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Abstract:

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Eckhard Heinold

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AN ANNOTATED BIBLIOGRAPHY OF BOOKS, PROCEEDINGS AND ARTICLES ON CONCURRENT ENGINEERING

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BY

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ENGINEERING MANAGEMENT PROGRAM

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1.0 Introduction

"Concurrent engineering is delivering better, cheaper and faster products to the market, by a lean way of working, using multi-diciplinary teams, right first time methods and parallel processing activities to continously consider all constraints."

Dr. Stephan Evans
Cranfield CIM Institute

The definitions of concurrent engineering or CE, which have been given, are all referring to the concepts of "Simultaneous Engineering" or "Parallel Engineering". They can be summarized shortly as: Design of a product and simultaneously design of the tools to produce it. Concurrent Engineering is a business philosophy whose three main objectives are to:[1]

- improve quality
- reduce costs
- reduce development lead times

Concurrent Engineering works toward the parallel proceeding of tasks and provides methods to enable different persons to solve problems under consideration of their specific point of views simultaneously. The term Engineering must not reduce these tasks to soleytechnical tasks, such as design and manufacturing. Other operational costs, from such functions as accounting, procurement, marketing and distribution have to be included as well. People from different disciplines must work together in a cooperative manner and understand each other. Moreover, an additional knowledge of social behavior has to be taken into account for the same objective. Concurrent Engineering is currently a leading concept in the process of product development and manufacturing. The principle issue of this concept is to avoid the situation in which effects of design decisions which follow the design process are not verified before real life cycle specific conditions are applied.[2]

Concurrent engineering (CE) involves simultaneously designing a product and defining the best way to produce, market and despose of the product through its entire life cycle. Justification for a CE program comes from reducing direct labor costs, cycle time, inventory, scrap and rework, warrenty, and engineering changes. To ensure success, companies need to:[3]

1. provide a formal mechanism for manufacturing to work with marketing and design from beginning of a product's development

2. design an employee participation program, which can boost morale and interpersonal communication throughout the company and thus create the environment necessary for CE to work

3. involve both shop and office workers in the cost reduction program

4. arrange workers properly

5. recruit engineering generalists who are able to influence others and tolerate and implant significant changes in their traditional job responsibility

6. train key employees in recognizing and solving problems and in improving interpersonal skills

7. exploit computer-aided design (CAD)

8. apply and exploit analytical tools and information networks

Concurrent Engineering (CE) approaches product design by forming a multi-disciplinary design team which may consist of experts from product design, control system design, electronics design, manufacturing, production planning, maintenance, quality control, service, and marketing, etc. Therefore, development of new products or modifications in existing products can simultaneously consider product functions, features, manufacturability, reliability, and inexpensively develop an initial design which is close to optimum. Because of its effectiveness and great potential in product design, concurrent engineering has received overwhelming interest from both industry and academia.[4]

To follow is an annotated bibliography of over 20 books, 8 proceedings, and 177 articles on or relating to Concurrent Engineering. This material was compiled and reviewed during the Winter Term, 1994 as an independent study project in the Engineering Management Program at Portland State University. Key sources were Infotrac, ProQuest and Portals among others.

2.0 ANNOTATED BIBLIOGRAPHY

2.1 BOOKS

CARTER, DONALD E., *CONCURRENT ENGINEERING: THE PRODUCT DEVELOPMENT ENVIRONMENT FOR THE 1990S*, ADDISON-WESLEY PUB., CO., READING, MASS., 1992

This book describes the concurrent engineering environment necessary for developing electronic, software, mechanical, and system products. Carter describes today's product development environment, the CE process and how it can be successful implemented and how it helps to create a successful product development. In the end, he tries to show a way to automate the concurrent engineering environment. This book tries to show managers and decision makers the basics of CE and a practical way to introduce and work with concurrent engineering.

CHAPMAN, WILIAM L.; BAHILL, TERRY A.; WYMORE, WAYNE A., *'ENGINEERING MODELING AND DESIGN'*, CRC PRESS, INC. BOCA RATON, FLORIDA, 1992

This book was designed to be a text for an upper-division course on Concurrent Engineering or Total Quality Management, or a capstone Senior Engineering Design course. However, its basic treatment of the key issues would also make it suitable as a supplemental text for a graduate course in Systems Engineering.

CLASSON, FRANK, *'SURFACE TECHNOLOGY FOR CONCURRENT ENGINEERING AND MANUFACTURING*, MCGRAW-HILL, NEW YORK, 1993

This book provides basic surface mount technology (SMT) design and manufacturing guidelines to equip concurrent engineering team members with the necessary basics and total overview to deal with the requirements driving company wide SMT activities. The book also gives management a quick overview of the scope and impact SMT can have on a company and how each division integrates with the whole. The focus of the book is on the integration of the multiple functions within the company: design manufacturing, quality, testing, procurement, material control, and management. It presents what every engineer should know about SMT and how to relate within the concurrent engineering environment.

DIMANESCU, DAN, *'THE SEAMLESS ENTERPRISE'*, HARPER COLLINS, INC., NEW YORK, 1991

Dan Dimancescu describes in his book 'The semaless enterprise', the general management problems of a manufacturing company, and possible ways to solve them. He discusses concurrent engineering, TQM and Design for Manufactruing (DFM).

GU, PEIHUA, *'CONCURRENT ENGINEERING: METHODOLOGY AND APPLICATIONS'*, ELSEVIER, AMSTERDAM, NEW YORK, 1993

This book collects the most updated research papers in concurrent engineering. It consists of thirteen chapters which are divided into two parts. Part I primarily focuses on methodology and applications of CE. Part II deals mainly with product design and information modeling.

HARTLEY, JOHN R., *'CONCURRENT ENGINEERING: SHORTENING LEAD TIMES, RAISING QUALITY, AND LOWERING COSTS'*, PRODUCTIVITY PRESS, CAMBRIDGE, MASS., 1992.

John Hartley provides in his book a balanced discussion of theory, implementation techniques and case studies from current practitioners of CE. He shows how the tools and methodologies - such as QFD, DFM, DFA, FMEA, 7QC Tools - become integrated and enabled in the CE environment. He also demonstrates the role of CAD and CIM in a concurrent engineering approach, underscoring the necessity to eliminate waste in the process before moving to computer integration. Hartley shows many examples of CE implementation in Japan, Europe, and the United States. he has studied the leading companies of the automobile manufacturers all over the world, and shows their experiences with CE. It really makes fun reading this book, and you can learn more about CE than from most of the other books, even if it is probably not the perfect handbook to implement CE.

HELANDER M.; NAGAMACHI M., *'DESIGN FOR MANUFACTURABILITY: A SYSTEMS APPROACH TO CONCURRENT ENGINEERING AND ERGONOMICS'*, TAYLOR & FRANCIS, LONDON, WASHINGTON D.C., 1992

This book contains 20 contributions of the 60 papers, delivered for the Conference on Human Factors in Design for Manufacturability and Process Planning in

Honolulu, Hawaii, August 1990. There are two main theses in this book: design of manufacturing processes and design of computer aids, such as systems for Computer Integrated Manufacturing (CIM). The book is devided into five parts. Part I discuss Computer Integrated Manufacturing: Advantages and Consequences for Human Factors Design. Part II deals with the Principles in Design for Manufacturability. Part III Analyses and Implementation of Design for Manufacturability Part IV Planning for Production and Design of Production Systems Part V The need for Field Studies and Cognitive Modeling

KUO, WAY, *'QUALITY THROUGH ENGINEERING DESIGN'*, ELSEVIER, NEW YORK, AMSTERDAM, 1993

This book focuses on quality-related engineering design. The application areas of particular interest are advanced materials formulation and processing as well as design and manufacture of electro-mechanical devises. It shows how to stay competitive in international markets with the help of concurrent engineering, computer-aided simulation, and physical experimentation.

KUSIAK, ANDREW, *'CONCURRENT ENGINEERING: AUTOMATION, TOOLS, AND TECHNIQUES'*, J. WILEY, NEW YORK, 1993

Andrew Kusiak presents in his book 21 articles of different authors, all dealing with the problem of life-cycle design and concurrent engineering. Life-cycle design of industrial products is a recent concept supporting development of a new generation of products. Life-cycle design means that all life-cycle phases of a product (i.e., development. production, distribution, usage, and disposal/recycling) are considered simultaneously from conceptual stage through the detailed stage.

MILLER, LANDON C. G., *'CONCURRENT ENGINEERING DESIGN'*, SOCIETY OF MANUFACTURING ENGINEERS, DEARBORN, MICHIGAN, 1993

This book introduces Concurrent Engineering Design to all parts of the organization. Concurrent Engineering Design crosses many traditional functional elements of a manufacturing organization. Because of its broad scope and impact, this book intended for a wide group of audiences. The book, as a whole, is directed at management. The first section introduces Concurrent Engineering Design. section II describes the business, technical and managerial processes within which

CE Design's activities occur. This section is important to engineering and production manufacturing management. Section III focuses on the Computing architecture necessary for CE Design and an overall implementation plan for CE Design.

NEVINS, JAMES L., *'CONCURRENT DESIGN OF PRODUCTS AND PROCESSES: A STRATEGY FOR THE NEXT GENERATION IN MANUFACTURING'*, MCGRAW-HILL, NEW YORK, 1989

Nevins focuses in his book on assembly as the crucial integrative activity, he describes a systematic and technically sound design process. All steps are treated, from single-part design to the design and financial justification of complete manufacturing systems. The author describes in detail the technical aspects of single-part assembly and then examine assembly as a process by which products are produced. the concepts of integrated design are extended to technical and economic models of workstations and systems. The process is illustrated with many examples and two detailed case studies. The author tries to make clear the importance of making vital early design decisions right the first time because their influence on the entire production process and product life cycle is made clear, as well as how to use the methods and analytical techniques to make decisions that are feasible and justifiable, technically and financially sound.

PARSAEI, HAMID R., *'CONCURRENT ENGINEERING: CONTEMPORARY ISSUES AND MODERN DESIGN TOOLS'*, CHAPMAN & HALL, NEW YORK, 1993

In the area of computer-integrated manufacturing (CIM), concurrent engineering (CE) has been recognized as the manufacturing philosophy for the 1990s . The mission of CE is to develop high quality products and bring them to the competitive global marketplace at a lower price and in significantly less time. However practicing the CE philosophy requires a large number of design tools during the design phase. This book explores a wide variety of CE topics, including popular tools for making CE a reality. This book is an attempt to address the central issues associated with concurrent engineering. this volume consists of twenty-five reviewed articles which are gramped into four parts. Part One deals with organizational issues in concurrent engineering and presents six chapters covering various aspects of management's challenge in implementing concurrent engineering. Part Two discuss proven tools and techniques of concurrent engineering. Part Three contains two chapters on the topic of designing for cost targets set in the marketplace. Current and future research directions of concurrent engineering that encompass artificial intelligence are considered in Part Four.

SHINA, SAMMY G., *'CONCURRENT ENGINEERING AND DESIGN FOR MANUFACTURE OF ELECTRONIC PRODUCTS'*, VAN NOSTRAND REINHOLD, NEW YORK, 1991

This book is intended to introduce and familiarize design, production, quality and process engineers, and their managers to the importance and recent developments in concurrent engineering (CE) and design for manufacture (DFM) of new products. The book introduce into the area of concurrent engineering and design for manufacturing in a practical and understandable way.

TURINO, JON, *'MANAGING CONCURRENT ENGINEERING: BUYING TIME TO MARKET'*, VAN NOSTRAND REINHOLD, NEW YORK, 1992

Jon Turino shows in his book 'Managing Concurrent Engineering' how to implement a concurrent engineering environment. The aim of his book is to educate managers and engineers alike in both the organizational and technical issues involved in successfully implementing concurrent engineering. It is a very easy-reading book and it makes really fun to work with it.

TWIGG, DAVID, *'MANAGING INTEGRATION IN CAD/CAM AND SIMULTANEOUS ENGINEERING: A WORKBOOK'*, CHAPMAN & HALL, LONDON, NEW YORK, 1992

This workbook presents a framework for reviewing how you may wish to change your organization in response to the capabilities of computer-aided design and manufacturing (CAD/CAM) systems, and the new approaches to managing the new product development process such as simultaneous engineering/concurrent engineering. A self-analysis approach to the change process is presented, which aims to promote an environment and focus within the company for continual review and appraisal; these are important elements of the framework, since implementation never creases. The workbook consists of four stages that provide a structure and procedure for considering the crucial issues and elements of implementation: 1. understanding the strategies involved; 2. auditing the current situation of CAD, CAD/CAM and the organization, and the potential for simultaneous engineering; 3. developing the organization and mechanisms for change; and 4. organizing for the analysis and establishing the infrastructure for the change process (people). Each step will be described, and will be supported by worksheets.

WILHELM, ROBERT G.; LU, STEPHAN C.-Y., *'COMPUTER METHODS FOR TOLERANCE DESIGN'*, WORLD SCIENTIFIC, SINGAPORE, 1992

Product development is a complex and multi-phase process requiring cross-disciplinary expertise from a team of engineers. To deliver products which simultaneously excel in high performance and quality with low costs and lead-time, specialized knowledge for design, analysis, and fabrication, must be synthesized, integrated, and applied across the whole spectrum of product life. This requirement leads to the concept of concurrent engineering which represents an improved product development methodology for shortening the time-to-market with highly competitive products. Realization of concurrent engineering requires new corporate culture, organizational structure, and technological support.

2.2 Proceedings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS ASME, *'DESIGN FOR MANUFACTURABILITY 1993: INTEGRATING MANUFACTURING AND DESIGN TO CREATE A CONCURRENT ENGINEERING ENVIRONMENT'*, PROCEEDINGS OF THE 1993 ASME NATIONAL DESIGN CONFERENCE, MARCH 9-10, 1993, CHICAGO, ILLINOIS

The papers of this volume were presented at the National Design Engineering Conference in Chicago, Illinois, March 9-10, 1993. The papers discuss the life cycle problem and design for manufacturing. They are devided into the following parts: 1. Emerging technologies in design-maufacture for concurrent engineering, 2. early cost estimating, 3. DFM applications through axiomatic design, and 4. industry applications of DFM. The papers describe a complete range of the subject, from design practices that can put to immediate use , to glimpses of the advanced research that will become part of the design environment of the future.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME), *'ENGINEERING DATA MANAGEMENT: KEY TO INTEGRATED PRODUCT DEVELOPMENT'*, PROCEEDINGS OF THE 1992 ASME INTERNATIONAL COMPUTERS IN ENGINEERING CONFERENCE AND EXPOSITION, AUGUST 2-6, SAN FRANCISCO, CALIFORNIA

This proceedings is a compilation of 18 papers presented at the sixth database Symposium, "Engineering Data Management: key to integrated Product Development", San Francisco, California, August 4-5, 1992. The papers can be divided into five groups. The first group focus on object oriented managers. The second group addresses the role of data standards in integrated product development. The third group describes the development of integration frameworks for product data. The fourth group focuses on actual experiences in integrating product data and the last group describes ongoing research projects in the area of product data integration.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, WINTER MEETING, NOVEMBER, 25-30, 1990, DALLAS, TEXAS; *'ADVANCES IN INTEGRATED PRODUCT DESIGN AND MANUFACTURING'*

This are the papers of 'The annual meeting of the american society of mechanical engineers, Dallas, Texas, 1990. The papers discuss the integration of design and manufacturing, especially in conceptual design, design for manufacture, integrated CAD/CAM process planing and tolerancing fixturing and systems issues in CIM. The papers in the symposium use expert systems, kinematics, solid geometry, statistics, optimization and other analytical approaches to solve a wide variety of problems generic to the integration of the design and manufacturing functions.

DESIGN AUTOMATION CONFERENCE (ASME), *'CONCURRENT ENGINEERING OF MECHANICAL SYSTEMS'*, SEPTEMBER 16-19., 1990, CHICAGO, ILLINOIS

This volume of the proceedings of the 16th design Automation conference, held in Chicago, September 16 - 19, 1990 contains 13 papers on the topic of concurrent engineering of mechanical systems. The papers can be divided into three areas. The first part discuss the integration of computer aided engineering methods, tools integration for design automation and tools for support of concurrent engineering objectives. The second set of papers focuses on failure analysis of mechanical systems using simulation tools with the objective of identifying failure modes and their causes as early as possible in the design cycle enabling rational design for failure avoidance. The final block of papers contains case studies in design of selected classes of mechanical systems for reliability and maintainability. The technical focus of the papers is on the design of mechanical systems for reliability and maintainability, but mainly with a high theoretical approach to concurrent engineering.

DUTTA, DEBASISH, *'CONCURRENT ENGINEERING, 1992'*, presented at the WINTER ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, ANAHEIM, CALIFORNIA, NOVEMBER 8-13, 1992; ASME, NEW YORK, 1992

This book contains the papers presented at the Symposium on Concurrent Engineering, 1992 ASME Winter Annual Meeting held in Anaheim, California. This symposium focused on two broad themes, (1) tools for automation in design, manufacturing and assembly, and (2) process quality management and improvement. Research in these areas is being actively pursued in industry and academia, and is the key to increased productivity and quality, and reduced time to market. The papers of these book reflect the entire production process dealing, for example, with issues in concurrent product/process design, NC machining, inspection, assembly and analysis.

HAUG, EDWARD J., *'CONCURRENT ENGINEERING: TOOLS AND TECHNOLOGIES FOR MECHANICAL SYSTEM DESIGN'*, SPRINGER-VERLAG, BERLIN, 1993

These proceedings contain lectures presented at the NATO Advanced Study Institute on Concurrent Engineering Tools and Techniques for Mechanical System Design held in Iowa City, Iowa, 25 May - 5 June, 1992. Lectures were presented by leaders from Europe and North America in disciplines contributing to the emerging international focus on Concurrent Engineering of mechanical systems. Participants in the Institute were specialists from throughout NATO in disciplines constituting Concurrent engineering, many of whom presented contributed papers during the Institute and all of whom participated actively in discussions on technical aspects of the subject. The proceeding are devided into the following five parts: Basic Concepts and Methods, Application Sectors, Manufacturing, Design Sensitivity Analysis and Optimization, and Virtual Prototyping and Human Factors. Each of the parts is comprised of papers that present state-of-the-art concepts and methods in fields contributing to Concurrent Engineering of mechanical systems.

IEEE INTERNATIONAL CONFERENCE ON SYSTEMS ENGINEERING, *'CONCURRENT ENGINEERING'*, AUGUST 1-3, 1991, FAIRBORN, OHIO

In this book are the papers of the third IEEE International Conference on Systems Engineering, Fairborn, Ohio, August 1-3, 1991. The theme of this conference was 'Concurrent Engineering', but the topic of most of the papers is in the area of systems engineering and discussing concurrent engineering is only a side effect of a few papers. This means, for learning something about concurrent engineering it is nor worth reading these papers.

IFIP TRANSACTIONS, *'MANUFACTURING IN THE ERA OF CONCURRENT ENGINEERING'*, NORTH-HOLLAND, AMSTERDAM, 1992

This book contains revised papers and discussions from the Working Conference on Manufacturing in the era of concurrent engineering, Herzlya, Israel, 13-15 April, 1992. They discuss several areas of concurrent engineering and present the research of the leading institutes of the world.

2.3 Articles

ALPERT, MARK, *'THE CARE & FEEDING OF ENGINEERS'*, FORTUNE, SEPTEMBER 21, 1992, PP: 86-95

Companies can harness the creative energy of engineers by first finding managers who are engineers themselves or who understand the engineers' work. Engineers must be assured that management thinks what they are working is important and supports their work wholeheartedly. Because engineers can get valuable insights into the market for their products when they talk to salespeople and customers, managers should encourage this interaction by assigning engineers temporarily to marketing and customer service departments. Although companies need managers with technical expertise, some engineers are not suited for supervisory roles. The ideal company would give engineers the freedom to stay on the technical side as long as they wanted. Many companies have created parallel ladders that allow engineers to receive substantial promotions and raises without switching into management.

ALTER, ALLEN E., *'CONCURRENT AFFAIRS'*, CIO, NOVEMBER 1, 1991, PP: 30-41

Concurrent engineering allows planners, designers, engineers, and assemblers to work together simultaneously as a product team and to share ideas, information, and feedback from overhaul of the corporate culture, since there are profound differences and rivalries between information systems (IS) professionals and design or process engineers. The IS role in concurrent engineering is to support the simplification of business processes. Because most of the life-cycle cost of a product is defined at the conceptual and preliminary design stages, IS must play a dynamic, supportive role by focusing technology-management efforts and providing feedback systems and data to the design team. Some believe that IS should not get involved until new manufacturing processes are well on the way to implementation. For IS, facilitating concurrent engineering means supplying information technology. In addition to requiring the creation of networks, databases, and analytical tools, concurrent engineering is inspiring some inventive application-development work.

ANDERSON, RICHARD E., *'HRD'S ROLE IN CONCURRENT ENGINEERING'*, TRAINING & DEVELOPMENT, JUNE 1993, PP: 49-54

Concurrent engineering is a product development process wherein engineers simultaneously work on design and manufacturability to lessen time-to-market and improve quality. The role of human resources development (HRD) in concurrent engineering is not always clearly defined. As with total quality management initiatives, HRD can assist in removing culture-bound obstacles to concurrent engineering and motivate employees' commitment to it. One area in which HR professionals can provide significant support to concurrent engineering is organizational process. Through organizational process, HRD can break down the wall that prevent designers and manufacturing engineers from collaborating. HR consultants can also provide support to concurrent engineering through quality function deployment which involves the integration of innovation, manufacturing and quality. HR assistance to concurrent engineering in four companies are discussed.

ANONYMOUS, *'BENCHMARKING YOUR COMPANY FOR CONCURRENT ENGINEERING'*, MACHINE DESIGN, OCTOBER 22, 1993, PP: 43-47

Concurrent engineering (CE) has been used successfully by many firms to measure their performance and then set specific goals for their operations. With CE, it is important to note factors such as the perading culture in specific companies and the activities of a company's competitors. A brief description of the successful CE programs of several companies and the benefits such programs have brought to them is presented.

ANONYMOUS, *'BF GOODRICH SAYS 'BRAVO' TO CONCURRENT ENGINEERING'*, DESIGN NEWS, NOVEMBER 23, 1992, PP: 36-37

BF Goddrich Aerospace used concurrent engineering and CAD/CAM software to fulfill the requirements in a contract it received from the Boeing Commercial Airplane Group. Goodrich used concurrent engineering and the software to design the wheels and a carbon-braking system for Boeing's 777 airliner.

ANONYMOUS, *'CAD/CAM PLANNING: ORGANIZING FOR CONCURRENT ENGINEERING'*, CAE, JULY 1992, PP: CC2-CC10

Concurrent engineering (CE) is the simultaneous design of products and their engineering, manufacturing, and marketing processes. The CE approach results in a product that takes less time to develop, has higher quality, and costs less since expensive changes and prototypes are eliminated. To implement CE, companies usually reorganize and train employees in both technology and a new company culture. The approval and support from top-level management is essential for success. As a part of the product development process, team members need to accept individual responsibility based on team goals and realize individual dependencies exist. One of the greatest barriers to overcome in developing a CE environment is the ability of employees to get along and work with each other. Communication is crucial for successful concurrent engineering. The CE project manager should have the authority as well as the responsibility to make necessary changes.

ANONYMOUS, *'CAD/CAM PLANNING: WORKING IN CONCERT'*, CAE, JULY 1992, PP: CC14-CC22

There are a number of computer-aided design and manufacturing (CAD/CAM) technologies that have been created to support engineering efforts. These include drafting software and solid modeling for design, analysis tools for performance and process evaluation, and NC programming and rapid prototyping. As powerful as these piont solutions are, the key to unlocking their true potential is to get them to work in harmony. In CAD/CAM language, harmony is defined by integration. Components of integration include: 1. same geometry, 2. same user interface, and 3. associativity. Despite the integration of geometry, associativity, and common user interfaces, an overall conductor is needed to coordinate all of the activities, both of the computer and product development processes. Some feel product data management systems (PDM) are the answer to this need. However, the real benefit of PDM packages will come when they are widely supported by various application developers.

ANONYMOUS, *'CHRYSLER WINS FIRST ANNUAL MACHINE DESIGN CONCURRENT ENGINEERING AWARD'*, MACHINE DESIGN, FEBRUARY 20, 1992, PP: 40-47

Chrysler Corp. has received the first annual Concurrent Engineering Award presented by Machine Design Magazine. The award is given to the American company that has experienced the most dramatic improvements from the concurrent engineering approach or has done the most to promote or demonstrate the validity of the concept.

ANONYMOUS, *'CIM LANDS AT LOCKHEAD'S AEROSPACE COMPANIES'*, DATAMATION, MAY 15, 1989, P: 72

Lockhead is adopting the concept of concurrent engineering, in which the product and the process are designed simultaneously. Concurrency presents problems for the organizational structure, the information flow, and for the complete methodology of doing business. Expected benefits of concurrency are that product throughput and the development time cycle should improve. Lockhead's investment in CIM will reduce the amount of engineering changes and improve quality.

ANONYMOUS, *'CONCRETE ADVICE ABOUT SOLIDS'*, MACHINE DESIGN, APRIL 9, 1993, P: 92

Product modeled in solids carry significant advantages for concurrent engineering groups. These include facilitating the design of large assemblies, interference checking, and lifelike rendering for presentations. Autodesk and author Ronald Leigh are trying to bring the benefits of solids to a wider audience through AutoCAD's modeling extension, AME, and through the book Solid Modeling with AutoCAD, respectively.

ANONYMOUS, *'CONCURRENT ENGINEERING AWARD HONORS OUTSTANDING MANUFACTURERS'*, MACHINE DESIGN, MAY 28, 1993, P: 16

The 2nd Annual Concurrent Engineering Competition to honor companies that have successfully implemented concurrent engineering to enhance competitiveness will be hosted by Structural Dynamics Research Corp. and Machine Design magazine. Winners will be announced at the National Design and Engineering Show in Chicago March 14-17, 1994.

ANONYMOUS, *'CONCURRENT ENGINEERING AT THE PROTOTYPE PHASE'*, PRINTED CIRCUIT DESIGN, MAY 1991, PP: 36-38

R&D Circuits, a prototype printed circuit board (PCB) shop, has been using concurrent engineering for several years. R&D president Vincent Russel recognized in the mid 1980s that, to be competitive, the company needed complete control and integration of all prototype PCB production. Once a client's computer-aided design and manufacturing design data are received, they are logged into a panelizer software system. All design data are reviewed for errors or inconsistencies. Among R&D's in-house test and inspectation hardware are: KLA automatic visual inspection station and verifier, 2. Probot Series Six bare-board tester, and 3. Glenbrook X-ray inspection station. Russel attributes R&D's effectiveness to the use of concurrent engineering.

ANONYMOUS, *'CONCURRENT ENGINEERING, COMPETITIVE PRODUCT DEVELOPMENT'*, IEEE SPECTRUM, JULY 1991, PP: 73-77

In concurrent engineering the key ingredient is team work. People from different departments collaborate over the life of a product, to ensure it reflects the customer needs and desires, marketing, engineering and manufacturing works together to anticipate the problems and to eliminate them early on. QFD, Quality Loss Function, Signal to Noise Ratio, S.P.C., Fishbone Diagram, Continuos Process Improvement, JIT, TQM, are also discussed in this article.

ANONYMOUS, *'CONCURRENT ENGINEERING, GLOBAL COMPETITIVENESS AND STAYING ALIVE: AN INDUSTRIAL MANAGEMENT ROUNDTABLE (PART I)'*, INDUSTRIAL MANAGEMENT, JULY/AUGUST 1990, PP: 6-10

In a roundtable discussion, industrial management executives discussed the concept of simultaneous engineering and initiatives that are being undertaken to guarantee competitiveness. Common initiatives that are strategically important for all companies include: 1. dissolving functional structures or ignoring traditional organizational structures and focusing on cross-functional teams, 2. promoting employee involvement throughout the organization, 3. realizing that a better environment is needed to allow change to occur, and 4. beating competitors to the marketplace as the key to survivability.

ANONYMOUS, *'CONCURRENT ENGINEERING, GLOBAL COMPETITIVENESS, AND STAYING ALIVE'*, INDUSTRIAL MANAGEMENT, SEPTEMBER/OCTOBER 1990, PP: 4-12, 16

On March 11, 1990, the 2nd part of an Industrial Management roundtable was held. The representatives of various companies presented their experiences and results with concurrent engineering.

ANONYMOUS, *'DESIGN: THE POWER BEHIND CONCURRENT ENGINEERING'*, DESIGN NEWS, FEBRUARY 22, 1993, PP: 25-26

The use of concurrent engineering in product development has become widespread. Concurrent engineering brings key participants in product development together so that their tasks are accomplished at the same time. Design engineers play a critical role in concurrent engineering schemes.

ANONYMOUS, *'DOWTY AEROSPACE INTRODUCES CONCURRENT ENGINEERING'*, INDUSTRIAL ENGINEERING, NOVEMBER 1991, PP: 30-31

Dowty Aerospace is a supplier of aircraft hydraulic actuation systems. The implementation of concurrent engineering has allowed Dowty to reduce the time from concept to manufacture by 50%-70%. Since opting for Schlumberger Technologies' Bravo3, Dowty's system has grown from 7 computer-aided design and manufacturing (CAD-CAM) workstations to 31. Dowty's entire development process is now driven by common Solids Modeling database, meaning that several phases of its operation can run concurrently. By generating designs in Editor, Solids and Surfaces achieve concurrent engineering, according to Dowty configuration manager Mike Steinwender.

ANONYMOUS, *'FUTURE VIEW: TOMORROW'S MANUFACTURING TECHNOLOGIES'*, MANUFACTURING ENGINEERING, JANUARY 1992, PP: 76-88

In the future, traditional methods of design and manufacture will give way to concurrent engineering strategies that target improved communications between design and manufacturing. As more manufacturers promote concurrent engineering, rapid prototyping technology will play a key role in helping them see a product before committing hard tooling. For companies planning a move to concurrent engineering, recent advances in computer-aided design and manufacturing, such as feature-based programming, show promise. Artificial intelligence techniques used in manufacturing will emulate human performance in such areas as decision making, natural language processing, vision, and robotics. Mechatronic systems will radically alter product design and development.

ANONYMOUS, *'HOW TO MAKE CONCURRENT ENGINEERING WORK'*, MACHINE DESIGN, JULY 23, 1993, PP: 21-24

Useful insights on successfully implementing concurrent engineering (CE) are provided by the winners of the 1992's CE competition. Several practitioners of CE discuss how their companies first became involved with CE and offer advice for companies just planning their first steps in CE. To be successful with CE, companies should: 1. Compare themselves to their best competitors, 2. reduce time to market, 3. look for a champion, 4. develop metrics, 5. get top management endorsements, and 6. plan for follow through.

ANONYMOUS, *'LINKING CAD AND CAM CUTS CHASSIS DESIGN TIME BY 85%'*, DESIGN NEWS, OCTOBER 21, 1991, PP: 26-27

General Motors' Chassis System Center has combined a CAD system and CAE system to achieve an 85% reduction in design time. Concurrent engineering allows firm to build part of a model in about 20 minutes.

ANONYMOUS, *'MADE IN THE U.S. WITH CIM WORKS FOR TI'*, MODERN MATERIAL HANDLING, JANUARY 1991, PP: 12-13

To defend against low-cost and foreign competitors, managers at Texas Instruments (TI) developed a 'made in USA' manufacturing strategy for low-end, scientific calculators. The strategy is based on computer-integrated manufacturing (CIM) techniques, including automated assembly and materials handling technologies, plus concurrent engineering of these technologies and calculator product design. Through concurrent engineering of product and manufacturing line, manufacturing cycle time takes only 20 minutes. Other results of automation include a reduced number of defects and a decreased setup time and downtime.

ANONYMOUS, *'NEW PROGRAM SPEEDS TIME-TO-MARKET BY 50 PERCENT'*, INDUSTRIAL ENGINEERING, MAY 1993, P: 8

The Design and Manufacturing Institute (DMI) of Steven Institute of Technology has demonstrated how it cut in half the best standard time-to-market by automating concurrent engineering.

ANONYMOUS, *'SOFTWARE SUPPORTS CONCURRENT ENGINEERING'*, MACHINE DESIGN, JUNE 1993, P: 76

The I-DEAS Series software system by Structural Dynamics Research Corp. relies on advanced knowledge base to promote team-oriented design in a concurrent engineering environment with the goal of streamlining and standardizing the concurrent engineering design process. The nucleus of the system is a master solid model that provides part geometry, form features, engineering equations, surface finish, dimensional tolerances, material properties, simulation results, test data, machining and NC tool-path data, and assembly hierarchy for all I-DEAS application modules. Its Navigator user interface requires 70% fewer commands than systems, and its Generative Machining knowledge base promotes strong NC capability and automatically accommodates changes to the master model by generating new tool paths and reapplying the rules to the machining process. The solids-based approach to NC provides a life-like 3-dimensional visualization of the entire machining environment and allows automatic and direct user control for 2-through 3-axis milling applications.

ANONYMOUS, *'THE RACE TO MARKET HEATS UP'*, MACHINE DESIGN, JANUARY 8, 1993, P: 14

According to Parametric Technology Corp.'s Strategic Relationships Consultant, Olimpio DeMarco, concurrent engineering is working effectively for industry, and CAD/CAM suppliers are now designing their tools with this in mind. DeMarco states that progressive companies no longer view design as an isolated event in the development cycle. Instead, design works with concurrent engineering to reduce rework and cost overruns. Practicing concurrent engineering ensures that all engineering disciplines can do their work parallel, without the risk that a change made somewhere else will make their work obsolete. Getting to market quickly can mean the difference between getting prime sales as opposed to coming to market after competitors are already there and are selling in a mature sales environment. Overall, concurrent engineering brings greater speed and productivity to a company. Concurrent engineering software should be intuitive to engineers, feature-based, parametrically driven, and should have a single data source. The software should have full associativity.

ANONYMOUS, *'THE CHANGING FACE OF PART DESIGN'*, MACHINE DESIGN, NOVEMBER 1989, PP: 4-16

A fundamental shift is under way in design engineering. No longer is engineering just one step in a long series of discrete steps. Instead, design now is done parallel with other manufacturing processes. In an effort to reduce long lead times, simultaneous engineering is bringing teams of manufacturing and design personnel to work on their respective tasks at the same time.

ASHLEY, STEVEN, *'DARPA INITIATIVE IN CONCURRENT ENGINEERING'*, MECHANICAL ENGINEERING, APRIL 1992, PP: 54-57

Looking for waysto apply concurrent engineering (CE) principles to American product-development teams whose members are often scattered around the country, the Defense Advanced Research Projects Agency (DARPA) launched a 5-year technology-development program called DICE (DARPA Initiative in Concurrent Engineering) in 1988. By the end of 1991, about $60 million in government funds had been spent on the development of a range of enabling technologies for CE by a consortium of manufacturers, software companies, and universities. General Electric Aircraft Engines has implemented a pilot CE environment in the development of a critical part of its next-generation gas-turbine aircraft engine, a hollow metal-matrix fan blade.

BECKERT, BEVERLY, *'INTEGRATING SOFTWARE FOR ELECTRONIC DESIGN'*, CAE, SEPTEMBER 1990, PP: 46-54

Electronics engineers used to pass their printed circuit board (PCB) schematics to PCB CAD layout designers who, in turn, passed their work to the manufacturing area. Although these users had little software to automate their jobs, the point solutions did little to increase overall productivity. An integration effort is under way in the electronic design automation (EDA) industry to change this. EDA software vendors are ensuring that their PCB programs link both front-end conceptual design tools and back-end manufacturing. Furthermore, they are opening up their product lines to third parties to enhance the solution set. Vendors claim that this integration strategy promotes concurrent engineering and improves overall productivity, enabling companies to bring their products to market faster.

BECKERT, BEVERLY; *'TECHNOLOGY FOR THE EXPERTS'*, MACHINE DESIGN, JULY 23, 1993, PP: SS18-SS25

The use of computer aided design/computer aided manufacturing (CAD/CAM) technology in an integrated system can offer companies the means to improve their total product development process. It can move organizations past a limiting point-solutions mindset to an encompassing concurrent-engineering philosophy. Companies striving to bring their employees up to an 'expert level' in CAD/CAM technology must invest in the appropriate tools.

BEERCHECK, RICHARD C., *'MANUFACTURING TECHNOLOGY: MEETING THE GLOBAL CHALLENGE'*, MACHINE DESIGN, AUGUST 23, 1990, PP: 64-69

The International Manufacturing Technology Conference's IMTS 90 trade show will exhibit a new generation of modular machines designed to boost productivity and quality. The push to get products to market has heightened the interest in the concept of concurrent or simultaneous engineering. The major benefit - dramatically shortened production cycles - would not be possible without an efficient means of transferring design data to the shop floor. To facilitate this transfer, software suppliers have devised closer interfaces between computer-aided design and computer-aided manufacturing, making the transfer of geometric data faster and easier.

networking - for integrating managerial functions, technical competencies, and information systems. A model of the Japanese innovation process is proposed which seeks to explain the processes of differentiation and integration used in Japanese firms, along with the managerial control systems and information flow structures.

BOGARD, TIM; HAWISCZACK, BOB; MONRO TOM, *'CONCURRENT ENGINEERING ENVIRONMENTS'*, PRINTED CIRCUIT DESIGN, JUNE 1991, PP: 30-37

Design engineering is now the critical factor in influencing product cost and quality as well as improving product development cycle time. As a result, designers are adopting tools and techniques that enhance their ability to evaluate cost and development criteria, such as manufacturability. While design for manufacturability (DFM) tools have proven their usefulness in several applications, an across-the-board implementation still evades designers. An understanding of the critical fir between the design system and design tools, particularly DFM tools, may provide the key to widespread fanout of DFM techniques. The effective implementation of DFM tools has been made possible by the development of integrated design process include: 1. standard design procedures, 2. specific design methodologies, 3. integrated computer-aided engineering tools.

BOURKE, RICHARD W.; MILLER, EDDY D., *'PRODUCT DATA MANAGEMENT SYSTEMS - THE IMPLEMENTATION PROCESS'*, PRODUCTION & INVENTORY MANAGEMENT REVIEW & APICS NEWS, MAY 1991, PP: 46-47

An overview is provided of the major implementation issues concerned with integrating product data management (PDM) systems with manufacturing resource planning (MRP II) and related issues. While PDM and MRP II systems implementations are similar, they do have some significant differences. There is, for example, a different motivation for concurrent engineering (CE) and PDM systems than for MRP II. A PDM implementation team must determine the scope of the initial effort and identify the evolutionary steps required to fully integrate all of the information about a company's product. Aiming for a single, coordinated bill of material system is a more pragmatic implementation approach in the short term. The degree of modification and tailoting to the software that may be necessary and/or allowable is another issue to consider. While the PDM project may need to be phased with other complementary improvement strategies, the gradual difference. Engineers basically deal with how a product operates. industrial designers are more concerned with how the product is operated, and thus consider function as well as form. For efficient teamwork, engineers and industrial designers must trust and appreciate the other's skill and contributions. The computer has revolutionized the way industrial designers work, speeding product development.

BRAZIER, DAVID; LEONARD, MIKE, *'CONCURRENT ENGINEERING: PARTICIPATING IN BETTER DESIGN'*, MECHANICAL ENGINEERING, JANUARY 1990, PP: 52-53

The concept of concurrent engineering techniques is beginning to dominate leading edge discussion of competitiveness in manufacturing. With the use of concurrent engineering methods, a number of manufacturers are speeding the product design cycle and are cutting costs at the same time. While computer-integrated manufacturing has helped bridge the gap between design and manufacturing, it has not tightened all the checks and balances within the product design cycle itself. Concurrent engineering, the simultaneous design of a product, and the process required to produce it involves participants from downstream functions, such as manufacturing, third-party suppliers, quality control, and customer support in the design engineering stage. The first step in the implementation of a concurrent engineering strategy is internal review. By implementing a common modeling technique that incorporates all design intelligence, such as feature-based solids modeling, it becomes possible for all disciplines to work concurrently on any given model from a single database.

BRONSVOORT, WILLEM F.; JANSEN, FREDERIK W., *'FEATURE MODELING AND CONVERSION - KEY CONCEPTS TO CONCURRENT ENGINEERING'*, COMPUTERS IN INDUSTRY, JANUARY 1993, PP: 61-86

Feature modeling is a relatively new way of storing information about objects in computer-aided design and manufacturing systems. Elementary features, also known as atomic features, are simple features that cannot be decomposed into still simpler features. Compound features are more complex features consisting of several elementary features. Each application has its own set of features and its own way of viewing an object. There can, for instance, be a design view, a finite-element view. In solid modeling, objects can often be characterized by restricted number of parameters. A constraint defines a relation between 2 elements in a generic object definition. Design by features, which involves the construction of a product model by features, is a relatively new approach. GeoNode, an experimental modeling system developed at Delft University of Technology, offers an interactive graphical user interface for modeling objects with features.

BROWN, DONALD H., *'PIM: A TOOL FOR CONCURRENT ENGINEERING'*, CAE, APRIL 1993, PP: 64

In the face of unrealized expectations for MCAE-CAD-CAM, concurrent engineering has become the war cry for the 1990s. Firms must shorten time-to-market - by eliminating nonvalue-added steps, by performing tasks in parallel, and by managing risk - to remain competitive. However, they quickly discover that concurrent engineering involves difficult changes in the underlying corporate culture. Those fundamental organizational and cultural changes represent the deepest challenge for manufacturing and design. Few traditional engineering tools address the process issues associated with concurrent engineering. The exception, product information management (PIM), deals with the technical issues. PIM offerings, when integrated with the full suite of MCAE-CAD-CAM applications, enhance configuration management and assembly modeling.

BULKELEY, DEBRA, *'IT ALL STARTS WITH DESIGN'*, DESIGN NEWS, JULY 5, 1993, PP: 56-64

Engineering firms use concurrent engineering to coordinate efforts to more quickly and efficiently produce products. Valuable tools in the concurrent engineering process include computer-aided design and continuos communication, which are described.

BURNETT, ROBERT W., *'SUCCESS STORIES IN INSTRUMENTATION, COMMUNICATIONS - CASE HISTORY 2: CISCO SYSTEMS'*, IEEE SPECTRUM, JULY 1991, PP 33-34

Much of the dramatic growth that Cisco Systems Inc. has undercome is attributable to concurrent engineering (CE). Revenues for the maker of multimedia and multiprotocol internet working products - routes, bridges, terminal services, and network managers for wide-area networks - jumped from $27 million in 1989, when CE was first adopted, to $70 million in 1990. Cisco had sales of more than $76 million in the first half of 1991. The genesis of CE at Cisco came in weekly review meetings that were set up in 1989 for engineering, manufacturing, and sales. Those meetings helped cut the cost of a multiport communications interface card providing up to 2 Ethernet connections and 2 serial connections. Cisco still has its weekly review meetings, but every new product is now guided by a team whose members come from many groups: hardware and software engineering, manufacturing, customer engineering, marketing, and business development.

CARRABINE, LAURA, *'CONCURRENT ENGINEERING: NARROWING THE EDUCATION GAP'*, CAE, OCTOBER 1991, PP: 90-94

Besides teaching even basic skills, companies working toward concurrent engineering CE) coaching engineers how to work in teams. Universities greatly affect how these firms spend their money. The consensus among many professors is that universities need to develop programs that mirror what graduating students will face on the job. The University of Illinois at Urbana-Champaign is working closely with several companies, including the Ford Motor Concurrent Engineering Lab. At the Massachusetts Institute of Technology, students study ethics as part of their program. Hands-on training has been part of Stanford University's Design School since 158. In addition to working in interdisciplinary teams, students can interact in an on-site machine shop using computer-aided design tools to build products. Many education experts emphasize the need for more internships for engineering students.

CLELAND, DAVID I., *'PRODUCT DESIGN TEAMS: THE SIMULTANEOUS ENGINEERING PERSPECTIVE'*, PROJECT MANAGEMENT JOURNAL, DECEMBER 1991, PP: 5-10

US technological leadership is under serious challenge in the global marketplace. Project management, one of the major innovations in the continued evolution of the management discipline, is clearly an idea whose time has come. In the particular area of manufacturing leadership, the use of an alternative organizational design, vis-a-vis the use of product design teams, can make dramatic improvements in a company's global competitiveness. Product design provides the ideal starting point for a study of the specialities that have to be evaluated and integrated into the final product or service. Integration of the required discipline in concurrent engineering can be accomplished in several ways. Product design teams enable the effective mobilization of all of a firm's resources, capabilities, and speciality input. Both new and mature products that are well designed through close collaboration with the manufacturing and marketing disciplines will be easier to build, maintain, and use.

CONE, DAVE, *'CONCURRENCY IN THE MANUFACTURING PROCESS'*, MANUFACTURING SYSTEMS, JUNE 1993, P: 17

The advantages of a manufacturing execution system on the plant floor are presented.

CONOLLY, JAMES M., *'CONTROL DATA ENHANCES DATA MANAGEMENT'*, COMPUTERWORLD, MAY 10, 1993, PP: 71

Control Data Systems Inc., a spin-off of Control Data Corp., recently enhanced an engineering package designed to speed concurrent engineering processes.

COUGHLAN, PAUL D.; WOOD, ALBERT R., *'DEVELOPING MANUFACTURABLE NEW PRODUCTS'*, BUSINESS QUARTERLY, SUMMER 1991, PP: 49-53

Product development success comes to those who integrate design, engineering, marketing, and manufacturing during the development process. Recommended actions include the following: 1. Appoint a powerful project manager. 2. Set up multifunctional teams. 3. Ensure 2-way communication. 4. Make sure that problem solving is iterative. Simultaneous or concurrent engineering is characterized by interactive and integrated development of both the product and the associated manufacturing processes. Manufacturing engineering (ME) has responsibility for the development, support, and improvement of products and manufacturing processes. By developing and applying design rules and carrying out manufacturability assessments during the product development process, ME achieves an emphasis on manufacturability. Effective product development requires ME and design engineers to be familiar with each other's responsibility, competencies, and limitations.

CRAIG, MARK, *'PREDICTING AND OPTIMIZING ASSEMBLY VARIATION'*, QUALITY, JUNE 1991, PP: Q16-Q18

A critical factor in reducing cost and increasing product quality is the ability to predict and optimize manufacturing and assembly variation early in design. Valisys Corp. and Applied Computer Solutions Inc. have introduced a software tool that combines the strengths of 2 existing products - variation simulation analysis (VSA) and Valisys - to help engineers optimize assembly variation in a fully integrated concurrent engineering environment. The tool's feature include: 1. direct integration with the corporate computer-aided design (CAD) system, 2. complete and accurate geometric dimensioning and tolerancing standards (GD&T)schemes based on national and international standards and rigorously defined mathematics, and 3. an ability to mathematically relate GD&T notes with CAD geometry and store them for consistent analysis. This new product will enable the design engineer to routinely perform complex 3-dimensional stack-up problems.

CREESE, ROBERT C.; MOORE, TED L., *'COST MODELING FOR CONCURRENT ENGINEERING'*, COST ENGINEERING, JUNE 1990, PP: 23-27

Concurrent engineering is a philosophy for improving quality, reducing costs, and reducing the lead time from product conception to product development for new products and product modifications. It emphasizes management as well as engineering skills and requires multidirectional information flow. A major difficulty in the implementation of concurrent engineering is the failure of management to recognize that it must be implemented at the top levels first. The philosophy will be implemented differently for different companies because of the variations in leadership styles, products, processes, employee abilities, customer requirements, and supplier capabilities. Concurrent engineering has had a dramatic effect on the critical elements of the concurrent engineering process; it is essential that unnecessary costs be reduced significantly for products to be competitive in the international market.

D'ABADIE, CATHERINE A.; FUNK, MICHAEL; NELSON, DAVID E., *'THE FAST DECISION PROCESS: ENHANCING COMMUNICATION IN PRODUCT DESIGN'*, QUALITY PROGESS, JUNE 1991, PP: 65-68

Motivated by increasing competitiveness and a need for sharper customer focus, AT&T Bell Laborities is dramatically reducing the time it takes to develop the movement and management of information. A new method and support environment - the fast decision process (FDP) - helps teams of technical planners reduce the time needed to develop specifications of new telecommunications services from months to weeks. FDP enhances the way the teams cooperate and communicate. FDP embodies 2 essential pillars of concurrent engineering: an improved design process and closer cooperation among design members. Teams using FDP typically produce a document describing the technical requirements for the new telecommunications service or feature. FDP consists of 7 major elements that work together to enhance communication among team members: 1. a well-defined goal or team product, 2. an empowered project team working together during a dedicated block of time, 3. the FDP environment, 4. a plan for the FDP session, 5. a process for identifying and resolving issues and documenting results, 6. a review of the team product, and 7. dedicated support and ongoing evaluation and improvement of FDP.

DAVIS, GLEN E., *'CONCURRENT ENGINEERING'*, <u>PRINTED CIRCUIT DESIGN</u>, SEPTEMBER 1992, PP: 26-31

Concurrent engineering uses a cross-functional team approach to involve pertinent players in each stage of product development. After engineering has finished the schematics and simulation, a team of engineering, marketing, and design personnel conduct a design review before the interconnect phase is done in computer-aided design. The printed circuit board (PCB) designer and the manufacturer need to work closely in the position placement stage of design. With knowledge of the manufacturing process, the designer can influence the output of the PCB vendor in terms of yield, quality, and costs. The designer also should construct a specification for bare-board manufacturing to produce the product to the customer's expectations; if done properly, the document can be used and modified for multiple vendors and products. Implementing a concurrent engineering system can result in a 40%-75% reduction in product development time and an 80% reduction in time-to-market. Product quality can be improved over 150%.

DEFOSSE, STEPHAN F.; BARR, TERESA D., *'IMPLEMENTING EDI/EGI WILL REDUCE TIME TO MARKET'*, <u>INDUSTRIAL ENGINEERING</u>, AUGUST 1992, PP: 30-31

Many companies have found outsourcing and concurrent engineering processes to be slow and inconvenient in reducing the time of bringing a product to market unless electronic data interchange/electronic graphics interchange (EDI/EGI) technology is used to achieve rapid, efficient, and error-free communication between disparate project members. As an engineering and consulting group that specializes in speeding product development cycles, the Plastics Technology Center (PTC) of Lexmarket International Inc. has proven the use of EDI/EGI to be an essential part of the concurrent engineering process. For concurrent engineering to work as it has for the PTC, there must be constant communication between the product designer, product engineer, model designer, and tool builder. EGI, which has been reserved to describe the transfer of massive graphic or geometric design files between computer-aided design systems, allows this communication of files to take place throughout the entire project. The PTC utilized this concurrent engineering process during its 13-month development of the IBM PS/2 L40 SX laptop computer enclosure and an original equipment manufactured notebook computer enclosure.

DEIVANAYAGAM, S., *'DESIGNING FOR MAINTAINABILITY: COMPUTERIZED HUMAN MODELS'*; COMPUTERS & INDUSTRIAL ENGINEERING, NOVEMBER 1992, PP: 195-196

Traditionally, the design and development of a typical human-machine system has been a sequential flow process in which the design is completed in one functional area with no significant level of input from other functional areas of the organization. This process can result in very serious deficiencies in such important areas as maintainability and manufacturability. The practice of simultaneous engineering/concurrent design, made possible by the introduction of the computer as a tool, is a design technique that requires interaction of personal from several functional areas, even during the early stages of design. It is therefore possible to incorporate all relevant system requirements in the design of the system sufficiently early so that design modifications may be kept to a minimum and the life cycle cost will be lower.

DOWLATSHAHI, SHAD, *'A NOVEL APPROACH TO PRODUCT DESIGN AND DEVELOPMENT IN A CONCURRENT ENGINEERING ENVIRONMENT'*, TECHNOVATION, APRIL 1993, PP: 161-176

The early design-marketing interface for the design and development of industrial products in a concurrent engineering environment is examined. Marketing concerns, contributions, and constraints are most appropriately reflected in the final product when there is a collaboration and dialogue between designer and marketers at the conceptual phase of the product development cycle. In order to effectively achieve such collaboration, an algorithm containing 4 steps is proposed. These steps ensure that the customer requirements and preferences are recognized and communicated in a timely, relevant, and accurate format so that they are incorporated in the physical embodiment of the product. It is eventually the collaboration between the marketers' critical utility factors and the designer's design specification or functions that determines the form, fit, and function of the product. This collaboration is not feasible unless top management provides full support and cooperation.

DOWLATSHAHI, SHAD, *'PURCHASING'S ROLE IN A CONCURRENT ENGINEERING ENVIRONMENT'*, INTERNATIONAL JOURNAL OF PURCHASING & MATERIALS MANAGEMENT, WINTER 1992, PP: 21-25

Early purchasing involvement in the design and development of a product is examined. Purchasing impacts are effective when they are an integral part of a concurrent engineering environment. In this environment, planned purchasing contributions, along with several other factors, are included in the early stages of new product design. Potential areas of collaboration between purchasing and design include, but are not limited to , such tasks as: 1. specification development, 2. the development of interchangeable parts, 3. part standardization and simplification, 4. value support of top management and a positive institutional culture can instill and foster an environment in which effective dialogue can take place between purchasing and design.

DUFFY, JAMES; KELLY, JOHN, *'UNITED FRONT IS FASTER'*, MANAGEMENT TODAY (UK), NOVEMBER 1989, PP: 131-139

Companies are finding that nothing succeeds like speed when they try to achieve a competitive advantage. Being first to market with a product or service generally ensures that a company obtains a 50% market share. Companies can gain speed simply by compressing the cycle, from concept to delivery, that they use to produce a product or service. Several UK manufacturers are using simultaneous engineering to improve their competitive positions in the area of product development. Simultaneous engineering can: 1. reduce the time lag between product development, marketing, and sales, 2. minimize development and product costs, 3. increase product quality, and 4. increase market share. In simultaneous engineering, all disciplines involved in product design work together from the onset to bring a unique, quality product from concept to market in less time and at a competitive cost. This sometimes requires sacrificing short-term profits to gain longer term competitive advantage, however.

DVORAK, PAUL, *'DESIGNERS GET SMART ABOUT MANUFACTURING'*, MACHINE DESIGN, AUGUST 20, 1992, PP: 101-106

Design for manufacturing ((DFM) enables engineers to reduce the number of design components and select the most efficient process to make the parts, resulting in savings in both costs, part tolerances, and assembly times. However, DFM is only half of a concurrent engineering tool. According to Geoffrey Boothroyed of

Boothroyed-Dewhurst Inc., designers gain most benefits when they look at both assembly and manufacturing early in the design cycle. Designing for assembly and manufacturing are most effective when assembly studies are done first. Once engineers reduce the design to the lowest number of parts, they can turn to DFM software. One of the first steps that should be performed in a DFM sequence is an examination of tolerances. The real benefit here pinpoints which dimensions contribute most to proper function. Once the dimensions are set, DFM software can help decide how the part should be manufactured.

DVORAK, PAUL, *'KEEPING TALENT WITH KNOWLEDGE SYSTEMS'*, MACHINE DESIGN, AUGUST 22, 1991, PP: 37-42

Generally, knowledge-based systems are based on object-oriented languages or expert-systems shell with features that adapt them to mechanical design. One big advantage of such systems is that they drive concurrent engineering. The knowledge base allows groups of engineers to work simultaneously on segments or modules of a product. The first step to generating a knowledge-based application is selecting a product that requires frequent design or for which variations are often requested. Typically, as rules are keyed into knowledge bases, engineers test their translations by running the rules as if they were a subroutine. While rules are taking shape, an object or product-structured tree also develops. The tree suggests where modules of one knowledge base can be used in another. A module is a group of rules, often a branch from the tree.

EGBELU, PIUS J., *'CONCURRENT SPECIFICATION OF UNIT LOAD SIZES AND AUTOMATED GUIDED VEHICLE FLEET SIZE IN MANUFACTURING SYSTEM'*, INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS, FEBRUARY 1993, PP: 49-64

Even though many subproblems related to the design of automated guided vehicle (AGV) systems interact with one another, current design approaches of AGV systems tend to focus on solving one subproblem at a time. Piecemeal solution leads to suboptimal design. What is required is a concurrent engineering design approach that integrates 2 or more subproblems into a design model that, when solved, yields the optimal design parameters for the entire system. Three areas that are amenable to integrated design for AGV systems are: 1. unit load specification, 2. vehicle size selection, and 3. fleet size determination. A procedure is presented for the selection of the best unit load sizes for all part types manufactured in a shop that uses AGVs for handling. The problem is modeled as a mathematical program and is solved by a hybrid algorithm that includes numerical search, computer simulation, and statistical analysis. The decision criterion is based on the minimization of expected total manufacturing cost.

EMIGH, JAQUELINE, *'FRAMEWORKS: NEW APPLICATIONS, NEW ENVIRONMENTS'*, MANUFACTURING SYSTEMS, JANUARY 1991, PP: 54-61

Frameworks are software systems aimed at speeding time to market and supporting concurrent engineering. They are an approach to design and production that has been gaining strong support from the Department of Defense. The market appears to be going in 2 directions - toward mechanical and computer-aided software engineering applications on one side and enterprise environments on the other. Most frameworks offer a common user interface and operate all the basic steps in the design process on a common database.

FISCHER, ROBERT A., *'CAN TECHNOLOGY IMPROVE PRODUCT DEVELOPMENT?'*, MACHINE DESIGN, MAY 28, 1993, P: 202

Computer-aided design, manufacturing, and engineering do not always guarantee solutions to manufacturers' problems. Companies design and manufacturing computer system need to embrace the manufacturing credo of concurrent engineering, a blend of manufacturing philosophies, processes, and products dedicated to bolstering new product development.

FOUNDYLLER, CHARLES, *'FINDING THE KEY TO CE'*, CAE, OCTOBER 1992, P: 96

Concurrent engineering (CE) is an approach to product engineering in which product styling, product engineering, manufacturing engineering, and process planning are done largely simultaneously. Implementing successful CE systems is not always easy. Typically, CAD/CAM systems are involved and are widely dispersed geographically , spanning many departments in one or more companies. Engineering data management (EDM) providers are beginning to solve this problem. Once viewed as a database application with an engineering accent, EDM is rapidly evolving into CE enabler, or concurrent engineering automation (CEA) product. To be a true CEA application, data management software must have strong networking features that support a wide range of open and proprietary networks, workstations, and personal computers, as well as software drawing and model formats. It also must be able to reach and service all participants in product development, regardless of what hardware and software they use.

GARRETT, RONALD W., *'EIGHT STEPS TO SIMULTANEOUS ENGINEERING'*, MANUFACTURING ENGINEERING, NOVEMBER 1990, PP: 41-47

Simultaneous engineering (SE) or concurrent engineering involves simultaneously designing a product and defining the best way to make it. Justification for an SE program comes from reducing direct labor costs, cycle time, inventory, scrap and rework, warranty, and engineering changes. To ensure success, companies need to: 1. provide a formal mechanism for manufacturing to work with marketing and design from beginning, 2. design an employee participation program, which can boost morale and interpersonal communication throughout the company and thus create the environment necessary for SE to work, 3. involve both shop and office workers in the cost reduction program, 4. arrange workers properly, 5. recruit engineering generalists who are able to influence others and tolerate significant changes in their job responsibility, 6. train key employees in recognizing and solving problems and in improving interpersonal skills, 7. exploit computer-aided design (CAD), and 8. apply analytical tools.

GEHANI, RAY R., *'CONCURRENT PRODUCT DEVELOPMENT FOR FAST-TRACK CORPORATIONS'*, LONG RANGE PLANNING, DECEMBER 1992, PP: 40-47

Fast-track corporations take strategic initiatives in responding quickly, even to weak signals from external environments. such strategic intent demands an effective mobilization of the organization's internal resources and configuration. A faster concurrent product development process requires a higher degree of integration across different parts of an organization. By nurturing and creating synergies of integration across various subunits of a high-technology organization, the process of new product development can be accelerated. different organizations rely on different competencies to integrate across department, including: 1. organization-wide integration by hardware, 2. organization-wide integration by human ware, and 3. organization-wide integration by software. The accelerated product development process helps the organization internally by rapid generation of economies of learning curve with lower overhead and labor costs, more information sharing and problem solving, and lower requirement of working capital.

GREENE, ALICE H., *'CONCURRENT ENGINEERING; IMPROVING TIME TO MARKET'*, PRODUCTION & INVENTORY MANAGEMENT REVIEW & APICS NEWS; JULY 1990, PP: 22, 25

There has been a strong movement toward breaking down barriers within manufacturing organizations and between suppliers and customers. One part of the movement is concurrent engineering, an approach that involves manufacturing operations and other departmental functions through the enterprise in the design of a product. The formula for concurrent or simultaneous engineering is the early involvement and simultaneous ownership of the product design and process by all functions of the enterprise, including marketing, design engineering, manufacturing or process engineering, manufacturing planning, production, customer service, logistics, and suppliers. Data sharing between multiple organizations, departments, and heterogeneous systems is a major factor in supporting concurrent engineering. NCR is among the leading manufacturers that are addressing concurrent engineering. The firm is using some of the concurrent engineering concepts and working with solid models to address manufacturability of board design and to communicate with its suppliers.

GRZESIK, TONY, *'TOP DOWN DESIGN'*, PRINTED CIRCUIT DESIGN, JUNE 1992, PP: 10-14

At engineering organizations, quality must be designed into a system at the beginning of a project because time-to-market pressures do not allow for a 2nd chance. The design process must provide early feedback on the ramifications of design decisions and must allow efficient, automated, and error-free design. After an appropriate design process is selected, the necessary tools to support the process must be procred. Enhanced methodologies, such as top-down design and concurrent engineering, are important ingredients in achieving goals. Top-down design is used to verify important design decisions during the early stages of the design cycle. Tools allow an engineer to describe a system architecture and obtain feedback on the performance of that system. A behavioral model of an application-specific integrated circuit (ASIC) can be created with a hardware description language (HDL). Other useful tools include libraries, analog tools, data links, signal routing, and design data management.

LARSON, ERIC, *'DESIGNING BETTER THERMOPLASTIC PARTS'*, MACHINE DESIGN, FEBRUARY 7,1991, PP: 83-86

The concept of concurrent engineering - considering the manufacturing process in design - is gaining in popularity among many industries. To take advantage of the opportunities this concept presents, design for injection-molded parts must take into account some basic factors that affect both function and manufacturing.

LIVINGSTON, DENIS, *'INTEGRATORS IN ACTION: IT'S A BIRD! IT'S A PLANE! NO, IT'S IGOR!'*, SYSTEMS INTEGRATION, MARCH 1990, PP: 46-52

Sikorsky Aircraft tries to design a new helicopter with the help of concurrent engineering. By facilitating concurrent engineering, the computer system is expected to help cut product development time.

MAIN, JEREMY, *'MANUFACTURING THE RIGHT WAY'*, FORTUNE, MAY 21,1990, PP: 54-64

Throughout the 1980s, manufacturing productivity grew much faster in Japan than in the USA. Academics, consultants, and executives agree that in the US industry must focus on 3 key aspects of manufacturing: people, process, and design. Companies that try to improve their manufacturing sometimes make the mistake of seeking piecemeal changes in automation or just-in-time inventory controls without first examining the whole process. The Japanese use concurrent engineering, simultaneous designing the product and the process to make it. Some US companies, such as Digital Equipment Corp., are now using this technique. The best designs are also simple. Giddings & Lewis (Fond du Lac, Wisconsin) designed a tool that performs as well as the old one but costs 35% less. the US production system is buffered and inflexible. The Japanese system reacts quickly to a customer's request, pulling goods through the factory on demand, and inventories are minimized.

MALINIAK, LISA, *'THE PATH TO CONCURRENT DESIGN'*, ELECTRONIC DESIGN, JUNE 11, 1992, PP: 18

Concurrent engineering may be the design methodology of the future, but the dream is not yet reality. The concept is to have engineers of all disciplines working on a project as a team to shorten time-to-market and reduce costs. Implementing a looking companies are not just updating the factory layout, but they also analyzing how a factory should be managed, who ought to run it, and how it should fit in with the rest of the corporation. In 2000, more factories will be focused. They will concentrate on a particular type of product rather than be a jack of all trades.

MCKINNIS, CRAIG; BRUSCH, RICHARD, *'CONVAIR GOES CONCURRENT'*, CAE, FEBRUARY 1991, PP: 18-27

In the mid-1980s, the Convair Division of General Dynamics decided to embark on a long-term program of continuos improvement in processes, organization, and methods, which the company called Integrated Management System (IMS). The program focuses on 3 fundamental elements of the product life cycle-design, production, and logistics support. The spirit of Convair's IMS program is embodied in a philosophy called total quality management (TQM). Because it is so fundamental to the TQM philosophy and success of the overall program, introduction of concurrent engineering was the first major objective of the IMS development team. Convair first implemented it in a prototype project over a period of 7 months in 1989. This project addressed real world technical issues and involved design, analysis, production, and logistics. It also produced a model for implementing concurrent engineering throughout the company. The project encompassed 2 principal characteristics of concurrent engineering - a multidiscipline team and free interaction among team members.

MCKNIGHT, SELDON W.; JACKSON, JERRY M., *'SIMULTANEOUS ENGINEERING SAVES MANUFACTURERS LEAD TIME'*, INDUSTRIAL ENGINEERING, AUGUST 1989, PP: 25-27

Simultaneous engineering is the concurrent development of project design functions and with open and interactive communication among all team members for the purpose of reducing lead time from concept to production launch. A leading example of simultaneous engineering is in the automotive industry, where it bring product, process, and facility personnel into the project at the outset of the design phase. also included on the project team are equipment and part suppliers and representatives from marketing, sales, and distribution. Simultaneous engineering saves time from project concept to launch because all disciplines required are members of the progression. Industrial engineers, because of their orientation toward efficiency, will be well-suited for process engineering, particularly with the current emphasis on design-for-assembly.

MERRICK, LEW, *'A BETTER WAY TO SEND ENGINEERING DRAWINGS'*, MACHINE DESIGN, JUNE 25, 1992, PP: 44-46

Concurrent engineering often involves transmitting drawings and design information to distant manufacturing sites. Fax machines, while good for sending text, are not the answer for technical sketches and drawings. Fax machines distort the drawing so that true scale is lost. Such a problem is avoided when computer-aided design (CAD) data sets are exchanged by modem. Neutral data formata allow CAD system to read information from others quickly and accurately. The 2 most widely used neutral data formats are Product Description Exchange Standard/Initial Graphical Exchange Standard (PDES/IGES) and Drawing eXchange Format (DXF). Wide use of DXF has made it the de facto standard equipment on half of the communication solution, should be standard equipment on every engineering computer. A 2,400-bps modem transmits a megabyte of data per hour, and DXF file for an average E-size drawing runs 1M to 1.5M-bytes. An archive utility, however, can compress the file down to 250k to 500k bytes.

MILLS, ROBERT, *'CONCURRENT ENGINEERING: ALIVE AND WELL'*, CAE, AUGUST 1993, PP: 41-44

There are as many interpretations of concurrent engineering (CE) as there are practitioners. Most experts divide CE into three areas: people, process, and technology. One of the primary people issues is the formation of teams. Teams are often used to help make the transition to CE. Training also plays an important role in CE. A popular word in the business press is reengineering, meaning, in short, to revamp the processes by which one satisfies customers' needs. By many accounts, CE means reengineering of the product development process. Software, hardware, and networks make CE practical in today's world of multinational corporations, multipartner projects, and virtual corporations. Some technologies commonly used in CE include soft prototyping, visualization, product data management, design for manufacture and assembly, and video. Most experts say CE takes years to implement. Everyone seems to agree that it is worth the effort. CE has helped the firm eliminate errors and cut design-to-production time.

MILLS, ROBERT, *'CONCURRENT ENGINEERING: HARDWARE ARCHITECTURE'*, CAE, OCTOBER 1991, PP: 78-86

Many engineers trying to implement concurrent engineering (CE) confess that they have a difficult time keeping up with the latest hardware. One solution is to borrow an idea from CE -teams- to tackle computer problems. Networks play a large role in linking systems together, creating a communications web that vastly increases the flow of information necessary for CE. Networks make it possible for each engineer to have a window onto the corporate computing system. Despite available technology, many of these networks are not extended to suppliers and clients. While CE is much more than integrated computer-aided design and manufacturing, systems integration plays a critical role in getting all the hardware and software to function together. Like CE itself, systems integration is often handled by a multidisciplined team.

MILLS, ROBERT, *'LINKING DESIGN AND MANUFACTURING'*, CAE, MARCH 1991, PP: 42-48

Networking enables virtually any user to access the multitude of computer workstations, personal computers, and larger computers present in today's design and manufacturing organizations. Amidst this environment, managers are trying to: 1. integrate design and manufacturing, 2. implement concurrent engineering, 3. reduce time to market, 4. design for manufacture and assembly, 5. foster teamwork, 6. reduce costs, and 7. eliminate late engineering changes. Product data management (PDM) could be the missing link for managing and controlling the flow of information between design and manufacturing. While there are many differences between products, the basic PDM system components are: 1. database management systems, 2. networks and network services, and 3. user interfaces. Their functions include file management, review and release management, and project and product management.

MILLS, ROBERT; BECKERT, BEVERLY A., *'CONCURRENT ENGINEERING: SOFTWARE TOOLS'*, CAE, OCTOBER 1991, PP: 58-76

In concurrent engineering (CE) efforts, software not only automates tasks, it actually allows companies to change their workflow to better facilitate communications, teamwork, and early involvement. Processes are reengineered to take full advantage of computer-aided design, manufacturing, and engineering tools. CE efforts involving mechanical design are typically built around 3-dimensional models. Solid models enable team members to visualize the product from the earliest stage of design. Rules-based engineering systems are said to be ideal for CE since rules concerning all facets of a product can be encapsulated into one program. In true CE, analysis guides rather than validates the design, providing early and continual feedback on product performance and sometimes even other factors, such as manufacturability. The task of ensuring that designs developed upstream actually can be built is becoming easier thanks to CE strategies and the software that supports them.

MILLS, ROBERT; BECKERT, BEVERLY; CARRABINE, LAURA, *'CONCURRENT ENGINEERING: THE FUTURE OF PRODUCT DEVELOPMENT'*, CAE, OCTOBER 1991, PP: 38-46

The basic concepts of concurrent engineering can be applied in almost any firm involved in design, analysis, and manufacturing. While current engineering in the 1990s practically demands computers, teamwork plays an equally vital role. Improved quality is a fundamental goal of concurrent engineering. Most of this comes in the form of playing attention to details, doing things right the first time, and catching mistakes early while they are still easy to fix. Probably the biggest barrier is natural human resistance to change. Changing responsibilities may result in turf wars as people are reluctant to give up grounds gained in the past. Experts warn that the impetus for change must come from top management. In the industrial world of the 1990s, where alliances and partnerships are the rule rather than the exception, concurrent engineering often means forging closer relationships with other companies, be they partners, suppliers, or clients.

MISKA, KURT H., *'ASSESSING AUTOMATED ASSEMBLY'*, MANUFACTURING ENGINEERING, JUNE 1990, PP: 65-68

Improved design or redesign of products can make automated assembly possible, even desirable. According to the vice-president of Bondine Corp., the biggest change in the industry is the trend toward simultaneous engineering and it requires builder-user collaboration. In addition to flexibility, users want modular assembly systems. one advantage of modularity is that it can accommodate moving stations around because of changes in product design or integrating other technologies, such as laser marking.

MURRAY, J. CHARLES, *'ENGINEERS AND RESEARCHERS: TEAMWORK'*, DESIGN NEWS, MARCH 7, 1989, PP: 66-69

This article presents how communication and simultaneous engineering concepts implemented in Deere management in order to bring 9000 series to market more quickly.

MUSSELWHITE, W. CHRISTOPHER, *'TIME-BASED INNOVATION: THE NEW COMPETITIVE ADVANTAGE'*, TRAINING & DEVELOPMENT JOURNAL, JANUARY 1990, PP: 53-56

A time-based innovation strategy for rapidly turning new technology into new products or for quickly making incremental improvements in existing products will be adopted by companies seeking a competitive advantage in the 1990s. Traditionally, clear boundaries have been maintained between the functional stages in the product cycle in manufacturing organizations, often resulting in a need for redesign. Approaches to product development and improvement that view manufacturing organizations as a system include: 1. early involvement manufacturing, 2. concurrent engineering, and 3. design for manufacturability and assembly (DFMA). Fortune magazine reports that the use of DFMA, which uses a cross-functional team approach to development and improvement, has reduced new product introduction time by 50%-70%. The early input of manufacturing and assembly people makes it easier to identify time-, labor-, and material-saving measures, eliminating lengthily delays for redesign and clarification.

NOAKER, PAULA M., *'MANUFACTURING BY DESIGN'*, MANUFACTURING ENGINEERING, JUNE 1992, PP: 57-59

According to Geoffrey Boothroyed of Boothroyed Dewhurst Inc., management at manufacturing companies must support the concurrent engineering (CE) team. In addition to using CE, industry consultant Sandy Munro, president of Munro & Associates, recommends a structured, analytical design for manufacturability (DFM) methodology. Munro uses DFA methodology developed by Boothroyed and Peter Dewhurst during the late 1970s: 1. Limit part count. 2. Encourage modular assembly. 3. Stack assemblies. 4. Eliminate assembly adjustments. 5. Design parts with self-locating or self-fastening features. 6. Specific standard parts. 7. Limit levels of assembly. James Wise of AMP Inc., which makes a variety of electrical connector housings, noted that it is not necessary to be a high-volume producer of deverse, complex assemblies to benefit from DFM. Wise reported that DFM is the foundation of AMP's effort to design for 6-sigma performance.

NOVELINO, JOHN, *'CONCURRENT ENGINEERING: ANOTHER VIEW'*, ELECTRONIC DESIGN, JUNE 25, 1992, P: 18

One of the major advantages associated with concurrent engineering is that it can bring products to market quicker than conventional development cycle technology.

Some analysts argue, though, that concurrent engineering should actually be called concurrent development, and is a parallel process that involves not only engineering and manufacturing, but also many product quality issues. These analysts argue that this approach to concurrent development will result in a more robust design, specification, and implementation. Some analysts support this theory by maintaining that most research and development failures occur due to management breakdown. They also argue that concurrent engineering alone may speed up the development cycle, but it will not ensure quality products at the end of it.

O'NEIL, CHARLES, *'CONCURRENT ENGINEERING WITH EARLY SUPPLIER INVOLVEMENT: A CROSS-FUNCTIONAL CHALLENGE'*, INTERNATIONAL JOURNAL OF PURCHASING & MATERIALS MANAGEMENT, SPRING 1993, PP: 2-9

The view that the traditional sequential, or pipeline, approach to technology and product development is no longer adequate is explored. The rapid escalation of global competition is demanding dramatic reductions in the time-to-market cycle, along with higher quality levels and lower costs. Anecdotal evidence points to concurrent engineering complemented by early purchasing and supplier involvement, as an approach with tremendous potential in addressing the 3 key issues of time, quality, and cost. The 2 most significant features of concurrent engineering are: 1. customer focus centering on doing the right things, and 2. cycle time reduction focusing on doing things right the first time.

O'NEIL, CHARLES, *'CONCURRENT ENGINEERING WITH EARLY SUPPLIER INVOLVEMENT: A CROSS-FUNCTIONAL CHALLENGE'*, INTERNATIONAL JOURNAL OF PURCHASING AND MATERIALS MANAGEMENT, SPRING 1992, PP: 2-9

Survival in a global market characterized by escalating competition demands an increasingly more rapid time-to-market cycle combined with higher levels and lower costs. The traditional sequential or pipeline approach to the manufacturing process is thus becoming inadequate. Concurrent engineering together with early purchasing and supplier cooperation is discussed as an alternative to the traditional manufacturing process. Concurrent engineering attempts to address the key issues of time, quality, and cost by identifying customer requirements up front and incorporation these in the initial manufacturing step of initial product or process design.

OMANOFF, DENNIS, *'STRATEGIC PARTNERSHIP'*, PRINTED CIRCUIT DESIGN, MAY 1991, PP: 24-31

Vendor-supplier partnership in the manufacturing process allows companies to effectively extend or increase the capability and capacity of their factories while improving quality, cycle times, and profitability. Other innovative approaches to purchasing and materials help to improve and increase the benefits of capacity and requirements planning. Concurrent engineering and data sharing enable vendors to work with their suppliers. Concurrent engineering is based on the belief that at least 80% of manufacturing costs are determined during the design process. Strategic partnership with suppliers are one way to reduce this percentage. Quality partnerships can reduce costs in design and production of printed circuit boards while improving yields through the implementation of a few simple processes. Critical to establishing quality partnerships is treating the printed wiring board (PWB) fabricator as a supplier and a customer.

OSSIN, ARCHIE; MANDL, VLADIMIR, *'PRODUCTION OPERATIONS' VITAL ROLE IN CONCURRENT ENGINEERING'*, MANUFACTURING SYSTEMS, MAY 1992, PP: 32-42

While the concurrent engineering (CE) concept was just being revived nationally in the mid-1980s, Martin Marietta's Missle Systems Co.'s Production Operations was already aggressively implementing a performance measurement team (PMT) process. PMTs meet weekly with their work-center management to discuss, track, and resolve production-related issues. In just 3 years, customer audit deficiencies were virtually eliminated, primarily through emphasis on job ownership and aggressive management support. CE provides a bridge between the design phase and production programs required to remain competitive in a shrinking defense-industry marketplace. Concepts that will greatly enhance the chance of CE success include: 1. Core technologies must be understood. 2. A cadre of manufacturing employees must be educated and trained in existing and upcoming production techniques. 3. design-to-cost models must be successfully manipulated. 4. There must be a clear awareness of the customers' requirements.

OWEN, JEAN V., *'CONCURRENT ENGINEERING'*, MANUFACTURING ENGINEERING, NOVEMBER 1992, PP: 69-73

The concurrent engineering (CE) strategy is based on time - spending more time up front to save even more time downstream. A recent report by the Computer and

POLI, CORRADO; GRAVES, ROBERT J., *'RETURN YOUR COMPETITIVE EDGE WITH CONCURRENT ENGINEERING'*, CONTROLS & SYSTEMS, APRIL 1992, PP: 28-31

Concurrent engineering (CE) is a design process involving design for function, design for manufacturablility, and design of the production process that points toward the timely delivery of a quality product to the marketplace. Design for function includes those steps of product design that consider various ways to implement the product functions into physical geometries. Once an initial design geometry for a component is available, engineers can introduce the various evaluation technologies of design for manufacturability. The evolving product design will ultimately require some process to produce it. One important area for close integration of product and process design is assembly, where technologies exist for integrating design for assembly analysis and assembly line design.

PORT, OTIS, *'A SMARTER WAY TO MANUFACTURE'*, BUSINESS WEEK, APRIL 30, 1990, PP: 110-117

While the potential advantages of concurrent engineering (CE) have been recognized for decades, earlier calls for CE were thwarted by middle management fiefdoms and lack of computerized tools to spur cooperation between departments. The present method of product development is like a relay race. Apart from wasting time, this approach fosters bureaucracy. The good news is that US manufacturers are beginning to catch on to CE, with many restructuring for this type of engineering. Using CE to harness the ingenuity of the US' small manufacturers could spark an industrial renaissance. The latest computerized tools are making CE much easier. Improved computer systems may bring CE to its most important customer of all, the Pentagon. The overriding lesson learned from the push to CE is that the US' shortcomings in producing high-quality products inexpensively and getting them to market on time are largely the result of self-fulfilling prophecies.

PORT, OTIS, *'MOVING PAST THE ASSEMBLY LINE'*, BUSINESS WEEK, SPECIAL 1992, PP: 177-180

The Agile Manufacturing Enterprise Forum (AMEF), a collaborations of 100 companies plus 2 dozen organizations and institutions, has developed a 15-year plan for creating a high-technology infrastructure that could get high-quality, low-cost products to market faster than the competition. Concurrent engineering provides a preview of the model. For peak agility, advanced computer networks will serve as an infrastructure to connect essentially every factory, job shop, and industrial design studio. The ultimate permutation would be virtual corporations - on-line partnerships. The National Research & Education Network, in the research and planning stage, will have capacity sufficient for manipulate real-time, shared computer simulations and CAD models. Agile manufacturing will face obstacles, especially in redefining management.

PORTER, ANNE MILLEN, *'JIT II IS HERE'*, PURCHASING, SEPTEMBER 12, 1991, PP: 60-67

Lance E. Dixon, director of purchasing and logistics for Bose Corp. (Framingham, Massachusetts), is the creator of JIT II, the ultimate in just-in-time (JIT) supplier partnering and concurrent engineering. In practice, the supplier representative sits in Bose's purchasing office, replacing the buyer and salesperson. Bose empowers the representative to use its purchasing orders to place orders on himself. The representative can also practice concurrent engineering, attending any and all design engineering meetings involving his company product area, with full access to Bose's facilities, personnel, and data. Dixon had the foresight to realize that, for different kinds of transactions, Bose needs people with various skills. Candidates are rigorously interviewed by Bose staff. For Bose, JIT II means fewer purchasing personnel, more favorable pricing, and reduced inventory. For suppliers, it means elimination of the sales increased volume, eergreen contracts, and efficient invoicing and payment administration.

PRATT, MAURICE D., *'CREATINGAND SUSTAINING CHANGE FOR BUSINESS RENEWAL'*, INFORMATION STRATEGY: THE EXECUTIVE'S JOURNAL, SPRING 1992, PP: 23-33

The need for fundamental change to cope with and ensure survival in an environment of dynamic markets and intense cost pressures is well documented. However, there have not been many success stories. What is necessary to bring about this change is a guiding thesis - a framework for change and business renewal and a description of the infrastructure necessary to achieve change are provided. Significant progress, however, can be made only when conventional thinking is put aside. A new paradigm is provided by the concept of concurrent engineering. Concurrent engineering is a systematic approach to achieving business renewal by considering from the outset ll the elements of a product and its related processes.

PRATT, MAURICE, *'CREATING AND SUSTAINING CHANGE FOR BUSINESS RENEWAL'*, INFORMATION STRATEGY: THE EXECUTIVE'S JOURNAL, SPRING 1992, PP: 23-33

The need for fundamental change to cope with and ensure survival in an environment of dynamic markets and intense cost pressures is well-known and well documented. However, there have not been many success stories. What is necessary to bring about this change is a guiding thesis - a framework for thinking about how to proceed or what actions to take. A framework for change and business renewal and a description of the infrastructure necessary to achieve change are provided. Significant progress, however, can be made only when conventional thinking is put aside. A new paradigm is provided by the concept of concurrent engineering. Concurrent engineering is a systematic approach to achieving business renewal by considering from the outset all the elements of a product and its related processes.

PUTTRE, MICHAEL, *'PRODUCT DATA MANAGEMENT'*, MECHANICAL ENGINEERING, OCTOBER 1991, PP: 81-83

About 30% of an engineer's time is spent finding data according to industry experts. Electronic databases are currently being used to speed the product development process at Texas Instruments Inc., Dowty Aerospace Division, Advance Machine Co., and Mattel Inc. Because computerized systems allow many different departments to access project data simultaneously, electronic databases will play an increasingly important role as companies implement concurrent engineering efforts.

RAIA, ERNEST, *'TAKING TIME OUT OF PRODUCT DESIGN'*, PURCHASING, APRIL 4, 1991, PP: 36-39

Every business is under pressure to speed up its product development cycle. Over the past decade, Xerox has not only managed to improve the quality of its copiers by almost a hundredfold, but it has also reduced product development time by more than half. These results can be attributed to the company's multidisciplinary commodity teams. These teams have become intimately acquainted with suppliers' production processes and management systems. Other companies, such as Ford and Ingersoll-Rand, have also adopted the team approach to new product development. Ford, for example, is working with selected suppliers from the outset, promising 5-year contracts in return for assistance in the early design phase. Behind the insistence on establishing partnerships with suppliers is the perception that part and process are one. This is the principal tenet of simultaneous or concurrent engineering. Simultaneous engineering not only confirms the supplier's role on the design team, but also emphasizes early involvement in the design process.

RAIA, ERNEST, *'THE CHRYSLER VIPER: A CRASH COURSE IN DESIGN'*, PURCHASING, FEBRUARY 20, 1992, PP: 48-52

The Chrysler Viper went from concept to production in 36 months. Chrysler used its suppliers as a part of the team effort in the car's design. Key suppliers were signed up even before Chrysler was fully committed to building the car. While some of Chrysler's regular suppliers balked over the size of the project, about 75 suppliers volunteered to help build the Viper. In some cases, different suppliers were teamed together to produce a complete system to accommodate the modular assembly process. The Viper represents the ultimate in concurrent engineering. For Chrysler, the Viper was a micro experiment that has provided a glimpse of how full-scale platform teams will operate in the future.

RANKIN, JEFFREY J.; OTT, DOUGLAS A., *'THE OPEN APPROACH TO FEA INTEGRATION IN THE DESIGN PROCESS'*, MECHANICAL ENGINEERING, SEPTEMBER 1992, PP: 70-75

The inability to satisfactorily integrate finite element analysis (FEA) with other design and analysis software packages is a major stumbling block on the road toward concurrent engineering - the hybrid process of fully integrated CAD/CAE/CAM technology. There are 3 general approaches to solving the integration problem: 1. direct, 2. integrated, and 3. open. Concurrent engineering requires the integration of multidiscipline technologies early in the conceptual engineering phase. Open systems provide the freedom to select the best technology for an application and add new technologies as they become available. There is a clear, progressive step path to the future of integration using open systems. At the present time, a CAD package's database is transferred through an Initial Graphics Exchange Specification (IGES) neutral file into an analysis package's data base. The next step will be to eliminate the IGES file by running a UNIX pipe between CAD and analysis, thus connecting the 2 software tasks. This will allow direct passage of the data from the CAD into the analysis package.

RASMUS, DAN, *'LEARNING THE WALTZ OF SYNTHESIS'*, MANUFACTURING SYSTEMS, JUNE 1993, PP: 16-23

Manufacturing and engineering disciplines are used to devise repeatable methods of satisfying customer needs. Concurrent engineering (CE) strives to integrate and balance product development, from initiation of the concept to the last word of customer feedback. Rather than serially extending a concept from department to department through complicated reviews, reports, and informal talk, CE strives for immediacy. Quality, manufacturing engineering, and other disciplines work together to solve problems with a proper sense of urgency. Organizational barriers break down to reveal a team dedicated to the goal of customer satisfaction. Only when opposing demands - like cost and quality - meet on a level field will customers receive the benefit of optimal solutions.

RASMUS, DAN, *'MANUFACTURING WITH A SMART WORKSTATION'*, MANUFACTURING SYSTEMS, NOVEMBER 1992, PP: 42-47

Most publications on concurrent engineering discuss teamwork and cooperation between engineers and production people. However, it can be difficult to get all the right people in the right place at the right time, therefore, knowledge-based engineering (KBE) systems, which integrate manufacturing rules with engineering tools, can be helpful in concurrent engineering. KBE tools capture the intent of the design and its underlying structure and history. By changing inputs to a product model, any number of actual products may be produced. KBE systems attend to details in ways that reflect company policy and customer wishes, allowing more time for concurrent engineering teams to resolve major variables such as functional requirements. In addition, KBE systems facilitate rapid design variations while maintaining model integrity. Several types of rules go into creating the knowledge in a KBE environment. Because KBE systems work with external systems, rules might call on knowledge in external databases like preferred parts lists.

REDDY, RAMANA; WOOD, RALPH T.; CLEETUS, JOSEPH K., *'THE DARPA INITIATIVE; ENCOURAGING NEW INDUSTRIAL PRACTICES'*, IEEE SPECTRUM, JULY 1991, PP: 26-30

The Darpa Initiative in Concurrent Engineering (DICE) was established to encourage the practice of concurrent engineering in the US military and industrial base. The development, integration, and dissemination of technologies are part of DICE's mission. The Defense Advanced Research Projects Agency (Darpa) launched

DICE in 1988 as a %-year program. DICE is conducted for Darpa by a consortium of more than a dozen industries, software companies, and universities. the consortium's overall goal is to develop an architecture for concurrent engineering in which the people working on a project can instantly communicate with each other and access, share, and store up-to-date information in a transparent way. The concurrent engineering services are being developed in conjunction with several pilot projects. West Virginia University's Concurrent Engineering Research Center operates a concurrent engineering testbed that is one of the principal vehicles for accomplishing DICE's mission.

ROSENBAUM, EUGENE S.; POSTULA FRANK D. , *'COMPUTER-AIDED ENGINEERING INTEGRATES PRODUCT DEVELOP-MENT'*, AACE TRANSACTIONS, 1991, PP: D3(1)-D3(7)

Recent advances in computer workstations are enabling the use of integrated product development (IDP), or concurrent engineering. General Dynamics/Convair and Digital Equipment Co. have entered into an agreement to develop a new engineering product development system that will seamlessly integrate diverse software programs. The IPD system is now being deployed on aerospace engineering hardware systems. The heart of the system is the Euclid 3-dimensional solid modeling system from Matra Datavision. This system enables fast, low-cost product development, rapid parametric designs, and the electronic mock-up of assemblies. The system also provides the structure to integrate analysis, productability, tool development, computer-integrated manufacturing, and integrated logistics support as part of the up-front design process.

ROSENBLATT, ALFRED, *'SUCCESS STORIES IN INSTRUMENTATION, COMMUNICATION - CASE HISTORY 4: ITEK OPTICAL SYSTEMS'*, IEEE SPECTRUM, JULY 1991, PP: 36-37

Even companies that make one-of-a-kind items, such as ITEK Optical Systems, a maker of high-technology optical and electro-optical products, find value in concurrent engineering (CE). As part of a move Litton Systems Inc. made in its divisions about 3 years ago to concrete an atmosphere of change and to improve operations, ITEK, a division of Litton, adopted total quality management and CE. ITEK decided to try CE by focusing on the teamwork aspects of design by involving many disciplines in the early stages of the design process.

ROSENBLATT, ALFRED; *'SUCCESS STORIES IN INSTRUMENTATION, COMMUNICATION - CASE HISTORY 3: RAYTHEON'*, IEEE SPECTRUM, JULY 1991, PP: 34-36

Raytheon Inc. began to adopt concurrent engineering (CE) in the mid-1980s in its Government Group, producer of such systems as the Patriot air-defense missile system. Raytheon's far-reaching CE environment now serves about 400 workstations at its Lexington, Massachusetts headquater, and throughout New England. the firm's emerging CE environment is divided into 3 parts: 1. system-level design, 2. module-level design, and 3. system management-level design. At the system level, a collection of programs being put under common user interface performs analyses. For the module-level design, an integrated set of printed-circuit board design and analysis tools, under a common framework called RAPIDS, is used. The System Management Environment, which is currently at the concept specification stage, monitors schedules and design goal budgets set by the concept environment.

ROSENFELD, LARRY, *'SMART ENGINEERING TACTICS'*, CAE, FEBRUARY 1993, PP: 80

Knowledge-based engineering (KBE) systems complement computer-aided design by adding the engineering knowledge that drives the product design process. A KBE system stores information about a product in a comprehensive product model, which is composed of design engineering rules that describe how products are designed, analyzed, and manufactured. The rule-based model is similar to a spreadsheet and can take an input specification, apply the engineering rules, and generate a product design. This model enables engineers to quickly evaluate many design alternatives or create new designs by altering the input parameters or the rules. With KBE, companies can capture the design knowledge of experienced engineers, thereby impacting the future of entire product lines. In addition, KBE promotes concurrent engineering by incorporating design, engineering, and manufacturing rules into a single product model.

ROUGHTON, JIM; *'INTEGRATING QUALITY INTO SAFETY AND HEALTH MANAGEMENT'*, INDUSTRIAL ENGINEERING, JULY 1993, PP: 35-40

The concept of total quality management (TQM) may seem new and complex, but the desire to produce quality products and services the first time, on time, and within budget is not a new idea. To be completely successful, everyone at all levels in an organization, regardless of its size, must firmly and unconditionally dedicate themselves to the philosophy and concepts of TQM. The safety and health professional is not excluded from this system. Concepts such as identifying customer needs, satisfying them, and obtaining feedback are essential to the success of any company. Safety, health, and quality managers in US companies see their jobs changed and expanded to include more supervision of supplier's product quality, employee training, and participation in concurrent engineering.

SAEED, BARUCH I.; BOWEN, DAVID M.; SCHONI, VINAY S., *'AVOIDING ENGINEERING CHANGES THROUGH FOCUSED MANUFACTURING KNOWLEDGE'*, IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT, FEBRUARY 1993, PP: 53-59

An exploratory analysis is presented of how product-development engineers can avoid many manufacturability-related engineering changes if they develop focused manufacturing knowledge. An engineer would develop focused manufacturing knowledge by working in an existing area of manufacturing most related to that engineer's development task. The occurrence of engineering changes that are avoidable with focused manufacturing knowledge does not justify that all product development engineers gain this knowledge. However, engineers who design components with significant history of manufacturability problems should develop this knowledge to realize the benefits of engineering changes avoidance. Organizations should manage the development of focused manufacturing knowledge.

SCHLACK, MARK, *'IS HAS A NEW JOB IN MANUFACTURING'*, DATAMATION, JANUARY 15, 1992, PP: 38, 40

One of the main improvements under way at US manufacturing companies is concurrent engineering. Although concurrent engineering complements some of the other cultural revolutions playing out in industry, it has its own set of dynamics and requirements. Chief among them is a highly automated flow of computerized product information between people and applications, made possible by enterprise networks. Substantial returns can be realized by implementing concurrent engineering. the cost of labeling products was reduced by 90% at Baxter Healthcare Corp.'s I. V. Systems Division by electronically linking desktop publishing systems used to all the product information. Considerations for companies implementing cross-departmental information systems include: 1. the messaging standard for sharing data between applications, 2. the standard for getting data in and out of databases, and 3. the global access method to reach databases.

SCHOPACH, STEPHEN C., *'KEY TO CONCURRENT ENGINEERING: MANAGING PRODUCT DATA'*, AUTOMATION, AUGUST 1991, PP: 36-37

A product information management (PIM) system puts all of the files created by computer-aided design ((CAD), engineering , and manufacturing tools under a central authority. PIM also manages the relationship among various design files and controls access to them throughout the product life cycle. The system performs all of the administrative chores in the release process automatically and consistently throughout the computer-integrated manufacturing (CIM) environment. However, most emerging automated PIM systems are vendor-specific and highly centralized. The need for a global PIM setting is essential in concurrent engineering. In concurrent engineering, design and manufacturing engineers collaborate on product development to ensure manufacturability of designs from the start. PIM is the key to a successful concurrent engineering environment.

SEITER, CHARLES; *'SUM TOTAL 1.01'* MACWORLD, OCTOBER 1993, P: 63

Concurrent Engineering Tools' Sum Total 1.01, a calculator utility, is reviewed. The calculator can operate in standard, programmer's and scientific modes, with a novel color mode that lets the user sample colors and use the numerical color values in calculations.

SFERRO, PETER R., BOLLING, G. FREDERIC; CRAWFORD, RICHARD H., *'IT'S TIME FOR THE OMNI-ENGINEER'*, MANUFACTURING ENGINEERING, JUNE 1993, PP: 60-63

The next decade will see the evolution of a new engineering philosophy called direct engineering (DE), a successor to concurrent engineering (CE), which attempts to change the way various engineering disciplines communicate. However, DE takes this process further by providing engineers with a complete knowledge about the design and manufacture of a part from an engineering database of existing designs. A key aspect of DE is that this database produces not raw data but manufacturing and production relationships among design parameters which are captured as constraints. Furthermore, DE reduces lead time at the start of manufacturing and reduces engineering changes. Nevertheless, the success of DE will depend on blending a number of technologies: 1. free-form fabrication, 2. engineering databases, 3. group technology, 4. constraint management, 5. engineering knowledge, 6. form features, and 7. geometric modeling. Should DE succeed, it will merge product and manufacturing engineering.

SHINA, SAMMY G., *'NEW RULES FOR WORLD-CLASS COMPANIES'*, IEEE SPECTRUM, JULY 1991, PP: 23-26

Many companies in Japan, the US and elsewhere compete successfully around the world because they have adopted a panoply of techniques for developing and manufacturing high-quality products that come under the heading of concurrent engineering (CE). CE can shorten the overall product-development process since the steps along the way are handled in parallel instead of in series, as is usual. In CE environments, new products are no longer the sole domain of the research and development department. From the start of CE, product development must involve all parts of an organization. As a result, effective teamwork depends on sharing ideas and goals beyond immediate assignments and departmental loyalties. The result of CE efforts can be gauged by comparing results gained with the new development process to those experienced with older products. The CE effort should combine computer-aided engineering and design and computer-integrated manufacturing with design for manufacturing.

SIEGEL, BRYAN, *'ORGANIZING FOR A SUCCESSFUL CE PROCESS'*, INDUSTRIAL ENGINEERING, DECEMBER 1991, PP: 15-19

An organizational model is presented that creates an environment for a successful concurrent engineering (CE) process. Known as the business team, this organization is used by Sun Microsystems Inc. during the introduction of a new product. The business team consists of representatives from design engineering, manufacturing, customer service, finance, and marketing. The business team creates a formal plan that is submitted to an executive-level committee within the corporation. This plan, known as the product approval form (PAF), is in essence a product-specific business plan. Once the team has an approved PAF, a transition takes place with the establishment of tactical implementation teams and the construction of the program's communication infrastructure. Through the cross-functional deployment of manufacturing individuals and engineering individuals under the business team organization, Sun Microsystems achieved on-time delivery at cost, with high quality and no major change orders.

SMITH, PRESTON G.; REINERTSEN, DONALD G., *'SHORTENING THE PRODUCT DEVELOPMENT CYCLE'*, RESEARCH-TECHNOLOGY MANAGEMENT, MAY/JUNE 1992, PP: 44-49

As techniques like cross-functional development teams and concurrent engineering become widespread, these approaches to shortening development cycles lose their competitive edge. Decisive advantage is likely to come from the techniques competitors are not using. There are untapped sources of cycle time reduction for R&D managers to exploit. These include opportunities to accelerate the development process around a company's largest projects can be dangerous, because this can excessively delay smaller ones. The use of phased development systems is questioned, which often causes delays in attempts to standardize control projects.

SMITH, PRESTON G.; REINERTSEN, DONALD G., *'SHORTING THE PRODUCT DEVELOPMENT CYCLE'*, RESEARCH-TECHNOLOGY MANAGEMENT, MAY/JUNE 1992, PP: 44-49

As techniques like cross-functional development teams and concurrent engineering become widespread, these approaches to shortening development cycles lose their competitive edge. Decisive advantage is likely to come from the techniques competitors are not using. There are untapped sources of cycle time reduction for R&D managers to exploit. These include opportunities to accelerate the 'fuzzy front end' in which half of a typical development cycle vanishes before the team even starts to work. Structuring a development process around a company's largest projects can be dangerous, because this can excessively delay smaller ones. The use of phrased development systems is questioned, which often causes delays in attempts to standardize control of projects.

SNITS, TERRY; *'TEAMWORK IN REAL ENGINEERING'*, MACHINE DESIGN, MARCH 22, 1990, PP: 99-104

By applying the precepts of simultaneous engineering, the General Motors (GM) Chevrolet-Pontiac-Canada Group (CPC) recently produced a new sports car engine in 4 years rather than the usual 7 years. Goal-setting was of key importance in getting engineering squads from CPC, Lotus Engineering, and Mercury Marine Division to work as a single team. As part of a team using simultaneous engineering, Mercury influenced designers to use existing equipment; the implementation of needed when a project has failed to meet its goals, and CPD can improve the quality, cost and time-to-market factors of an off-target project by 10 to 30 percent.

SUHOZA, KEITH; CREQUE, ANDY, *'USING CUSTOMERS TO TRAIN ENGINEERS'*, MACHINE DESIGN, JULY 23, 1992, P: 116

Listening to customers helps engineers design product that are better differentiated and in demand and that command premium prices in the market. Implementing this theory, or bringing the voice of the customer through marketing into design engineering, usually determines a company's effectiveness in merging customer inputs with product design. Keithley Instruments Inc. has implemented a program that allows engineers to spend 2-3 months in the Application Department with individual goals for each engineer. The rotation program produced the following changes: 1. better product definition, 2. better informed engineering decisions, 3. better and faster concurrent engineering efforts, 4. the shipment of improved demo programs with new products, and 5. the improvement of the Applications Department because of the informal communications established between it and the Design Engineering Department.

TERESKO, JOHN, *'ENGINEERING: WHERE COMPETITIVE SUCCESS BEGINS'*, INDUSTRY WEEK, NOVEMBER 19, 1990, PP: 30-38

The steps to world-class manufacturing in the engineering context begin with an understanding of the benefits of designing the product and the process together and the need for quickly getting product concepts to market. The emphasis is not on technological solutions, but on how people integrate solutions. At General Motors' Saturn Corp. subsidiary, the conventional practice of dividing product development into separate tasks to be done sequentially is not followed. Instead, the organization uses simultaneous engineering so that projects are shaped by teams. Represented on these teams are finance, marketing, product design, manufacturing engineering, materials engineering, service, and suppliers. By getting everyone together at the engineering-concept stage, when 70% of a project's costs are committed., problems are solved before any implementation begins.

THURSTON, DEBORAH L., *'CONCURRENT ENGINEERING IN AN EXPERT SYSTEM'*, IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT, MAY 1993, PP: 124-135

Concurrent engineering requires site-specific, simultaneous evaluation of manufacturing cost and other performance measures early in the design process. This paper explores the synergistic relationship between knowledge-based expert systems and multiattribute utility analysis (MAUA). MAUA is an operations research tool for problem solving where a choice must be made between alternatives, each represented as a set of conflicting objectives. The integrated artificial intelligence/MAUA approach leads to improved selections for atypical users without compromising the performance of the system for the more stereotypical designer. An additional advantage is that introduction of new materials is simplified, as tradeoffs between the new and existing materials are handled by utility analysis. This computer aid permits engineering managers to incorporate factors specific to their manufacturing system into the design process. The methodology is illustrated using the material selection process for components of an automobile bumper.

TUNC, ENAR A.; GUPTA, JATINDER N.D., *'IS TIME A COMPETITIVE WEAPON AMONG MANUFACTURING FIRMS?'*, MANAGEMENT JOURNAL OF OPERATIONS & PRODUCTION, 1993, PP: 4-12

A study investigated the use of time as a competitive weapon in manufacturing firms in Indiana to determine the extent to which time-based management is used as a competitive weapon. Nineteen firms responded to mailed surveys. The average size of responding firms was 800 employees, ranging from fewer than 50 to more than 2,000. The results revealed that the majority of responding firms believe that quality is the most important competitive priority and that it will remain the most important in the 1990s. The firms' inventory turnover and customer order processing time do not affect their total sales. While the use of processing time do not affect their total sales. While the use of several innovative techniques seemed to be related to total sales, computer-integrated manufacturing and concurrent engineering did not have any effect on total sales. the results indicated that manufacturing firms in Indiana are not using time as a competitive weapon.

technologies and methods can improve productivity and reduce cycle times and costs.

VALLENS, ANSI, *'PROGRAM IS UPGRADED TO SUPPORT CONCURRENT PRODUCT ENGINEERING'*, MODERN PLASTIC, JUNE 1993, PP: 107-109

Structural Dynamics Research Corp. has revamped its I-DEAS design, manufacturing, and engineering software to better support concurrent engineering. The Master Series software features an intuitive user interface that is designed to anticipate and preselect menu commands according to the geometry selected for product design. The series creates a 3-D model that incorporates virtually all design data, including dimensions, variational constraints, and manufacturing information. Decimal conversions are claimed to be simplified with Conversion-Master, a program from Hillcrest Software Products. Conversion-Master can exchange over 500 units of measurement in 10 general classifications and 70 physical quantities. A program to speed price quoting and improve the accuracy of volume and area calculations has been developed by Dyna Prise Inc. The program, called CVA is designed to perform difficult and tendious calculations on complex shapes to estimate material costs.

VASILASH, GARY S., *'DESIGN FOR ASSEMBLY: ONLY PART OF THE COMPETITIVE EQUATION'*, PRODUCTION, SEPTEMBER 1992, PP: 54-56

Bart Huthaite, founder and director of the Institute for Competitive Design (Rochester Hills, Michigan), contends that the results of design for assembly (DFA) have not all been beneficial. He now trains blue-chip manufacturing firms on 'design for total competitiveness'. DFA deals mainly with reducing materials and labor, but those are not the only considerations in today's manufacturing environments. According to Huthwaite, companies should work beyond DFA and design for manufacturing (DFM), in concurrent engineering environments that consider serviceability, maintainability, and reliability. Manufacturers must come to the design table early on prepared to describe what they can do and how that will affect the DFM, DFA, and other design considerations.

VASILASH, GARY S., *'HOW YOUR TEAM CAN FLY AS HIGH AS AN SR-71'*, PRODUCTION, FEBRUARY 1992, PP: 62-66

One of the biggest problems involved in concurrent engineering and design for manufacturing (DFM) is the amount of articles, papers and conferences on the subject - which do not galvanize people to action. The US is not doing well in the manufacturing business, specifically, computer hardware and software, because too much talk goes on without enough action. The problem with NASA technology is that the mode of project coordination is sequential, and that is not conducive to concurrent engineering. An elite group of engineers who comprised Lockheed's Skunk Works created 14 rules which can lead any organization to the practice of concurrent engineering, and hence DFM. These rules include: 1. Someone must be in control. 2. Strong but small project offices must be provided. 3. The number of people involved must be restricted.

VASILASH, GARY S., *'SIMULTANEOUS ENGINEERING WITHOUT THINKING ABOUT IT'*, PRODUCTION, AUGUST 1991, PP: 58-59

The employees of Ford Motor Co.'s Rawsonville Plant Ypsilanti, Michigan, may have found the right way to perform simultaneous engineering (SE). After determining that they wanted a new type of alternator, they set about optimizing the product and process. Teamwork abounds throughout the entire program, even among hourly employees. Each employee gets 2 months of training - half on the plant floor, half in a classroom. Partnering is done with equipment suppliers as well. Ergonomics has been considered wherever manual intervention required in the plant.

VASILASH, GARY S.; BERGSTROM, ROBIN P., *'CONCURRENT ENGINEERING: YES, THIS MAY HAVE A FAMILIAR RING'*, PRODUCTION, MAY 1991, PP: 64-67

A conference titled "Managing Concurrent Engineering: A Full Spectrum Approach" was held to help people meet the challenge of effectively managing all aspects of the concurrent engineering process. One speaker at the conference, DEC's David Thorpe, said that the simple working relationship between people was the single biggest difficulty related to establishing concurrent engineering program.

VESEY, JOSEPH T., *'SPEED-TO-MARKET DISTINGUISHES THE NEW COMPETITORS'*, RESEARCH-TECHNOLOGY MANAGEMENT, NOVEMBER/DECEMBER 1991, PP: 33-38

The new competitors in manufacturing are time-to-market accelerators, and they talk in terms of speed-to-market. Their product life cycles often look more like spikes than smooth flowing curves. Speed-to-market creates opportunities in market share, market leadership, and profits. It is based on 2 premises: 1. Create an organizational environment where change and innovation come naturally. 2. Adopt technology that gives people the most current, proven tools to perform their job. Key to the success of accelerators-to-market is the ability to remove the artificial barrier between the design engineers and manufacturing. Known primarily as concurrent engineering, the goal of tightening this innovative team is to produce an easily manufacturable product. As in most successful major business changes, top management must be at least supportive and , it is hoped, spurred to action.

VESEY, JOSEPH T., *'THE NEW COMPETITORS: THEY THINK IN TERMS OF SPEED TO MARKET'*, PRODUCTION & INVENTORY MANAGEMENT, FIRST QUARTER 1992, PP: 71-77

During the 1990s, the emphasis in manufacturing companies will be time to market, the elapsed time between product definition and product availability. The new competitors are time-to-market accelerators that focus on speed in engineering, sales response, and customer service. Speed to market creates opportunities in market share, market leadership, and profits. It is based on 2 premises: 1. Create an organizational environment where change and innovation come naturally. 2. Adopt technology that gives people the most current, proven tools to perform their job. The time-to-market bottleneck in manufacturing firms is in the combined design-engineering/manufacturing activity. Accelerators to market have an organizational environment that includes concurrent engineering and integrated information systems. Success requires the support of top management and its commitment to a speed-to-market operating philosophy.

VESEY, JOSEPH T., *'THE NEW COMPETITORS: THEY THINK IN TERMS OF SPEED-TO-MARKET'*, ACADEMY OF MANAGEMENT EXECUTIVE, MAY 1991, PP: 23-33

Time-to-market is becoming a highly competitive issue for manufacturing companies. In the 1990s, it may be the most critical factor for success across all markets. A new group of accelerating competitors is emerging that thinks in terms of speed to market. These business units are using shorter product life cycles and have a propensity for change that is winning market share and increasing profits. The success of speed-to-market companies depends on concurrent engineering, which gives manufacturing managers a say in designing the production and ensuring that flexibility and efficiency are available in the product phase of product development. Technological advances in information processing provide the tools necessary for concurrent engineering.

VESEY, JOSEPH T., *'TIME-TO-MARKET: PUT SPEED IN PRODUCT DEVELOPMENT'*, INDUSTRIAL MARKETING MANAGEMENT, MAY 1992, PP: 151-158

Time-to-market is becoming a highly competitive issue for manufacturing companies. It may be the single most critical factor for success across all markets in the 1990s. A new group of competitors is emerging that thinks in terms of speed-to-market. Such business units use shorter product life cycles and propensity for change to win market share and increase profits. Crucial to their success is concurrent engineering, which gives manufacturing managers a say in designing the product and ensuring that flexibility and efficiency are available in the product phase of product development. Technological advances in information processing provide tools used in concurrent engineering. Integrating computer systems is essential to informing all team members about what is happening in the product development cycle. Meanwhile, top-line executives must commit to a speed-to-market operating philosophy, providing a time-to-market goal that product developers continually strive to meet and exceed.

WHEELER, ROY, *'SUCCESS STORIES IN INSTRUMENTATION, COMMUNICATIONS - CASE HISTORY 1: HEWLETT-PACKARD'*, IEEE SPECTRUM, JULY 1991, PP: 32-33

The experiences of Hewlett-Packard Co.'s (HP) Colorado Springs Division in getting started in concurrent engineering (CE) in 1980 illustrate that all an engineer needs to get started in CE is a pencil, paper, some intelligence, and a willingness to work with peers in other functional areas. If the budget permits, computer-aided tools may be added along the way. HP's CE development process evolved naturally out of the need for increased cooperation between the various functional areas of the business as HP focused on improving manufacturability and reliability. From idea to finished product, it took HP about 1/3 the time to complete the development of its 54600 oscilloscope than it would have without CE. In applying CE to small projects, it is often difficult to ensure that part-time team members are productive on other projects when the team does not require their services that they are immediately available when their services are needed.

WHITELEY, LINDA, *'NEW ROLES FOR MANUFACTURING IN CONCURRENT ENGINEERING'*, INDUSTRIAL ENGINEERING, NOVEMBER 1991, PP: 51-53

A necessary and vital precondition to the implementation of concurrent engineering is the understanding that the design process must be integrated with materials and process requirements. Using a multidisciplinary team approach usually results in the facilitation of communication across the project, ensuring that all relevant interrelations are in the design decisions. Key team members should include not only design engineers, but also quality assurance, manufacturing, logistics, materials, reliability and maintainability, and the customer. The design team need to clearly understand the functions and performance of the product and the design phase. value engineering is planned and formalized, and it contributes over and above what the normal application of common sense can accomplish without it. Manufacturing executives must explore a structured team approach to improving overall performance in the design, manufacture, and sale of products and systems.

WONG, JULIUS P.; PARSAEI, HAMID R.; IMAM, IBRAHIM N.; KAMRANI, ALI K., *'AN INTEGRATED COST ESTIMATING SYSTEM FOR CONCURRENT ENGINEERING ENVIRONMENT'*, COMPUTERS & INDUSTRIAL ENGINEERING, 1991, PP: 589-593

Concurrent engineering is the simultaneous design of a product and the processes required to produce it and support it. When implemented, concurrent engineering can help to reduce product development cycle time for the introduction of high quality products at low cost. Often, the traditional cost estimating systems are utilized in the concurrent engineering environment. The traditional cost estimating systems are not structured for concurrent engineering. An integrated cost estimating system specifically designed for concurrent engineering (ICESCE) is designed to work in the concurrent engineering environment and to enhance the power of concurrent engineering. The design of ICESCE consists of 4 modules: a database module, a central processing module, an interface module, and a utility module. The construction of a prototype of ICESCE is being initiated at the University of

Louisville. The database management utilities will use relational database techniques and conform to structured query language standards.

WOODRUFF, DAVID; PHILIPS, STEPHEN, *'A SMARTER WAY TO MANUFACTURE'*, BUSINESS WEEK, APRIL 30, 1990, PP: 110-117

This article gives concurrent engineering examples from NCR, Westing House's electronic group. In Atlanta, NCR the specialists involved in design, software, hardware, purchasing, manufacturing, and field support all work side by side and compare notes - the overriding factor is getting products out of time. At Westinghouse's Electronic Systems Group, both design and manufacturing have been put under one manager, cross-functional teams are working together more smoothly and mediating their own disputes in a fraction of time, teams communicate electronically and make decisions themselves, this eliminates organizational approval process.

YANG, DORI JONES, *'BOEING KNOCKS DOWN THE WALL BETWEEN THE DREAMERS AND THE DOERS'*, BUSINESS WEEK, OCTOBER 28, 1991, PP: 120-121

Until recently, design engineers and manufacturing types at Boeing Co. seldom mixed; Boeing inserted an invisible barrier between the dreamers and the doers. With the 777 airplane operation, engineers are working side by side with designers in an approach called concurrent engineering (CE). A computer system that runs a solid-modeling program allows engineers to solve problems on video screens instead of on expensive life-size mock-ups. The new process brings together representatives from design and production and Boeing's outside suppliers, with regular input from customers, maintenance, and finance. Boeing hopes that this paperless design will save as much as 20% of the 777's estimated $4-billion to $5-billion development cost.

YESERSKY, PAUL T., *'CONCURRENT ENGINEERING - YOUR STRATEGIC WEAPON IN TODAY'S JUNGLE'*, CMA MAGAZINE, JULY/AUGUST 1993, PP: 24-27

One of the most exciting changes taking place in North American industry is the shift in attention to process and people. Concurrent engineering (CE) is a business strategy that is focused on the planned deployment of a corporation's resources. It involves major changes because it requires the integration of people, business methods, and technology and is dependent on cross functional organization. Collaboration rather than individual effort is standard, and shared information is the key to success. CE is not a quick fix to an organization's problems; it is a long-term strategy that should be considered only by firms willing to make the up-front investments required to reap the long-range benefits. CE involves major organizational and cultural change. The role of the leader is to supply the basic foundation and support for change. Team members must commit to working cross-functionally, be collaborative, and constantly think and learn.

ZIEMKE, M. CARL; MCCOLLUM, JAMES K., *'SIMULTANEOUS ENGINEERING: INNOVATION OR RESURRECTION?'*, BUSINESS FORUM, WINTER 1990, PP: 14-17

In contrast to the incremental system that US automobile makers have been using in product development, a simultaneous engineering system has all key personnel needed for product development and production working together as a team. The results in a major reduction in product development time. The development of the current simultaneous engineering management concept is a response to the lack of the kind in leadership provided in the past by such "industrial gurus" as Henry Ford and Walter Chrysler. In addition to understanding all of the main aspects of product development and production, these men had the leadership qualities needed to inspire teamwork between departments. Unfortunately, in today's specialized management of technology, few managers are able to develop the broad expertise necessary to provide balanced, integrated management. Even if simultaneous engineering can match the short model change schedules of the Japanese automakers, new US car models will remain inferior until US manufacturers overcome their fear of technical risks.

ZIEMKE, M. CARL; SPANN, MARY S., *'WARNING: DON'T BE HALF-HEARTED IN YOUR EFFORTS TO EMPLOY CONCURRENT ENGINEERING'*, INDUSTRIAL ENGINEERING, FEBRUARY 1991, PP: 45-49

Concurrent engineering, a modern organizational buzzword in the US, is a process in which a major new product or significantly different new model of an existing product line is designed, developed, manufactured, and marketed. The serial approach to the process often taken in many large US firms has several disadvantages, such as a lengthened product development cycle. The failings only become apparent in comparison with approaches taken by competitive products in less time. They typically form design and manufacturing teams around senior gurus and work as a united, interdepartmental group on major projects. Concurrent engineering stands a far greater chance of success if it is used as a tool, rather than a crutch, and is applied wholeheartedly.

ZORPETTE, GLENN, *'SEEKING NUCLEAR SAFEGUARDS - PART 1: HOW IRAQ REVERSE-ENGINEERING THE BOMB'*, IEEE SPECTRUM, APRIL 1992, PP: 63-65

If it had succeeded, Iraq's attempt to produce a nuclear weapon might have yielded a stunning case study of concurrent engineering. The Iraqis pursued many phases of development in parallel and closed off options only when they presented insurmountable obstacles. The program used elements of reverse engineering by exploiting projects and developments that had been abandoned by earlier experimenters in the US and elsewhere. It drew heavily on materials, hardware, and information acquired from outside the country, often illegally or unethically. The facility at the Al Tarmiya industrial site is typical of how Iraq combined deception, secrecy, hard work, research, exploitation of open literature on nuclear science, illegal acquisitions, and the expenditure of large sums of money to build an immense program for nuclear weapons development. The exact dimensions and scope are still not fully known and may never be known. It is estimated that the country spent the equivalent of billions of dollars over a decade and employed at least 12,000 people in its pursuit of an atomic bomb.

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