development of automation phase, networks are the weak link in CAD/CAM. Incompatibility between CAD and CAM systems prevents the continuous communication that is necessary for the complete and instant sharing of the same database between design and manufacturing. When these problems are overcome, we will have CIM.

What is CADD?

On occasion one will see the term CADD used. This means *computer-aided design and drafting*. It is a term that evolved partially in an attempt to solve the problem of whether CAD means computer-aided design or computer-aided drafting. It also resulted from the evolution of CAD systems from the earlier models, which were strictly for enhancing the design process, to today's models, which produce design documentation in addition to aiding designers in calculations, modeling, analysis, testing, and so on.

What is CNC?

CNC means *computer numerical control*. It is one of the better-known forms of CAM. Numerical control is a concept in which machines are controlled by programs that are interpreted by a reader rather than manually, as they were during the mechanization phase. Computer numerical control (CNC) is an advanced form of numerical control in which programs may be written on and stored in a computer.

What is Robotics?

An industrial robot is a computer-controlled electromechanical device used to perform certain manufacturing tasks traditionally performed by humans. Robotics is probably the best-known form of CAM because of its controversial nature and its long-standing starring role in science fiction.

What is CIM?

CIM means *computer integrated manufacturing.* This concept represents the ultimate in manufacturing automation. CIM systems will be the key components in the wholly automated factories of the future. In fact, at some point in time, the term CIM will replace the term CAD/CAM. True CIM is the total integration of the various individual CAD/CAM concepts of CAD, CNC, Robotics, computer-aided process planning, computer-aided quality control, and materials handling. With CIM fully developed, the manufacturing continuum mentioned earlier will have gone full circle back to the total integration which existed in the days of the early craftsman.

In a fully developed CIM system, CAD systems will be networked with computer-controlled manufacturing systems which might include CNC machines, robots, and a materials-handling component. All components of the system will share the same database and have instant access to it. There will be immediate and continuous feedback at every stage of operation.

CIM is in its infancy at present. As you will see later in this book, there are CIM systems currently in place and operating. However, many are limited systems that have integrated only some of the manufacturing processes necessary to produce certain products. The total integration of all processes, from design to production to quality control to shipping of the product, is a goal that is yet to be realized.

FMS means *flexible manufacturing system* and is a term sometimes used synonymously with CIM. In reality, a flexible manufacturing system is one type of CIM system. The others are *transfer lines* and *work cells.* As you will see later in this book, transfer lines rate high in productivity and low in flexibility. Flexible manufacturing systems have medium productivity and medium flexibility ratings. Work cells have low productivity and high flexibility ratings.

Chapter One
Computer Technology

The computer is the technological development that is at the heart of computer integrated manufacturing. In order to understand CIM, one must understand computers. This chapter will help students develop an understanding of computers that will, in turn, serve as the foundation upon which to build an understanding of CIM.

The functional term in the phrase "Computer-Aided Design, Drafting, and Manufacturing" is *Computer*. The computer is the technological development that has enabled the corresponding development of computer-aided design, drafting, and manufacturing, or CAD/CAM. In order to understand CAD/CAM, one must first understand computers.

This chapter presents a comprehensive overview of computer technology. It contains the information design, drafting, and manufacturing personnel need to know in order to be computer literate.

Major Topics Covered

- A Definition of Computers
- Historical Development of Computers
- Computer Hardware
- Computer Memory
- Data Representation
- Computer Software
- Computer Firmware or Microcode
- Computer Operation

case study

One of the hot topics in manufacturing today is Computer Inte grated Manufacturing (CIM). CIM, like other currently popular topic such as MRP, FMS, and JIT, means different things to different people Some people believe that CIM is akin to science fiction and is far off in th future. Others view it as an instant fix to all manufacturing problems.

This paper will describe the work done at Cone Drive during th last five years implementing a computer system to improve our com petitive position, free up working capital through inventory reduction, an improve our overall productivity.

Background

When we started this program five years ago, we had never hea of the term CIM. What we had was a series of business problems that w had to overcome in order to stay in business. The problems were the san that face many companies: too much inventory, part shortages in assemb machine bottlenecks, missed customer delivery promises, inaccurate bil of material, and a constant barrage of Rush, Hot, Critical, and Urg orders on the shop floor. In addition, like many of you, our mark department was saying that we had to shorten our lead times, and ou porate people were saying that we needed to reduce inventories, "or To solve these problems we assembled the top management of our com They determined that the best and perhaps only long-term solution to current and future problems was to increase our use of computers.

Our business and our company had a major influence on o implementation methodology, although we are not at all unique. Co Drive is a part of Ex-Cell-O Corporation, a billion-dollar corporation wh primarily serves the capital goods markets. Decision-making is essentia decentralized. However, capital budgets must be justified to and appro by corporate management.

Courtesy of SME Technical Paper #MS86-724 "Building Toward Computer Integrated Manufacturing" by Paul Brauninger and John Welch, 1986.

Building Toward Computer Integrated Manufacturing

Cone Drive markets, engineers, and manufactures double enveloping worm gearsets and speed reducers to a variety of both domestic and international customers. We sell both standard and special units, but only assemble a finished reducer after receipt of a customer order. We are basically a job shop employing about 350 people, with sales between 25 and 50 million dollars annually.

Implementation

Our plan for computerization had four basic criteria: acquire grams, purchase hardware and software from a single source, rain all employees thoroughly, and change our business practices to the oftware requirements whenever practical. In addition, we decided on a lan that required us to build a good foundation of data and reporting ystems before entering areas of new technology. Because of increased ustomer dissatisfaction with lead times and deliveries, we first started oking for a good Inventory/Production Control system.

As soon as we started looking into MRP systems, it became clear we needed a new integrated business system. This needed to cover all of our business in order to give us the maximum benefit. We selected ware package called MAPICS that ran on an IBM System 38 computer.

The MAPICS package included all of our business functions: P, routings, bills of material, job costing, inventory management, order ry, invoicing, accounts receivable, accounts payable, payroll, capacity anning, and shop floor data collection. We installed this package in uary 1982, after planning and training for eighteen months. This nning included the rental of an IBM System 38 computer to train ployees and test out the software. Because of the planning that had gone before—and, of course, a lot of luck—we were able to install all the dules at one time without serious disruption of the manufacturing floor

(continued)