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Development of a Systematic Approach to the Implementation of a Computer Integrated Manufacturing (CIM) for Small to Medium Sized Companies

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DEVELOPMENT OF A SYSTEMATIC APPROACH TO THE IMPLEMENTATION OF A COMPUTER INTEGRATED MANUFACTURING (CIM) FOR SMALL TO MEDIUM SIZED COMPANIES

by

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I cannot proceed without acknowledging the support from my wife, Mary, and family. They sacrificed while I stepped away from the manufacturing environment and pursued a personal goal. I hope that they will always consider their sacrifice as worthwhile.

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CIM technology is rapidly becoming an essential part of businesses of all types and sizes. The impact on the culture of the enterprise is possibly of even greater complexity. Most existing implementations have been done by large businesses large teams of specialized talent.

The unique scope of this work is to simplify the implementation of CIM for small companies. The basic research derived from the WMU/IBM CIM Management Center, a fully functioning CIM facility that provides hands on experience to students and regional businesses.

The cultural references concerning CIM are derived from reading and personal experiences with industry while setting up CIM technology to satisfy competitive needs.

The appendix of the paper is a listing of significant hardware, software, and functions supported in the WMU/IBM CIM Management Center. While not directly transferable to any other CIM system it provides valuable reference to functioning technology. The paper should also help others attempting to evaluate available CIM options.

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CHAPTER I

INTRODUCTION

The introduction of computers to the manufacturing environment continues to create difficulties and strategic problems. Computers continue to be cited as a salvation to many of the problems plaguing the manufacturing companies around the world. With all the positive press, and the continual advances in the power of computers, why are many of the manufacturing firms in the United States falling behind. Obviously the existence of computers, or their placement in manufacturing firms is not the critical issue. The fact is, that computers are only a sophisticated tool that if properly used can benefit the manufacturing community. Improperly used these same computers can create massive roadblocks to success. They can generate mounds of data in seconds, when they are programmed to do so. Because of the strict rules of instruction that they demand, they can also absorb countless hours of a users time in learning, and debugging applications.

These and many other technical problems are slowing the productive use of computers in the manufacturing environment. Rather than detail all the reasons why computers are not contributing to the productivity of manufacturing companies, this report will develop a systematic plan for the implementation of Computer Integrated Manufacturing (CIM) for the small to medium sized company. The plan is not a step by step program for the introduction of CIM to the manufacturing enterprise, because of the myriad of differences found in this class of organization. This report will identify the broad scope of considerations necessary to successful application of CIM technology in this class of organization. This report will fully develop the decision factors required, so that an individual company might recognize where they can benefit, and where they should deviate from the mainstream.

Definition of Terms

A definition of technical terms, is essential to the common understanding of the requirements to develop a CIM system for small to medium sized companies. No single source provides a comprehensive definition of even one of these items, that is not at least contradicted by at least one other reliable source. This listing should only be used to settle disputes with regard to my position. A listing of many of these definitions follows:

1. CIM - Computer Integrated Manufacturing: CIM links Automation to optimize the flow of information and material through the manufacturing process. Targowski (1990) states, "The CIM process simplifies, automates, and integrates manufacturing" (p. 253). This definition shifts the emphasis away from the computer hardware to the information that the computers process. This is a critical issue, it is important to realize that the final goal is to improve productivity through the use of CIM not just to insert computers into the

manufacturing process.

2. CAD - Computer Aided Design: CAD is the use of computers to aid in the efforts to speed the process of design. CAD can be defined as any design activity that involves the effective use of the computer to create, modify, or document an engineering design. CAD is most commonly associated with the use of an interactive computer graphics system, referred to as a CAD system[1].

3. CADD - Computer Aided Design & Drafting: The enhancement of CAD that provides a graphical output ie: a sketch, plan, or design of something to be made. This picture is frequently used by the manufacturing organization to convey size specifications of a component or part.

4. CAM - Computer Aided Manufacturing: CAM is defined as the effective use of computer technology in the planning, management, and control of the manufacturing function. CAM can be divided into two broad categories[2]: (1) manufacturing planning and (2) manufacturing control.

5. Manufacturing Planning: CAM applications for manufacturing planning are those that develop the organization and planning necessary to forecast activities. Activities such as: (a) cost estimating, (b) process planning, (c) production planning, and (d) inventory planning.

6. Manufacturing Control: CAM applications for manufacturing control are those that deal with the physical operation of the manufacturing process: (a) process control, (b) quality control, (c) shop floor control, and (d) process monitoring.

7. Electronic Mail (not telecommunication): E-Mail is a system that supports the manufacturing process paperwork function. Primarily it replaces the "Memo" and "Note" level of paperwork with an Electronic substitute. The advantage is the speed of transfer in information, E-Mail is almost instantaneous.

8. Documentation: Documentation in a manufacturing system consists of letters, memos, notes, drawings, bill of materials, specifications, test requests, test results, accounting information, and other "written" material that is associated with the design and manufacturing of a product. Archiving this documentation is a major activity.

9. BOM - Bill of Material: A listing of raw materials, parts, and subassemblies, generally in a tree-like structure. This listing provides the organization with a complete list of necessary components in order to put a product together.

10. Master Production Schedule: A listing of what end products are to be produced, how many of each product are to be produced, and when they will be ready for shipment. The master production schedule must be based on an accurate estimate of demand and a realistic assessment of the production capacity[3].

11. CAPP - Computer-aided Production Planning: The scheduling of labor and equipment capacity required to meet the master production schedule. Identifies the limitations of the production resources so that an unrealistic master schedule is not planned.

12. Office Automation: Computer-aided systems that enhance and speed the processes in an office environment. The ability to query the database, develop special reports, analyze trends, develop strategies utilizing live information from the enterprise.

13. Bar Code: A sequence of thick and thin bars and spaces that can be interpreted electronically to represent code characters. The use of bar coding greatly enhances the component movement and control through the manufacturing process.

14. LAN - Local Area Network: A non-public communications system that facilitates the connection of computerized devices, so that data can be transferred and shared.

15. Sequential Engineering: The traditional design to production cycle, where each task is completed before the next is initiated. This leads to a long design process time and frequent conflicts in processing the final product.

16. Concurrent Engineering: A technology based design to production cycle that compresses the process by making all data available at all times to each group in the design phase. This leads to interactive design concepts, adjustments in design to improve processes, the incorporation of innovative design features, and a greatly reduced design to process time.

17. Generalists Specialist: A non-traditional technologist. One that cross connects technologies, translates technical concepts from area to area of expertise. Usually a very technical person with exceptional insight and communication skills.

18. MIS - Management Information Systems: An organized use of data, computer equipment, and system logic that provides information to management. The purpose is to help in the decision processes used by an organization. Frequently the name of the Computer Systems Department.

19. WIP - Work In Process: The production output that is in an incomplete state, during the normal manufacturing process.

20. ROE - Return on Equity: A financial term that compares an investment to the percentage profit that it earns. Equity is a general term for the companies value on the market.

21. DCF - Discount Cash Flow: A financial term that values an investment over its profit return during the expected useful life.

22. NPV - Net Present Value: The current value of an investment, taking into account interest, depreciation of assets, and profits earned.

Definition of Conditions

1. Target Size of Company: The small to medium sized company target is between approximately 50 to 400 employees.

2. Product Type: Short run manufacturing and or assembly of small to mid sized products sold through a limited distribution system, not the public.

3. Customer Base: The customers are a limited group primarily made up of repeat business. The customers probably have already developed many of the CIM technologies for their own use.

4. SKU's - Stock Keeping Units: SKU's are the number of variations of the final product. This total number is probably between 50 and 200 discreet variations.

5. Competition: The major competition for the small to mid sized company is probably regional or national. A small percentage of sales may possibly be international. The bulk of the competitors are currently profitable and are expanding the market.

6. Finances: The company is profitable and can sustain a multi-year commitment to introducing new technology and philosophies at all levels.

7. Design Teams: The Individual members chosen to work on a project. Usually selected from multiple departments, so that the design teams have a balance of "experts" to maximize the benefits of the design.

8. Current Technologies: The company has already introduced some of the specific technologies defined in the core technologies of CIM.

9. Current Resources: The company has a small core of technical personnel capable of implementing CIM technology along with continued support of the manufacturing efforts.

Endnotes

1. Groover, Mikell P., Automation, Production Systems, and Computer Integrated Manufacturing, 1980, Prentice Hall, p. 709.

2. Groover, p. 718.

3. Groover, p. 733.

CHAPTER II

ENVIRONMENTAL AND ENTERPRISE EXPECTATIONS

CIM Enterprise

A truly Computer Integrated Manufacturing Enterprise may never really be achieved. Computer Integration is a continuum, from virtually no use of the computer to a fully integrated and automated enterprise. To simplify the working definition of CIM, we can look at some definitions. Dr Andrew Targowski defines "Computer Integrated Manufactory (CIM) - links together Computer Aided Design and Drafting, Computer Aided Process Planning, Computer Aided Manufacturing, and Operations Control System through Manufacturing Automation Protocol".[4]

International Business Machines Corporation (IBM) suggests that in today's world a business has to function in a complex business environment. To manufacture a product the business must coordinate resources, facilities, and people, such that they can interact flexibly to meet changing market conditions. IBM goes on to suggest that any system must respond to changing requirements in the enterprise (conditions inside the company) and its environment (conditions outside the company). To this end IBM defines CIM:

> CIM is a long-term strategy for the management and implementation of multiple technologies through information systems technology. Its purpose

> is to support management efforts in meeting the goals and objectives of the business by integrating the enterprise's business processes, data and resources. (Computer Integrated Manufacturing, p. 2)

These two definitions and many others have several common threads. CIM is the interfacing technology between the complex and diverse operating systems within the manufacturing enterprise. Although CIM is closely aligned with the operating systems, it really is not dependent on any specific technology or operating system. CIM is more of a Corporate Culture than a combination of particular hardware and software to do a specific task. There is no line of demarcation to tell us when a company has achieved Integration in manufacturing or any other area in the enterprise. The highly regarded CIM company of today, may not be considered a CIM company by standards established at a relatively short future date. The measure of integration that is required for a Company to claim that they are a CIM company will continually change. As new technologies emerge and find their way into the manufacturing work place CIM technology will be required to advance accordingly. The continuum span of CIM should broaden, rather than converge to a single point.

There may be some worth in looking at corporate cultures to help define CIM. Terrence Deal and Allan Kennedy, in their book, Corporate Cultures: The Rights and Rituals of Corporate Life, say, "a corporate culture, a cohesion of values, myths, heroes, and symbols that has come to mean a great deal to the people who work there" (1982, p. 4). The values include: flexibility, efficiency, responsiveness, open communication, profitability. The myths include:

automation, reduced inventories, shortened lead times, minimized excessive inventories, maximum inventory turns, JIT. The heros include: Corporate icons like IBM, Allen Bradley, General Electric; industrial leaders like Donald E. Petersen, former CEO of Ford Motor Company, Steven Jobs, founder of Apple Computer, Bill Gates of Microsoft, technical leaders from within the organization, the implementors of technical excellence. The designers of the latest products, the coordinators of the new process, the justifier of the newest equipment. The symbols of the Corporate Culture include: Computers on every desk, E-Mail, cellular telephones, beepers, multimedia presentations.

All of these symbols, heroes, myths, and values are found in the typical CIM system. This should only provide incentive to organizational leaders to implement the many practical manufacturing enhancements that are developed to improve productivity, and improve profitability.

Steps to a CIM Enterprise

If we proceed on the assumption that CIM is a Corporate Culture, rather than specific hardware and software, it is necessary to define the scope of the project. Starting with a block diagram (Figure 1) of the business will provide a central foundation.

The major components of the common manufacturing business include: (a) production, (b) engineering, (c) distribution, (d) administration, (e) marketing, and (f) finance. The design and manufacturing team is made up of members

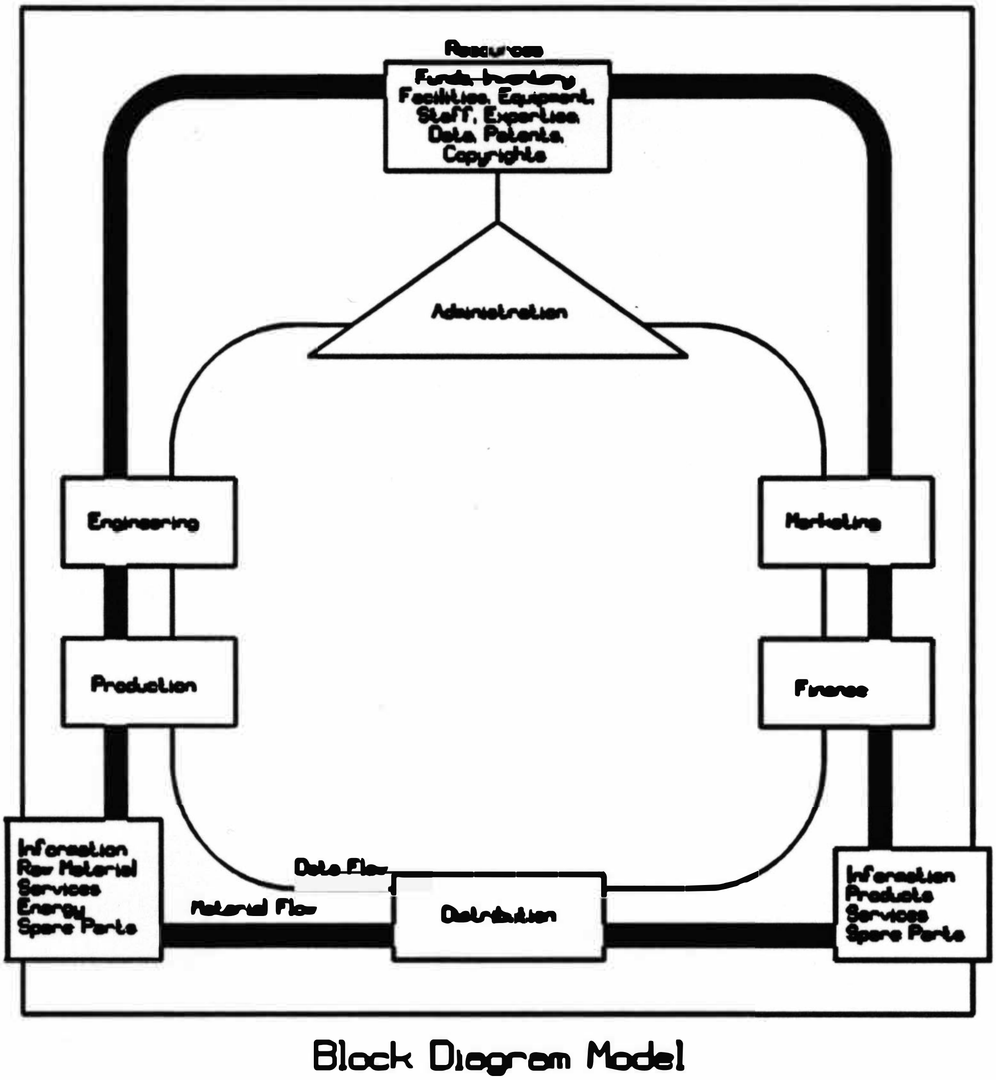

Figure 1. Functional Flow Diagram of a Company.

from each discipline working together towards an effective design and manufacturing process.

The company's mission, goals, objectives, and strategy must be defined. Then the specific changes to the organization must be implemented. IBM suggests that the implementation of CIM is a long-range strategy.

> To develop an integrated information system that will support these objectives, the enterprise must start with a long- range strategy. This strategy should provide a foundation that can accommodate today's needs and will take tomorrow's requirements into account. These needs include supporting users, integrating business and manufacturing processes, incorporating new data functions, hardware and technologies, and establishing new data base and data distribution channels. (Computer Integrated Manufacturing, p. 1)

The mission of publicly held companies is stated in many ways, but the bottom line is profitability to the share holders. Other slogans or missions such as "Quality is Job 1" (Ford), "Good Things for Better Living" (G.E.), tend to be short term or of a secondary nature as individual companies are swallowed up be holding companies, and conglomerates. Profitability to the share holder might be recognized in either a long term strategy or a short term strategy. The short term profitability strategy closely associated with leverage buy outs (LBO), conflict strongly with long-range corporate strategies. The long term profitability strategy fits very well with the long-range CIM strategy.

The next step in fulfilling the corporate mission is establishing specific goals. The goals develop along short range issues, medium range issues, and long range issues. Short range issues in a manufacturing business are characterized by existing product and process improvements, i.e, cost reduction, alternate component vendors, quality improvement projects. Medium range issues develop around research driven projects, i.e., new product design, new process development, dramatic changes in material usage. Long range issues are frequently driven by changing external conditions, i.e., governmental regulations, changing population demographics, changing manufacturing competition conditions.

There are two distinct directions to the implementation of CIM:

1. The Strategic Process: a long-range planning process which calls for a thorough analysis of the products, processes, environment, goals and strategies. Then the development of an implementation and optimization approach to achieve the long-range goals developed in the planning process.

2. The Growth Process, which is characterized by technological development in specialized areas throughout the manufacturing environment. Each major area of the business takes advantage of the technological advances in their area of responsibility, and improves the localized productivity wherever and whenever possible.

Although these are logical approaches to CIM, they lead to particular problems that need to be considered.

The Strategic Process

The Strategic Process tends to establish a baseline technology at the planning horizon. The planners must make decisions based on the available technology at the planning horizon, to avoid the possibility of developing a system that will not function due to an expected technology breakthrough that did not come to pass. The horizon can be pushed to some extent, by developing alternate solutions for critical technological expectations. The alternate solutions method cannot be broadly applied because of the cumulative lost efforts of the planners that pursued these none used technologies. While the Strategic Process appears to be an advanced method, it generally produces a conservative technological approach and a limited predictable risk solution (Figure 2). A lot can be said for this method; it is frequently used by well established companies, and the leading consulting firms. The Strategic Process produces predictable results, with predictable costs, and can be installed in a predictable time period, this leads to neat accounting evaluations for Return on Investment (ROI) and Return on Equity (ROE) used to show economic progress to the shareholders.

The Strategic Process is usually a multi-disciplined team approach to the solution of a problem, it involves a great deal of compromise from every department to generate the most good for the overall business environment. This process limits wasted efforts in the implementation of the final results. Individual specialists are not comfortable in contributing to the strategic process, since they have not developed an awareness of the needs of others. The term "generalists specialist" has been coined to define the good strategic planner. Theoretically, this person is both an specialized expert in the technology and a renaissance man in all related areas of the business. In fact, the generalists specialist is more likely neither. The Strategic Process rewards the organizational shareholders with increased profits and long-range potentials, the team vicariously benefits by knowing that the job was well done, the ideas well developed, and the project was well justified. The individual contributions are shared by all.

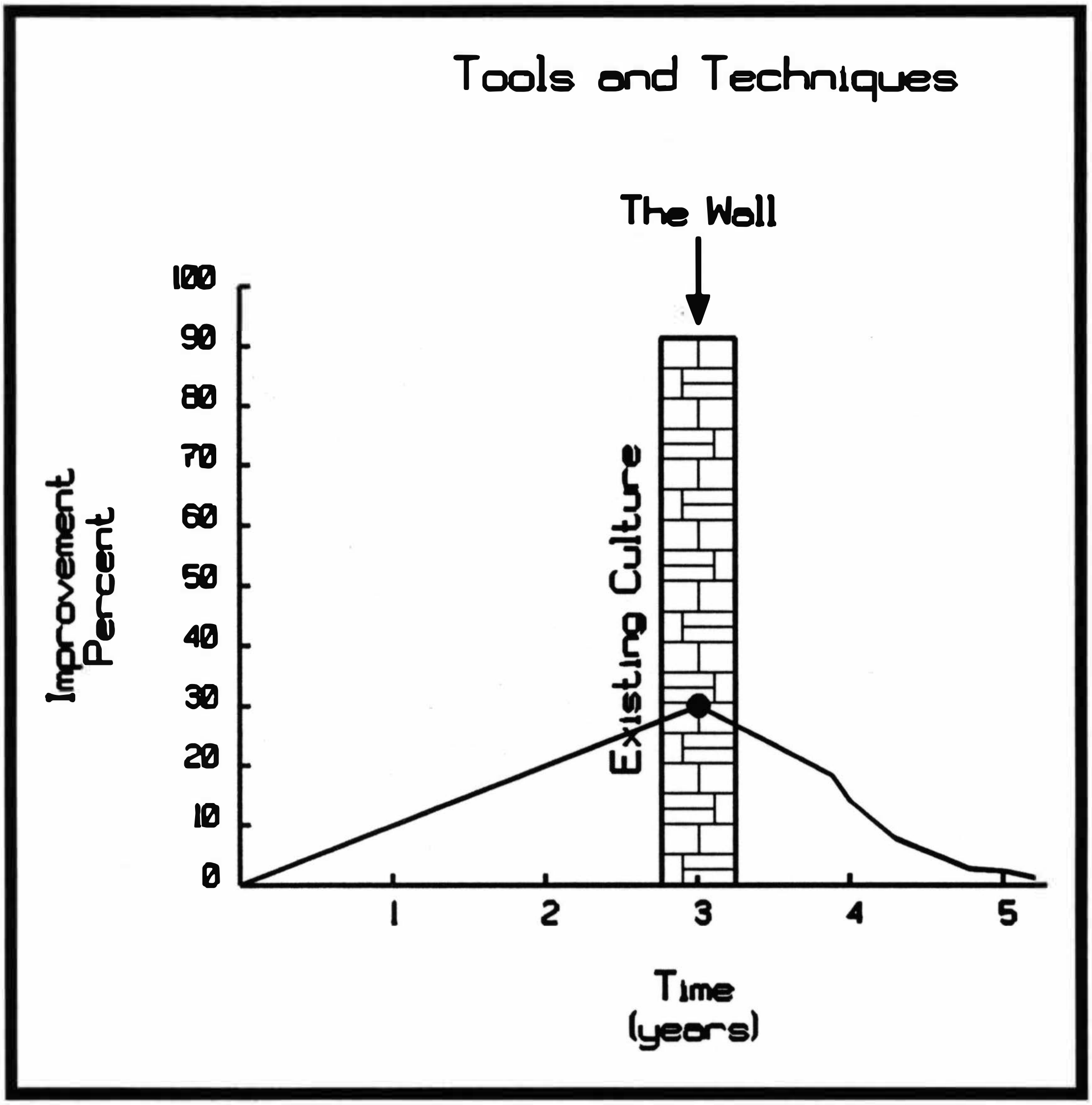

Figure 2. The Strategic Process Model.

The Growth Process

The Growth Process tends to produce outstanding examples of technological development. The introduction of Computer Aided Drafting (CAD) could produce the first drawing at about the same time as the manual method. The subsequent revisions of the drawing were frequently 6 to 8 times faster than the manual method. A quality improvement was the byproduct of this change in technology, the accuracies of the drawings improved, because the computer did not make the mathematical errors in dimensioning that the manual methods allowed. The introduction of E-Mail provided a quick and efficient way to contact other employees working on the same project, this in turn produced the end product faster than previous methods. A byproduct of E-Mail is a reduction in organizational formality and an enhancement of participative management.

The Growth Process (Figure 3) is the major driving force behind the development of "Islands of Automation" isolated pockets of automated or computer driven excellence. Unfortunately the development of extremely efficient pockets of automation creates an integration nightmare. The more specialized these islands become, the more difficult it is to share the information throughout the organization. The Growth Process follows and utilizes the breakthrough technologies as they become economically feasible. The hardware and software that is used in their development is closely guarded and frequently not in the mainstream. To integrate this technology information must be translated into a multitude of different computer languages and transposed into a multitude of discreet forms. At every translation and transformation, some of the original information is lost. Each translation and transformation adds additional time to the integration process. Occasionally an "Islands of Automation" develops that cannot

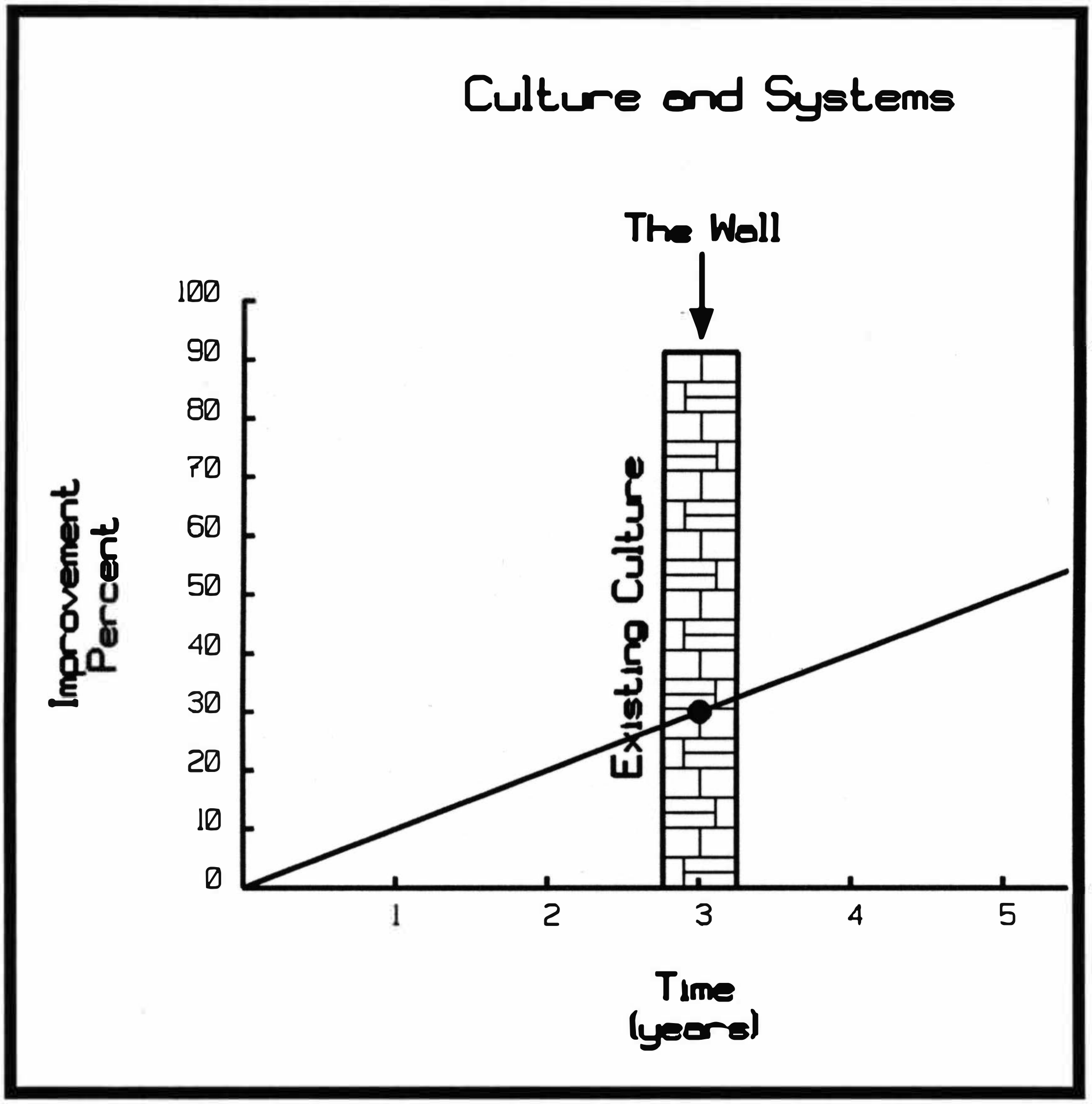

Figure 3. The Growth Process.

be integrated into the CIM Architecture and an alternate solution must be developed, implemented and integrated. This produces a significant setback to the overall process along with a high cost in time, money, and manpower.

The Growth Process development is driven by small groups of similarly skilled individuals with a limited view of the overall organizational needs. They are extremely aware of the available technology and its importance to their particular needs. They are unwilling to compromise on the performance issues of the technology. They are extremely aware of the time and effort needed to secure new technology for their group, and are driven to the latest technology to avoid repeating the justification process again. They want to push the technology envelope as far as possible at each attempt. The Growth Process rewards the working employee, by providing new challenges, promotional opportunities, and peer recognition of technical skills.

David Sirota suggests that most companies are implementing strategies aimed at improving their position against their competitors. The efforts usually result in positive change, but overall the results fail to live up to the expectations. Implementing tools and techniques, such as those developed through the Growth Process, provide a positive change, but do not live up to expectation because they cannot overcome the Corporate Culture inertia supported by the other areas. The new technique cannot be shared by other areas and the benefits are therefor forced to be localized. The Strategic Process supports a long-range Corporate Culture shift that shares in the overall developments. The automation areas were developed in a conservative approach, the integration was considered in the strategic plan providing for sustained growth. This growth is probably slower because of the conservative technology, it sustained nature provides a larger overall business return.

CIM Environment

The environment in today's business world is driven by competition and uncertainty. The implementation of CIM may be undertaken by both healthy and unhealthy companies, but given the necessary effort and time needed to complete the task, possibly only the healthy will survive until completion. Assuming a healthy company the first step in implementing CIM is the creation of the idea and the sales of the idea to the organization. The five steps (Figure 4) in this process as described by Karl Albrecht[5] are: (1) absorption - paying attention to the environment and the changes made by others, (2) inspiration - collating the absorbed information into new areas, (3) testing - valuing the concept in the environment, (4) refinement - removing the rough edges, and (5) selling - showing the benefits to the enterprise.

Kurt Lewin found a core principle within an organization, "We are likely to modify our own behavior when we participate in problem analysis and solution and likely to carry out decisions we have helped make."[6] If we take both concepts together we come to a group development and implementation program that can be described as participatory management, that is quite popular today. This management style and the CIM system are quite compatible and in fact may be mutually inclusive.

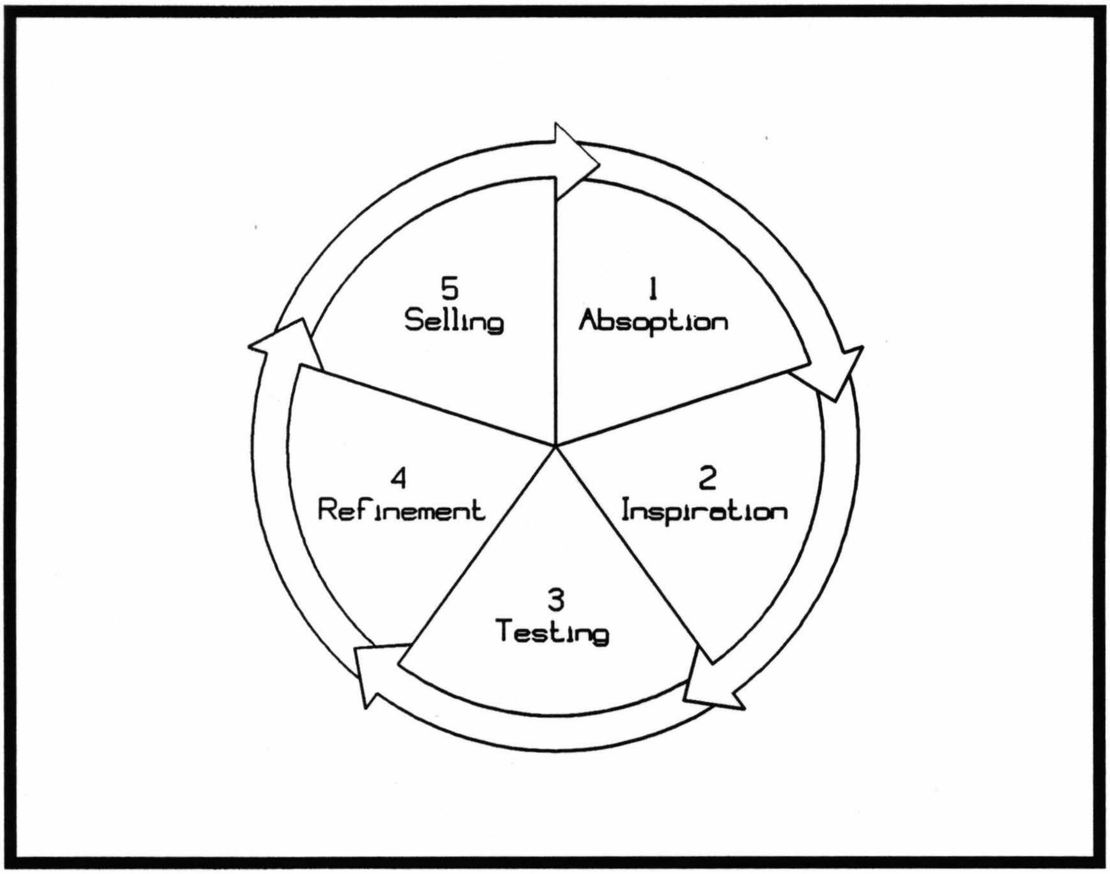

Figure 4. The Process of Creativity and Innovation.

Resistance to Change

The resistance to change within an organization is widely known. Overcoming this resistance is critical to implementing a CIM system. The changes in equipment, job structure, and culture will all be resisted in many ways. Including strategic items designed to overcome this resistance must be a major design item. Understanding the types of resistance starts by defining the basic types. L. M. Markus breaks the resistance down into three theories:

1. "People determined theory - focuses upon causes of resistance involving cognitive style, personality traits human nature. It is sufficient to educate users and get their commitment to avoid resistance" (Targowski, 1990, p. 93). The involvement of the users in the development process provides for education and thus avoids this resistance.

2. "System determine theory - recognizes causes of resistance resulting from a lack of user-friendliness, poor human factors, inadequate technical design or implementation. To eliminate resistance one must educate designers, improve human factors, modify software to conform to organizational procedures, and get users involved to obtain a better design" (Targowski, 1990, pp. 93-94). The involvement of the user in the development allows for their input and the modification of the design. This improves the ergonomics and the input and output characteristics of the design. This interaction reduces the overall resistance to the system.

3. "Interaction of system and context of use theory - looks at causes of resistance from sociotechnical (the interaction of a system with the shift in required skills) and political (the interaction of systems with distribution of interorganizational power) point of view" (Targowski, 1990, p. 94)[7]

This resistance is harder to deal with than the others, simply because it deals with job security. The threat of automation to jobs is a real threat. Two issues become important to reduce this type of resistance. The introduction of a successful CIM system is designed to improve the competitive nature of the company and stimulate profitability and growth. This growth means additional jobs to offset those lost through the productivity improvements of CIM. The employees that contribute to the CIM system design and implementation become better educated concerning the new technologies and are therefore more valuable to the company. "If you can't beat it join it" becomes the survival axiom during this type cultural change.

Implementation Strategies

Why do we need to look at the small to medium sized company differently than the typical large company CIM implementation? Computer integrated manufacturing is a very complex and technical area. In many situations the complexity of a functioning CIM organization can greatly exceed the complexity of the products being produced. This level of complexity is not sensible or advantages to the small or mid-sized company.

This project targets small to mid sized companies. These companies have minimal resources to expend on untried technology or unproven theories. The success picture of CIM is at best a scattered story, with highly publicized examples, particularly the Allen Bradley example; however, if Allen Bradley is a good example, why are other areas in the same factory still operating in the more traditional ways?

A successful CIM implementation needs a balance of technology, employee skills, management backing, resources, and enthusiasm along with a reasonable amount of luck. Planning to implement a CIM program should start with an evaluation of the existing company resources. A survey of existing technology is a good first investment of time and energy.

Islands of Automation Strategy

What technologies exist within the organization? Almost all companies have computer technology in use in many areas throughout the organization. Typical examples are word processing, and decision software such as Lotus in the office. The payroll is usually automated very early in an organizations development. Computer Aided Drafting and Design, CADD, is frequently an early addition to engineering area. Manufacturing applies computers to data acquisition and machine control in isolated areas as they buy new equipment.

Many of the islands of automation developed to satisfy a closely held need are not recognized outside of the immediate group. Fully understanding the resources already available within the company will lead to a more efficient CIM implementation.A systematic survey of existing computer technology should be a first step in implementation of CIM. What information is needed and how should it be organized? The computer technology should probably be treated as a tree structure developing out of the actual hardware (Figure 5).

On the assumption that any computers in the company were properly justified, it is reasonable to assume that the functions they perform are useful to the function of the company. Although as the final CIM environment may eliminate

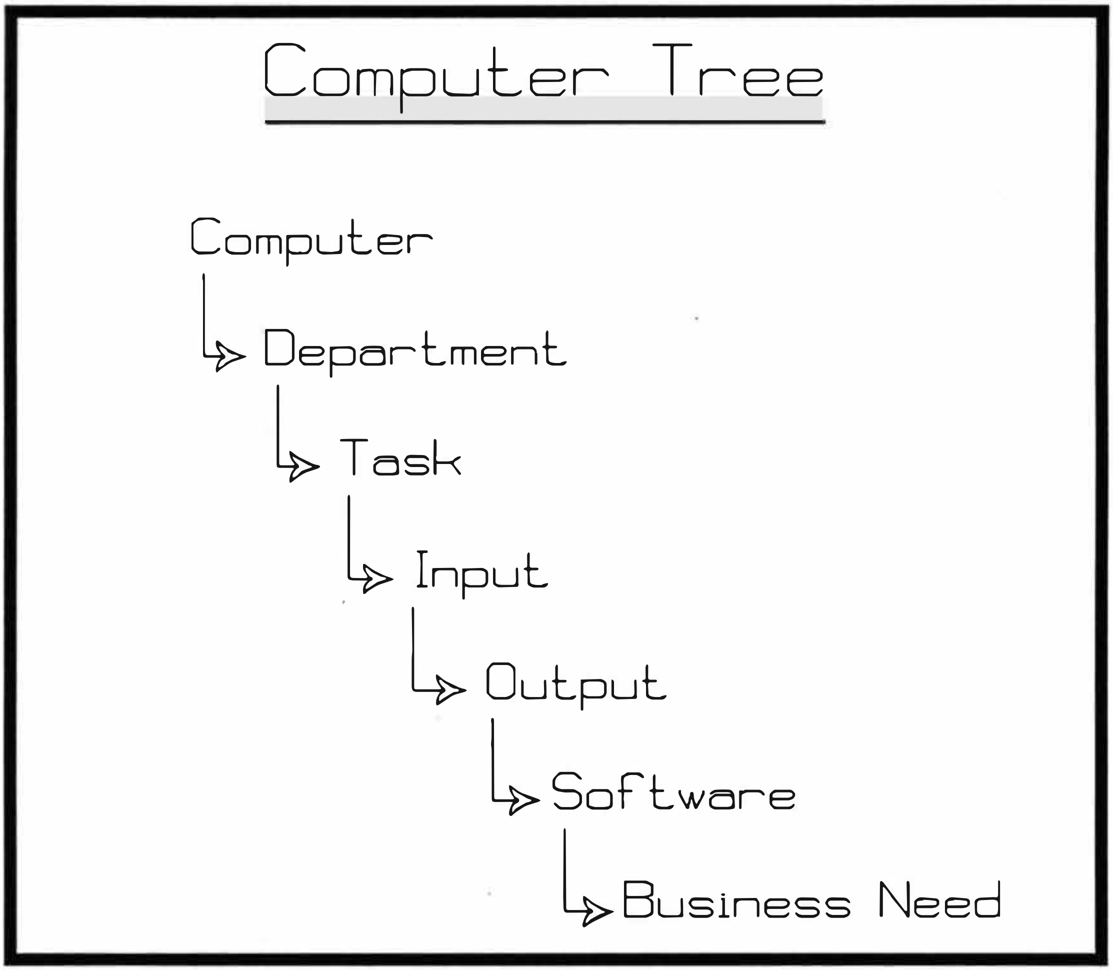

Figure 5. Computer Tree.

the function, or drastically change it, following the computers is probably an efficient starting point.

It identifies the computer resources already operational within the company. Following the computer tree through departments, tasks, input requirements, output information, through the software logic, should lead to the underlying business needs.

Implementing a CIM system through an island of automation approach tends to lead to a minimum of company re-engineering. It utilizes all of the efforts taken to initially install the technology currently in use. Like most change efforts we start with what exists and fix it up. The implementation of CIM in this context is that if the business is working, we are only attempting to work faster and eliminate duplicate efforts. Look at the overall operation as a series of black boxes, each one with inputs and outputs. Each black box is a necessary business process, i.e., BOM, CAD, CAM, Costing, Production Control, etc. Through an island of automation CIM implementation the task is to connect the islands not reinvent them.

An island of automation approach taken with the product development process pictured in Figure 6 shows the logical progression of the process flow. This process flow was developed initially using either an existing company flow diagram, or by tracing the computer technology already in use. Detailing the business needs should show the desired final process specifications. It is necessary for the CIM system to fully support the concept development all the way through to production and distribution.

Breaking the process down to its component parts begins to identify the black box concept. The areas requiring specialized inputs, outputs or processing requirements. Another important concern is the development of the interactions between the black boxes (Figures 7, 8, and 9). The easiest CIM implementation probably limits the control of each black box to the minimum sized group. In this

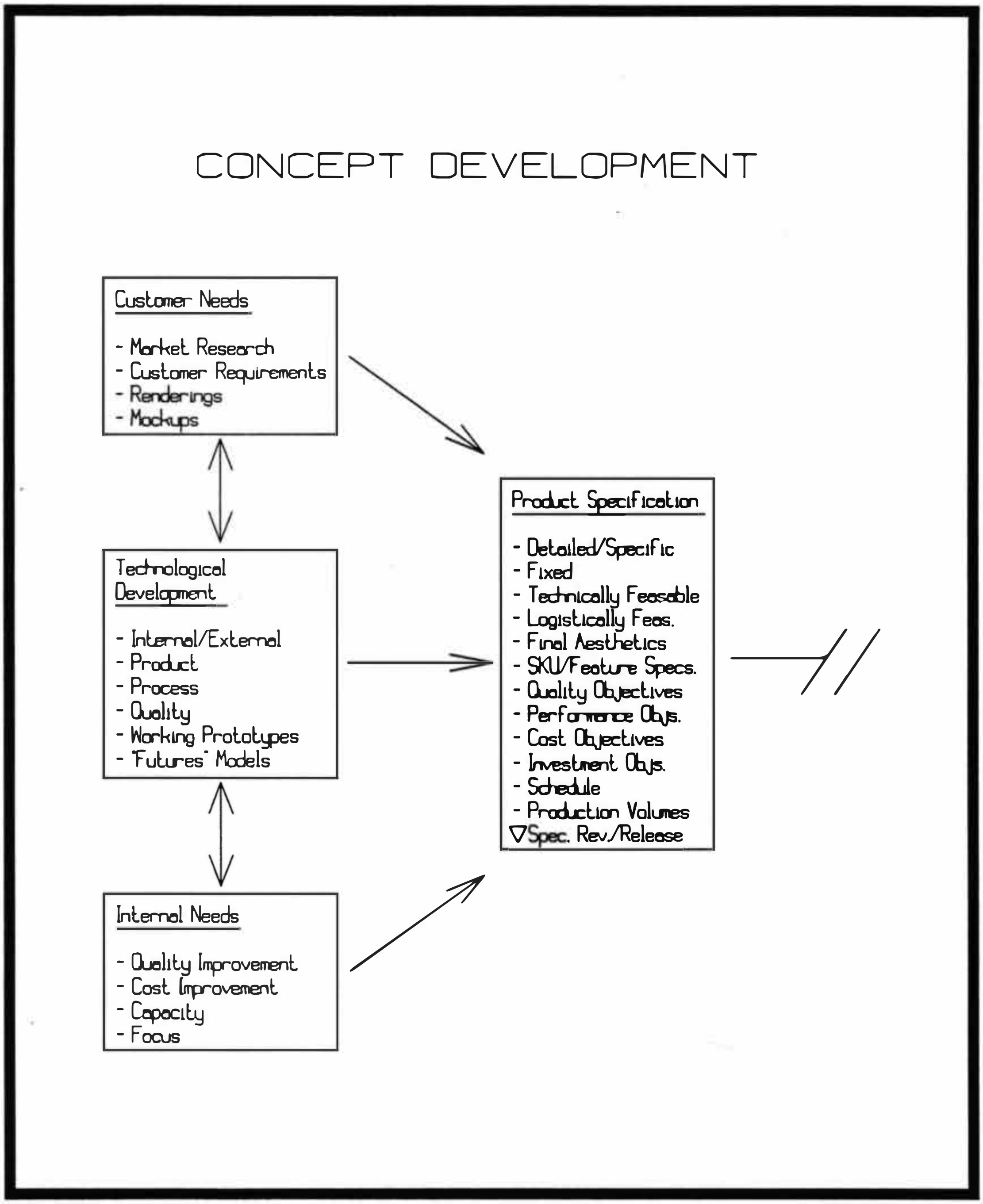

Figure 6. Concept Development Process Flow.

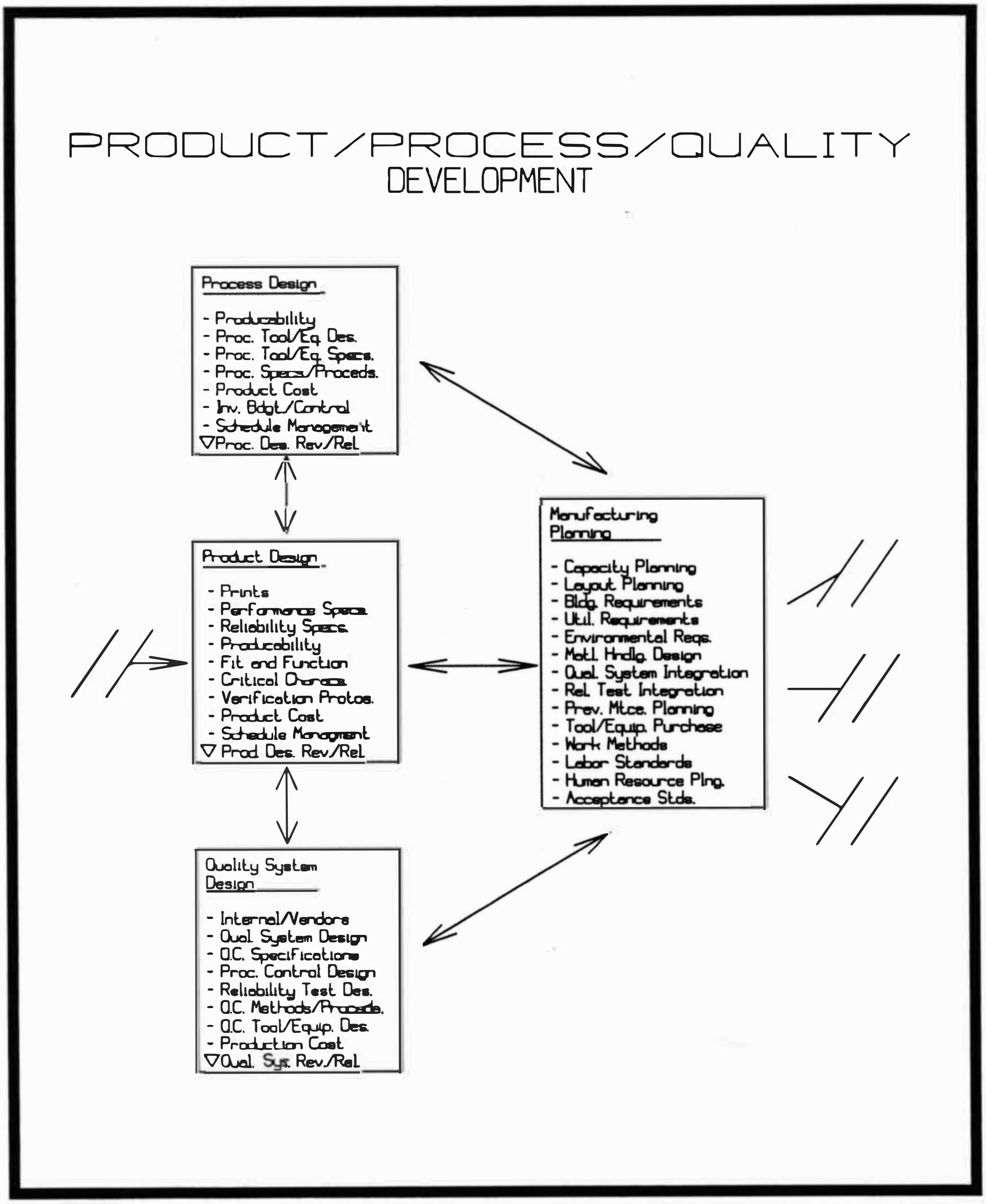

Figure 7. Product/Process/Quality Development.

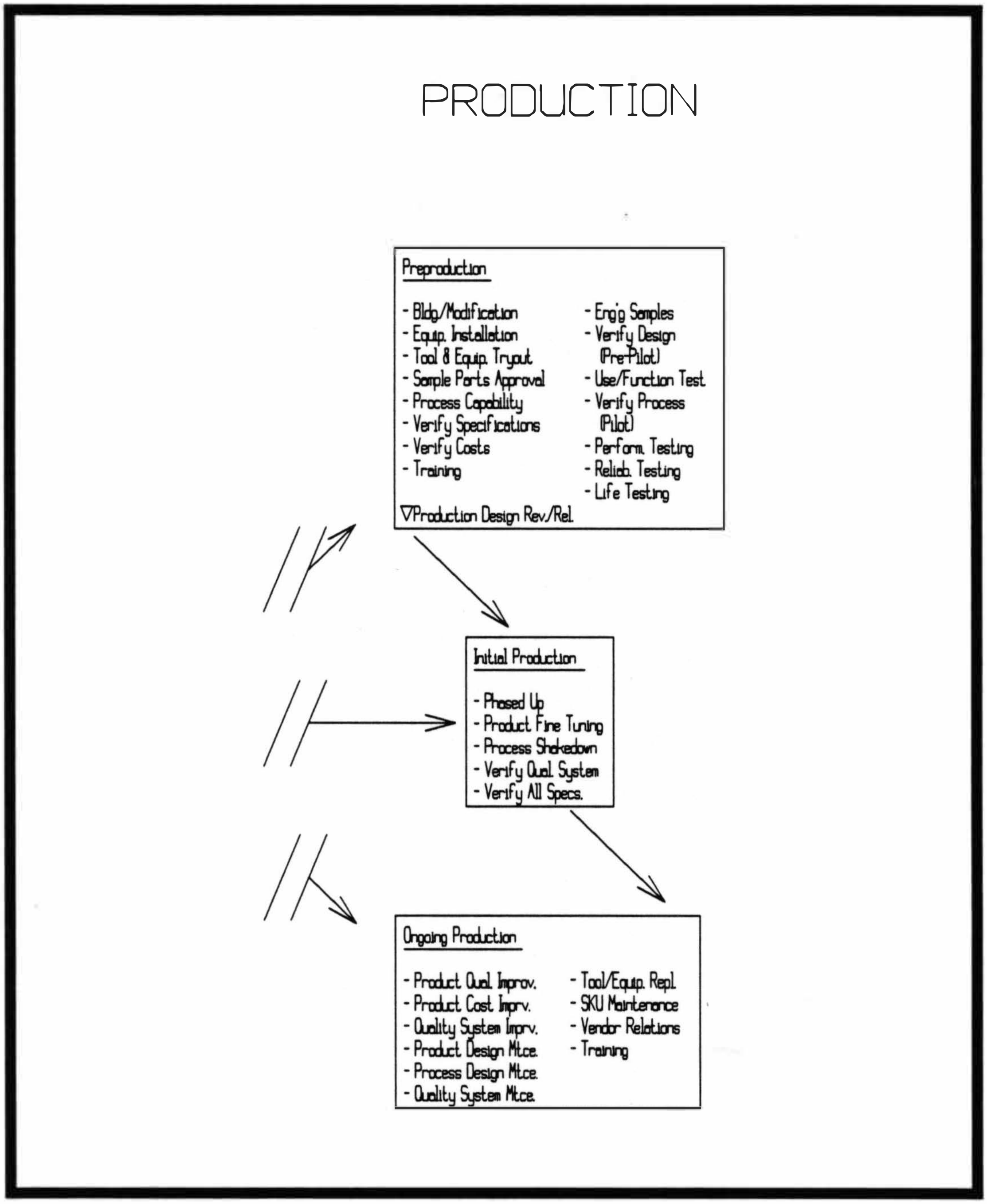

Figure 8. Production Process Flow.

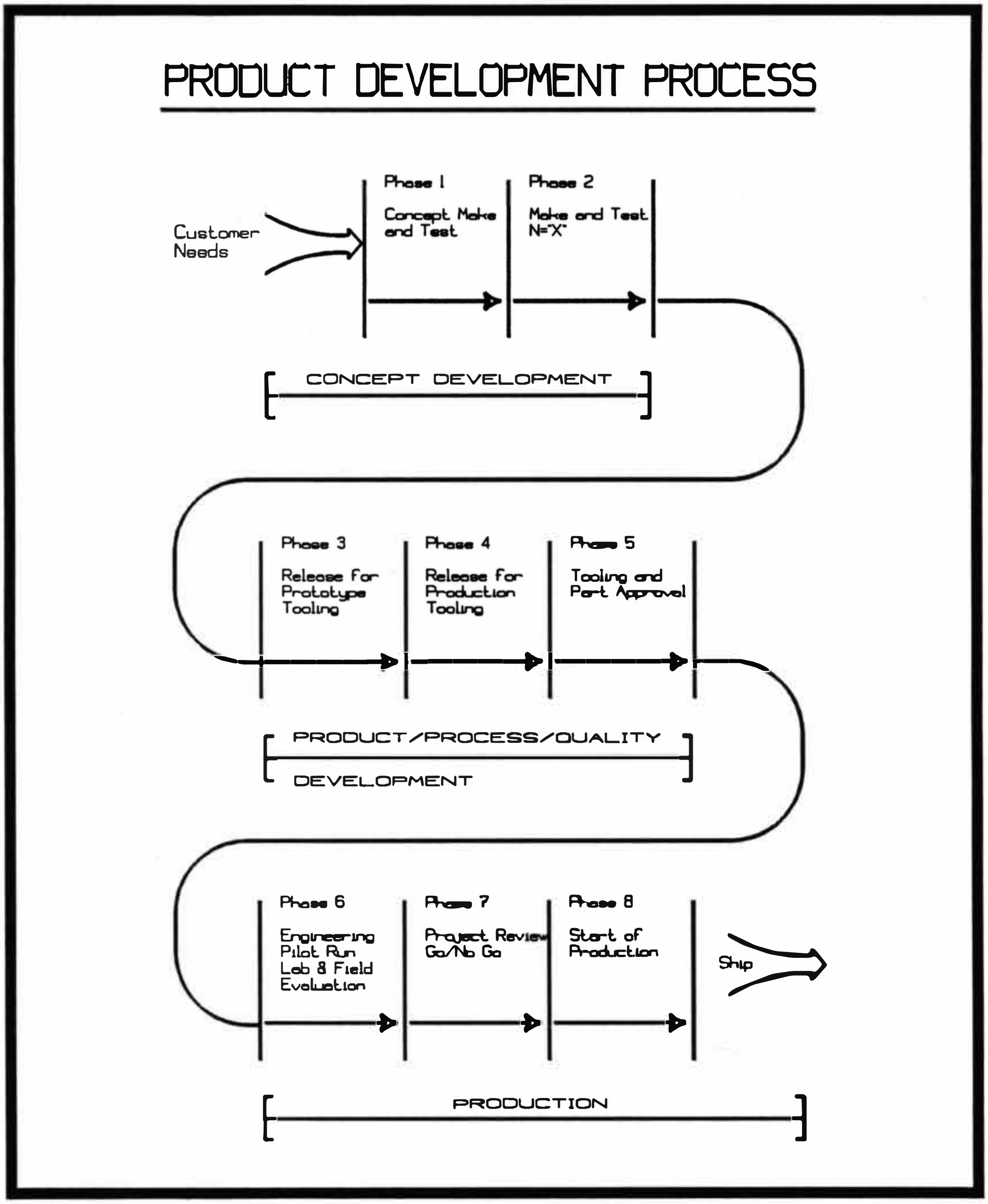

Figure 9. Product Development Process.

way conflicting requirements are resolved at the end user level.

While this technique minimizes the disruption of the existing departments and company functions it creates a great deal of difficulty to the implementation team. Since this method allows each group to specify the requirements to satisfy their own needs, it almost automatically creates a proliferation of hardware and software requirements. Each group is constantly looking for solutions that efficiently satisfy their particular requirements at the time of specification. With the rapidly evolving technologies in both hardware and software any solution developed at different times probably means unique hardware and software solutions.

To control this type of implementation effectively several rules can be helpful. The first is to establish common data communication requirements. Since the movement of data between systems is crucial to the CIM environment, the technical methods of data transfer must be controlled. The selection of a network protocol is not absolutely essential, but the ability of all selected networks to communicate is crucial. Selecting the minimum communication requirements should be an initial system wide specification. By making the bulk of the CIM decisions at the user level, the efficiency at the user levels for departments is enhanced. By making limited CIM decisions at an environmental level, no one group is limited by the restrictions of another.

The island of automation CIM implementation does not generate the most overall efficient solution either immediately or in the future. It does, however; utilize any previews or existing islands of automation with a minimum disruption to the ongoing business applications. This technique can easily be funded with available capital, expenses, and personnel resources. This technique also provides ongoing upgrading of technology areas with no essential changes in outside areas.

Top Down Strategy

Most strategies start in the upper levels of an organization. It is not that the smartest people are at this level, so therefore the best ideas are developed there. It is probably because the culmination of the enterprises information is only available to the top levels. The coordination of this information in most organization is a highly guarded top management burden. In fact much of the critical information required to make decisions on strategy are carefully hidden from the rest of the organization.

The Top Down Strategy is represented in the CIM system by the pyramid structure in Figure 10. The traditional MIS department given the business need, begins to develop a solution based on a particular computer platform, as shown in Figure 11. They are driven by the information that they know, and only after many decisions are made do they consider the needs of the end user. Although the user's needs are frequently given lip service throughout the program development, rarely are the user screens developed first.

The Top Down Strategy is not wrong; it is really a logical first step in the system design. It represents a logical developmental use of existing hardware and software. The proper installation of any large project begins with planning. A

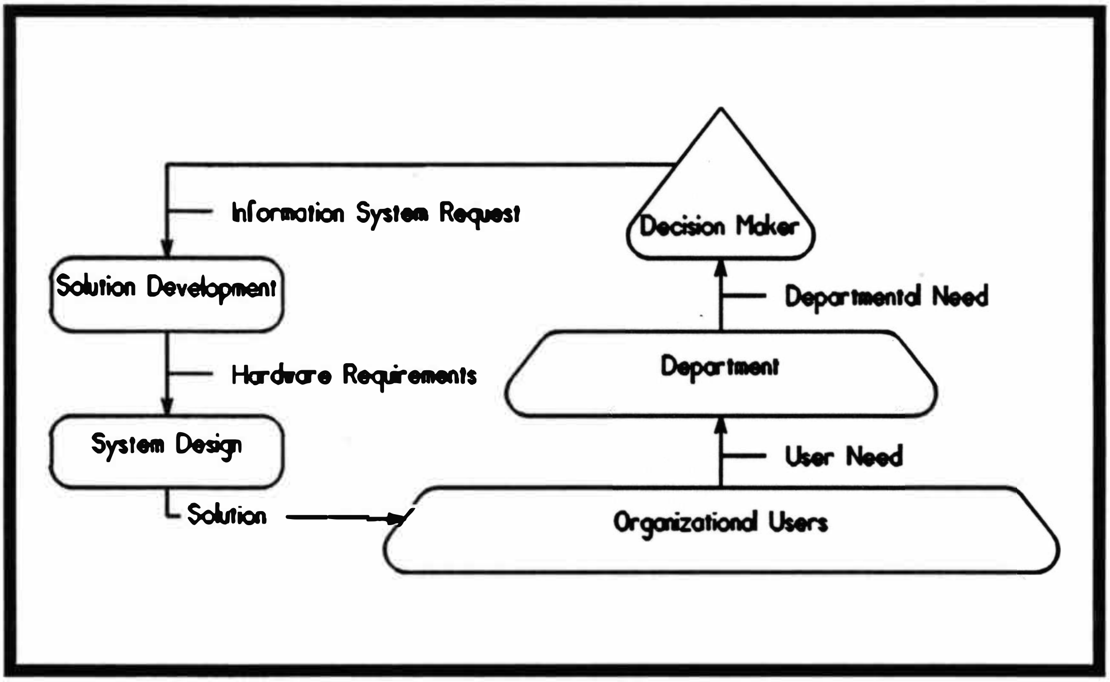

Figure 10. Pyramid Structure.

well developed structure and a clear set of objectives is essential. To achieve this the objectives that drive the implementation should be clearly controlled by the top levels of the organization. Targowski (1990) says "CIM must be designed top-down but implemented bottom-up" (p. 253). Programs not initiated in this manner are quickly dissipated or lost to the pressing needs of the day-to-day operations. Promised funding disappears at the later stages of the implementation, leaving isolated pockets of independent computer automation at best and useless hardware at the worst.

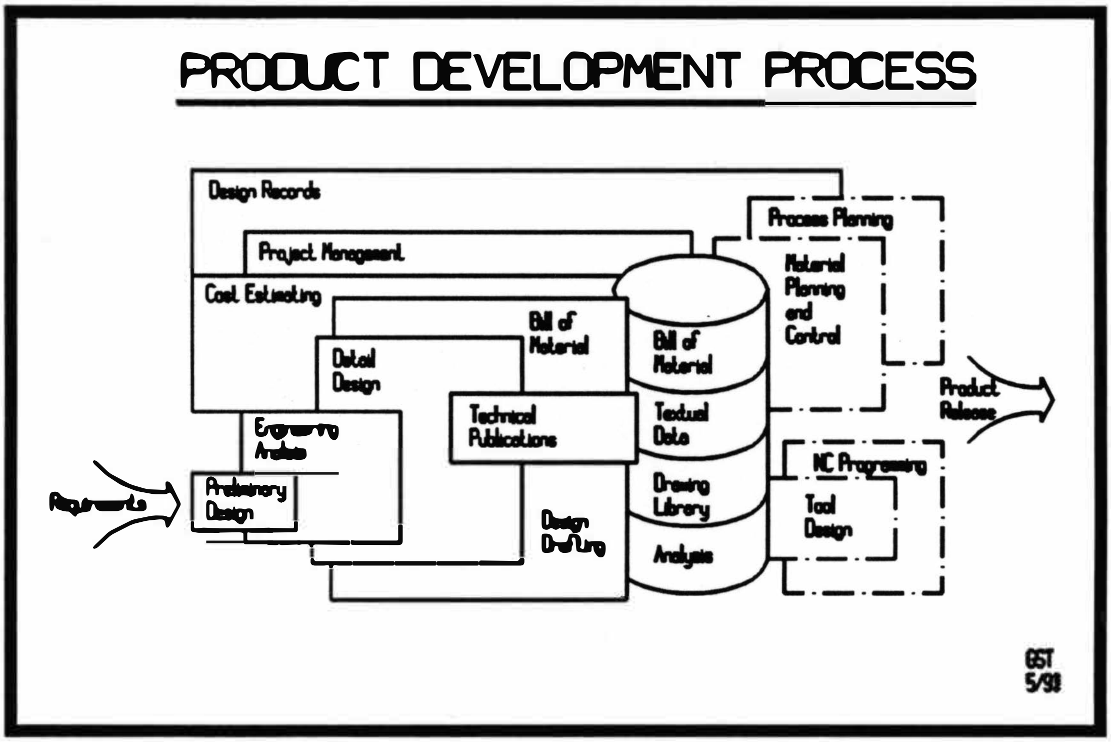

Figure 11. Platform Process.

Bottom Up Strategy

To understand the Bottom Up Strategy, I referred to a well developed psychology concept. Abraham H. Maslow was an American psychologist who developed a hierarchy of human needs (Figure 12). Maslow asserted that the lower levels of human needs dominated activity until they were reasonably well satisfied. Until these basic needs were assured, human activities could not be productively directed toward the fullest potential.

The CIM system can also be considered to have a similar hierarchial structure. The needs to successfully operate a CIM system can be shown in Figure 13:

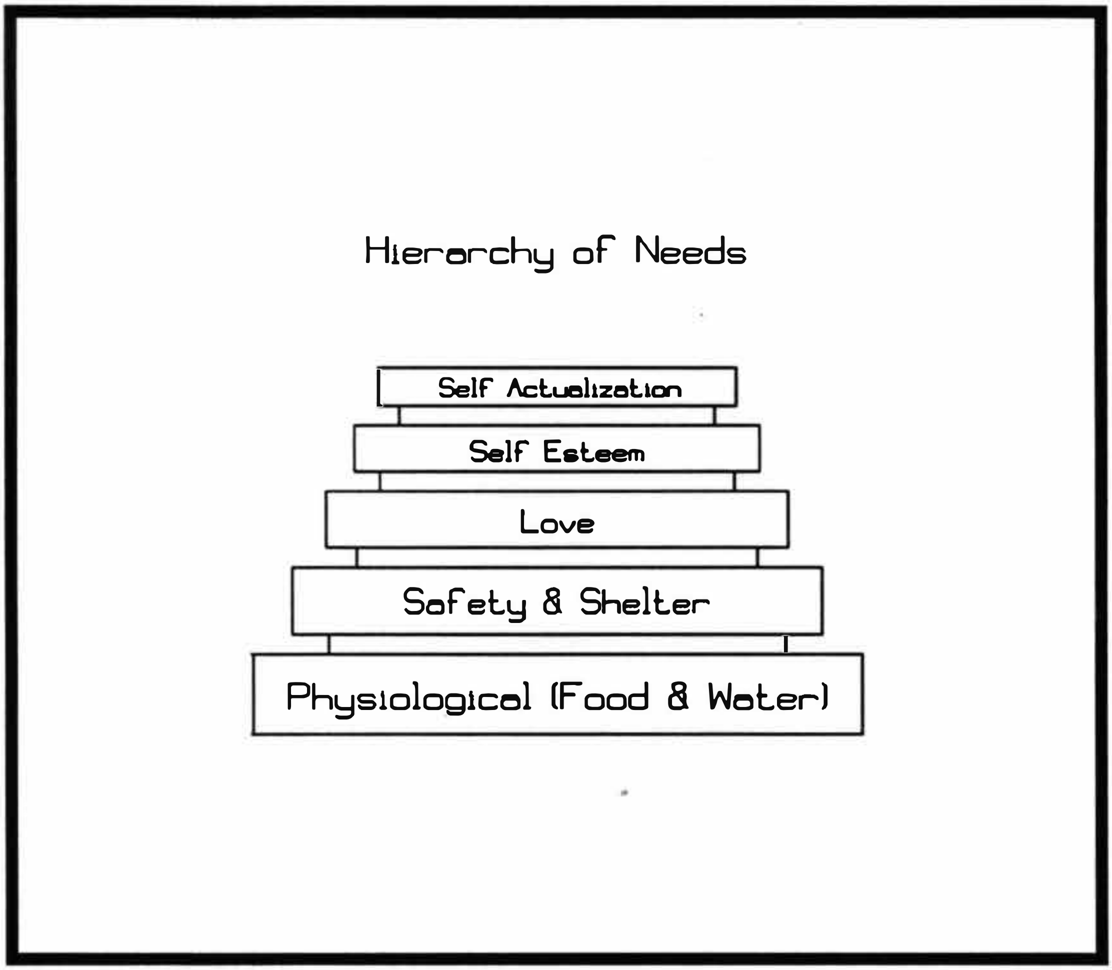

Figure 12. Maslow's Hierarchy of Needs.

CIM Hierarchy of Services. Like Maslow's proposal on human needs, the CIM system is also addressed from the bottom up, the lower levels must be satisfied before the upper levels. The top level, Mission Critical Applications is the last satisfied. Unfortunately the Mission Critical Applications in the CIM environment are the essential activities required to run a business.

The higher the CIM system is able to support the organization, the more

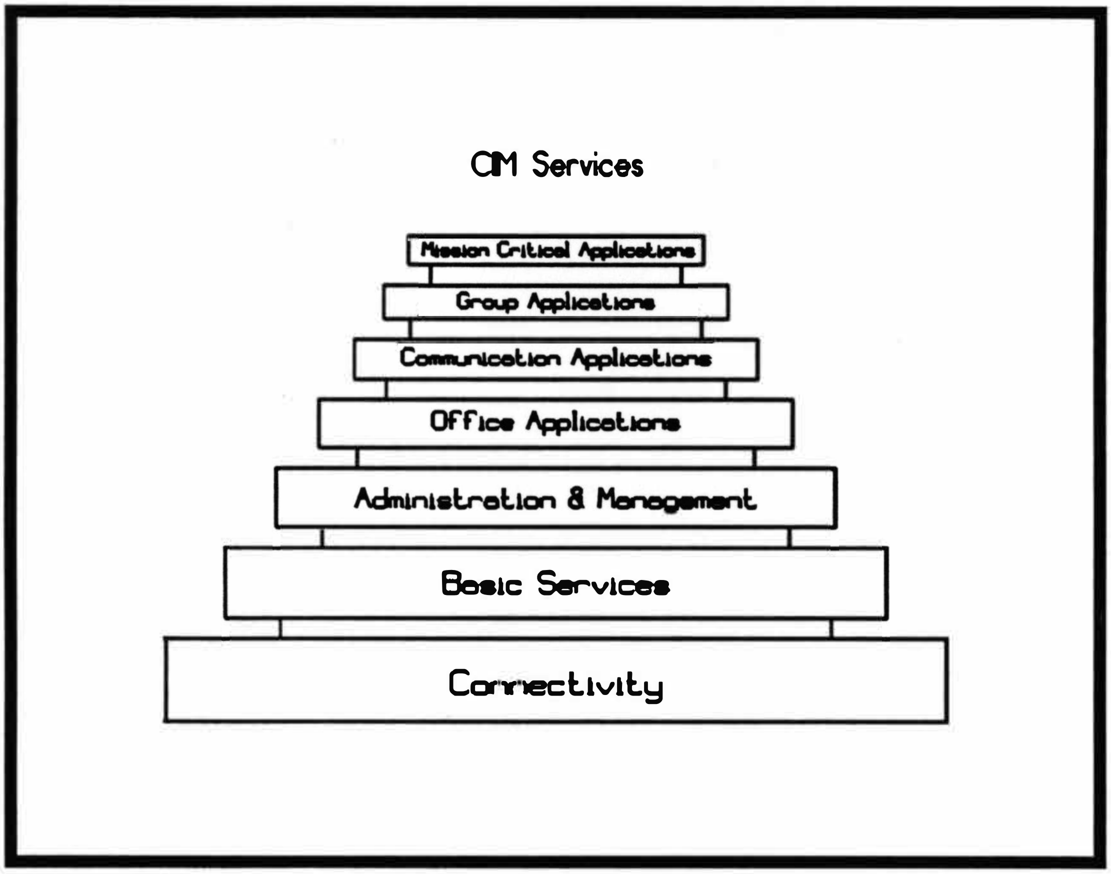

Figure 13. CIM Hierarchy of Services.

productive the organization will be. The overall CIM environment is not dependent on the specific hardware or software utilized. The CIM environment is also not dependent on the number of workstations or the size and speed of this hardware. While all of these characteristics are essential to the overall support of the CIM system, they really only support the lower levels of the CIM hierarchy. They only indirectly support the highest level of the hierarchy, and should not be the driving force behind the final system configuration.

None of these strategies is clearly the optimum solution for all situations.

Each has advantages, and disadvantages and must be used utilized to maximize the effectivity for a given situation. It is also possible to effectively combine these strategies to develop a CIM plan. Actually a well balanced and cost effective program probably always takes into account any existing island, the long range plans driven by management, and the experience and desires of the end user.

Endnotes

4. Targowski, p. 298.

5. Albrecht, Karl and Albrecht, Steven, The Creative Corporation, Dow Jones-Irwin, 1987, Homewood, Illinois, p.36.

6. Weisbord, Marin R., Productive Workplaces, Jossey-Bass Publishers, San Francisco, CA., 1987, p. 89.

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CHAPTER III

ASSESSMENT

Whether this is a new CIM environment or a change to an existing one, the assessment approach should be similar. The most important aspect of creating a successful CIM system is to establish clear goals and expectations. With this understanding, implementing a solution that enables future growth and opportunities becomes a more likely outcome.

Because implementing a CIM system requires so much technical knowledge, it is easy to forget that it is less about technology than culture. The successful CIM system changes how people do their jobs and provides new business opportunities for the organization. Not only must the CIM system utilize relevant technology, but it must satisfy the users and their goals.

Before developing the final system, the initial investigation must be done to make sure that the system is capable of supporting the tasks required. The overall plan must be detailed so that an appropriate foundation can be established.

Survey Needs and Expectations

"Quality is Job #1" is the Ford Motor Company slogan. Underlying this slogan is the demand to satisfy the "customer". In a CIM system the driving force behind the efforts to change the company is to satisfy the end user of the product faster and at a higher level than anyone else. The first step in satisfying the customer is to find out what the customer wants. Surveys, interviews, and questionnaires are all effective tools for this process.

Do not limit the assessment surveys to existing computer users. It is essential that the results be as unbiased as possible. Those people that are not current computer users will ultimately be expected to use the CIM system when it is complete. Gathering their expectations is important to make sure that the final system will support all potential users. Look to groups inside the company to find standards and procedures. Survey management for cost guidelines and group goals. Interview vendors and customers for descriptions of communication needs. Many of those surveyed are not literate concerning CIM systems, so their suggestions and requirements need to be fully understood as they apply to a CIM environment. The survey technique is only a data gathering method, the analysis of this raw data and the filtering to a final plan is where the critical work is done.

Each interview or survey should always work to move the discussion up the needs hierarchy to locate the mission critical applications. These key processes or information sources can provide a competitive advantage or a significant cost reduction. Certainly the CIM system provides many small productivity improvements, the message advantages of E-Mail certainly are improvements over the phone tag games played today. These small productivity gains and the Mission Critical Applications add up to major competitive advantages for the company.

Surveys should be short and simple. A typical user survey, developed by Jeffrey Farris, is listed in Appendix A, User Survey[8].

Strategic Profile Analysis

During the survey process, the skills of the users should be assessed. The concern is whether the skills are adequate to satisfy the new CIM system or if additional training is required. The employee skills that are of most interest are: (a) current skill levels requiring training, (b) skill levels that can assist in peer level support, and (c) skill levels that can be system evaluators.

The available resources for the CIM program should also be evaluated. Existing resources must be evaluated for fit to the final system. Not all existing applications will be suitable for the CIM environment. The earlier that these applications can be eliminated the less effort they will absorb in the conversion. If a resource is questionable assume that it will not work. Later, finding out that a resource will work is less traumatic than finding one that will not.

Plan on making applications run on a wide variety of platforms, functionality is more important than speed for the casual user. Where an application is the predominate application of a work group, hardware enhancements should be available to improve productivity.

Perform a detailed inventory of computer equipment, including operating system version and levels, manufacturer, monitor type, network connectors, and graphics capabilities. As new equipment is purchased a policy that limits unnecessary diversification can be extremely critical. To restrictive of a policy will greatly increase equipment cost, while to liberal of a policy will greatly increase connectivity, and administration costs.

Economic Issues

Implementing a CIM environment cannot be successfully completed without the proper funding. The cost to a company consists of three main areas: (1) capital cost, (2) ongoing expense, and (3) development costs[9]. Each cost area must be justifiable for the CIM implementation to be valid. It is not always reasonable to assume that new systems will improve productivity in a given department. Often the measurable improvements of a CIM system will not come from the immediate area of improvement. Adding a CAD system to the Engineering Department should certainly improve the productivity of the engineers, however this productivity improvement may not offset the initial cost. In fact the long term cost savings may actually take longer than the expected life of the equipment. Economically the addition of this CAD system may seem in jeopardy, until the benefits to manufacturing and marketing are included. The system wide benefits can far exceed the localized benefits.

The difficulty to the determination of capital costs is the actual assessment of the savings throughout the complete enterprise.

William Smith cites Yamazaki Machinery as an example of this difficulty: When the Yamazaki Machinery Company in Japan installed an $18 million flexible manufacturing system, the results were truly startling: a reduction in machines from 68 to 18, in employees from 215 to 12, in floor space needed for production from 103,000 square feet to 30,000, and in average processing time from 35 days to 1.5. After two years, however, total savings came to only $6.9 million, $3.9 million of which came from a one-time cut in inventory. Even if the system continued to produce annual labor savings of $1.5 million for 20 years, the project's return would be less than 10% per year. Since many companies in economies outside Japan use hurdle rates of 15% or higher and payback periods of five years or less, they would find it hard to justify this investment in new technology despite its enormous savings in number of employees, floor space, inventory, and throughput times[10].

The apparent inability of traditional modes of financial analysis like discounted cash flow to justify investments in computer integrated manufacturing (CIM) has led to a growing number of managers and observers to propose abandoning such criteria for CIM related investments. The opinion is that most managers have become too absorbed with DCF (discounted cash flows) to the extent that practical strategic directional considerations have been overlooked. Faced with outdated and inappropriate procedures of investment analysis, all that responsible executives can do is to cast them aside in a bold leap of strategic faith. They have come to believe that capital investment represents an act of faith, a belief that the future will be as promising as the present, together with a commitment to making the future happen.

But must there be a fundamental conflict between the financial and the strategic justification for CIM? It is unlikely that the theory of discounted future cash flows is either faulty or unimportant: receiving $1 in the future is worth less than receiving $1 today. If a company, even for good strategic reasons, consistently invests in projects whose financial returns are below its cost of capital, it will be on the road to insolvency. Whatever the special values of CIM technology, they cannot reverse the logic of the time value of money. The trouble then lies not in some gulf between the logic of DCF and CIM but in the poor application of DCF to these investment proposals. There is no need to abandon the effort to justify CIM on financial grounds. Instead the need is to apply the DCF approach more appropriately and to be more sensitive to the realities and special attributes of CIM.

Complex acquisition problems should consider not only the positive (benefit) aspects, but also the negative (cost) aspects. Therefore, a second hierarchy depicting these "cost" elements should be considered. The priorities of the technologies from the benefit and cost perspective are then used to arrive at a decision. It should be noted that the acquisition of CIM technology is motivated by three major considerations: (1) the economic consideration is concerned with cost reduction in the enterprise process, (2) the production consideration is concerned with enhancing the operational flexibility, and (3) the organizational consideration is concerned with the ability of the organization to respond quickly to changing market demands without loss of opportunities.

Justification

In this method company management was primarily interested in: (a) identifying business functions that would benefit most from CIM technologies, (b) developing realistic short-term improvements that would improve productivity and enhance management controls with minimal investments, (c) justifying longer term CIM technologies that would effectively support the company's business strategy, and (d) developing a tactical approach for implementing CIM technology projects that would lead to an integrated and flexible manufacturing environment.

This approach incorporates the use of both a cost-benefit analysis and a cost-benefit tracking process.

Cost benefit analysis is the analytical process which assists in (a) identifying those functional areas where the introduction of an improved CIM technology will have a substantial financial impact, (b) evaluating the life cycle cost profiles of potential cost reduction programs, (c) addressing the risks posed by the introduction of new technologies, and (d) identifying cost-benefit tracking requirements so that the management control loop can be closed to monitor whether or not benefits are realized.

Cost benefit tracking is the continual assessment of the actual level of program investment and the associated recurring costs and savings as compared to plans. This information is useful in taking corrective measures for ensuring that the benefits of CIM implementation are fully realized and/or that estimates for future projects are fine-tuned based on actual experience.

Cost Benefit Analysis

The cost-benefit analysis approach used follows these steps: (a) define manufacturing functions; (b) prepare "as is" cost baseline; (c) prepare "as is" performance baseline; (d) develop opportunity matrix; (e) evaluate CIM technologies for implementation; (f) develop "to be" cost-behavior patterns; (g) assess intangible factors, risks and integration; and (h) evaluate time-phased economics.

At the completion of the cost-benefit analysis process, a time-phased implementation plan for moving toward a CIM environment can be approved. This implementation plan includes the introduction of short-term improvements identified during the analysis process: (a) capital-intensive technology projects that would lead to CIM environment, and (b) a cost-benefits tracking approach that would support feedback to management on its strategy for implementing CIM.

Cost Benefits Tracking

The purpose of cost benefits tracking is to measure the actual impact of CIM technologies on facility-wide costs and related performance measurements as compared to the predicted "to be" cost baseline. Four principles were utilized in implementing cost benefits tracking: (1) capture actual cost and performance data, (2) maintain compatibility with CIM justification practices, (3) support verification and audit, and (4) ensure appropriate time horizons.

In reality it is seen that capital justification of CIM requires substantive changes in management thought processes. Key factors that need to be recognized are:

1. A top-down approach is essential to gain the full "integration" benefits of CIM.

2. Very few companies today have cost accounting processes to support the financial justification of CIM.

3. Operational, engineering, management information systems and financial disciplines must organize a unified business approach to justify investments in CIM.

4. Education in such a business approach at all levels of the organization is essential to support inter departmental communications regarding CIM justification.

5. Computer modelling approaches are available to simulate the financial impacts of alternative CIM technologies.

The Investment Approach

Popular engineering economy methods which have been used for tactical investment decisions are payback period, rate of return, and net present value. Surveys in the past have indicated that of a sample of companies considered, 26% used the rate of return method, 5% used the net present value method, and 4%

used other methods. The popularity of the payback period is its ease of use. However, payback period does not account for the time value of money and, therefore the validity of the payback period as an economic justification tool is very questionable.

The rate of return and net present value methods take the time value of money into account, and they are viable economic justification tools. An explanation for the rate of return method is the ease of comparing the rate of return of the investment project with the "hurdle" rate of return. This comparison results in a binary decision. If the rate of return of the project is above the "hurdle" rate, the project is a candidate for funding; otherwise it is rejected. Like the rate of return method, the net present value (NPV) method is capable of providing a binary decision. If the NPV of the project is positive, then the project is a candidate for funding; otherwise it is rejected. The use of NPV is advocated as a tool for tactical analysis of manufacturing investments.

Technology Forecasting

Though the benefits of CIM are tactical as well as strategic, in the final analysis CIM investment is a strategic investment. Let us consider the justification process.

Step 1: Establish cash flows and operational parameters of the alternatives.

In order to develop cash flows of a CIM project, the cost elements and benefits as shown below should be estimated. Some strategic benefits of CIM to watch for are: (a) improvement in ROE, (b) better competitive advantage, and (c) ability to adjust to shorter product life cycle.

Development of Engineering and Management Expertise

The effort put into quantifying the costs and benefits is directly proportional to how detailed and accurate the economic justification must be and the type of data available.

In addition, the depreciation methods, the cost of capital, inflation rate, tax rate, and investment credit should be stated. Since some of the costs and benefits of CIM depend on the operational characteristics of the environments, scheduling and rules, reliability of hardware, reliability of data, and reliability of the communication network should be specified: (a) lower exposure to labor unrest, (b) being viewed as the leader in the use of new technologies, (c) increase in the price per share, and (d) ability to introduce some products faster to the market

The benefits of CIM attributes to manufacturing systems are: (a) lower WIP inventories, (b) reduced through put time, (c) improved manufacturing control, (d) improved quality, (e) reduced scrap, (f) reduction of floor space used, (g) reduced labor costs, and (h) reduced tooling costs.

The benefits of CIM attributes to manufacturing are: (a) better status monitor of machines, tools, and material handling devices; (b) improved data management; (c) improved operations control; (d) improved parts control; (e) improved response time to demand variations; (f) improved ability to adjust to machine variations; and (g) improved ability to respond to design or process change order.

The cost elements and parameters needed for the economic evaluation of CIM technology are: (a) system design cost, (b) installation and training costs, (c) programming costs, (d) maintenance costs, (e) computers and communications network costs, (f) labor and supervision costs, (g) burden costs, (h) floor space costs, (i) raw material inventory costs, (j) WIP inventory costs, and (k) finished parts inventory costs.

Step 2: Work through analytical models of CIM alternatives.

Analytical models rather than simulation models are adequate for this stage of analysis. Generally, building a detailed simulation model will be an effort with a very small benefit to cost ratio or simply "overkill". It is usually sufficient to have operations personnel estimate costs and potential savings within their area of responsibility. Suggestions of costs or savings outside their area of expertise should be evaluated by operations personnel responsible for the costs.

Step 3: Engineering economy analysis, ranking of alternatives including status quo.

The NPV is recommended for the economic analysis of the alternatives. Each configuration of CIM will be treated as an independent alternative. Different types of capital budgeting methods are available for the ranking of alternatives.

Step 4: List strategic factors.

Strategic factors have already been mentioned. These benefits, along with the NPV will become the strategic factors to be considered. Each factor will be assigned a weight, which represents a relative importance of each factor among the factors.

Step 5: Carry out strategic analysis and selection of alternatives.

This phase will justify the selection of the CIM project. Strategic analysis is done by a scoring method. By this is meant that each strategic factor is assigned a score. Each score is multiplied by its respective weight and the weighted scores of the factors for each alternative are summed. The alternative with the largest total score is the best alternative.

Steps 1-5 constitute a deterministic analysis of justification of an CIM project. It is possible to perform a stochastic analysis; however, deterministic models are most frequently chosen.

Tactical Planning

There are four simple tests that can be used to judge the success or failure of a CIM system. These test easily translate to many areas within the CIM environment, so that various automation projects can be individually judged. If these simple tests are kept in mind during the planning and implementation stages, it is highly likely that the final results will be favorable. The tests were modified from the work of Jeff Farris on LAN development.[11] The tests are:

1. Usability - Can the users operate their applications and the required functions without "cheat sheets" or lengthy non-job related seminars?

2. Reliability - Does the system perform its operations consistently from operation to operation, from day to day, and cover all contingencies?

3. Maintainability - Are employees focused on new ways to use the CIM system, or are they struggling just to keep it running?

4. Auditability - Does the CIM system provide a logical trail to follow the data to the final form of information?

While these tests are useful, they should not be used as the final evaluation. They are intended to be a lowest common denominator across the CIM environment. Every CIM system is unique, and that uniqueness should be understood and developed. The final measure of success is in the market place, against the best in the world.

Preliminary System Planning

Why should a company plan for the long range (long range = 5 years or longer)? What benefits are derived when the plan extends beyond the immediate event horizon? Who contributes to the content of a long range plan? When should the long range plan be established and later updated? Where should the long range plan be utilized?

These questions taken from the newspaper trade axiom "who, what, when, where, and why" are appropriate for any major undertaking. Certainly the implementation of CIM technology must be considered a major undertaking. The long range (5 years) is probably an aggressive implementation of a full CIM enterprise wide system. Without careful planning and consistent goals the project will probably deviate from the original intent. This deviation may negate the original economic justification used to initiate the project.

All of this information is important to the assessment of a CIM project. As in any assessment the accuracy of the evaluation is more critical than the format. Good assessments have been done on the back of an envelope, or in a fishing boat clearly away from the enterprise. While a good assessment might be done in a frivolous manner, most good assessments are completed in very methodical fashion, and are cross checked by all of the experts available. The experts are not necessarily highly paid consultants, they are more likely the end users or customers of the new system. The responses may not be elegant, but they will most likely be accurate.

Endnotes

8. Farris, Jeffrey L., Saber LAN Setup Guide: A guide to Network Planning, Saber Software Company, 1993, Dallas Texas (Introduction), p. 6.

9. Must CIM be justified by faith alone? Robert S. Kaplan. Harvard Business Review.

10. The Justification Challenge. W. Smith. CIM International.

11. Farris, p. 6.

CHAPTER IV

RESEARCH

Research of new ideas and of new equipment technologies is critical to the implementation of CIM. While critical it is extremely difficult to find the adequate resources within the enterprise. This becomes a tactical planning issue that needs to be addressed. Who should perform this research? Fidoten is emphatic on this issue and says "Do not use consultants; it is too costly, causes upset to current system and their recommendations are usually similar to those arrived at internally, or they come up with the wrong answers" (p. 226).[12] If you don't use consultants how does the research of this complicated equipment and concepts get done. Generally a team of in house experts is most productive.

The research team, later to become the implementation team with some minor staffing adjustments should be chosen from within the organization. The criteria should be technical excellence not management excellence. Fidoten suggests three conditions for the research team that probably will work well. The first is "Hire the smartest person you can get who will be responsive and easy to deal with" (p. 226).[13] The team should be made up of team players, but technical excellence should be the prime consideration. The second suggestion is "Hire the strong systems oriented person; this practice has been successful at

Engineering Index" (p. 227).[14] The team members should fully understand that the enterprise efficiency is the ultimate goal. That the final CIM system must work well together. The third suggestion is "New ventures should not be undertaken with new personnel" (p. 226).[15] The team members should fully understand the requirements of the enterprise system. This understanding comes from experience and does not usually import well from outside.

Now that the team is assembled there is still another problem, how do we support the team during the research process. The team is made up of some of the best and brightest employees. Who is going to do the work of the team members, while the team researches the CIM technology. Possibilities that exist are again suggested by Fidoten: (a) redesign the organization as appropriate to accommodate the change, (b) hire new personnel to acquire the skills necessary in either key management positions or in line and/or staff technical capacity, (c) use outside service and consultation, and (d) re-train the existing staff.[16]

While Fidoten elaborates on the organization in may ways, the arguments are not really new. Hammer and Champy suggest that the industrial revolution is based on a similar principle, "Adam Smith argued that people work most efficiently when they have only one easily understood task to perform" (p. 51).[17] In short, don't confuse the research by distracting the team members with day to day activities from their original job duties. The success of the CIM project is more important than the short term.

What are the activities of the research team? Primarily the evaluation of the competing products in the market. With the competitive business climate that is operating today, finding the available options is not difficult. Deciding between them is the problem. The questions that should be answered are:

1. Identify and rank the special, subtle, and elusive performance factors of each product.

2. Develop a clear understanding of the critical performance factors that yield a superior product.

3. Identify critical decision point in the design cycle and adjust the timing of inputs to comply. Drop efforts that provide information to late to support the decision.

Coordinate Organization Goals

Along with the selection of the technical aspects of CIM has to be a good understanding of the Long Range strategy of the company. Developing clear goals and objectives for the organization by management also provides the target for the CIM research team. Corporate policies on service, delivery, sales and marketing can alter the overall CIM selections. The research team must have a clear understanding early in the process.

The short range goals of the enterprise are also important to the research. The current methods, rules, standards, procedures, and practices must be accounted for in the new system. The transition from the old system to the CIM system should be as gradual as possible. Many changes will have to be made in equipment and job structure. By separating these changes from cultural changes it will be easier to control the outcome.

As early in the process as possible an effort to streamline policies and procedures is advisable. One of the tasks of the research team should be to review and recommend the appropriate changes. The limiting of unnecessary policies and methods reduces the constraints placed on the system and its design. The simplification of any wording and the development of an open access to the policies and procedures will not only simplify the later implementation, it could be a general aid in enlisting the later cooperation of the whole enterprise during the implementation.

It is inevitable that any CIM enterprise will rely on the introduction of additional computer technology. The research team should understand the potential impact to the organization and make their decisions accordingly. Whisler categorized the computer impact as follows:

Changes in Organizational Structure

A. There will be less definition between line and staff functions.
B. A short range trend toward centralization, but the long range trend is unclear.
C. Departmental structure will change and functions will be realigned.
D. Clerical work forces will be reduced.
E. The structure of departments will move toward functional units.
F. The organizational location of the computer is an important but unresolved issue.

Changes in Job Content

A. Managerial jobs content will change and take on increased research content.
B. There will be an increase in skills at all levels.
C. Managers will have to develop increased computer related skills.

Changes in Decision-Making
- A. The installation of larger computer systems will conflict with existing problems of inflexibility and resistance to change.
- B. A reduction in the number of decision-making executives can be expected, but these executives will be utilizing the capabilities and consultive services of an increasing number of specialists.

Inhibiting Factors
- A. Exploitation of potential in computers too slow.
- B. Higher placed executives lack understanding and imagination, and have inadequate computer-related skills. (p. 142-151)[18]

Additional areas that will require research to match the new system to the existing enterprise include special information requirements, BOM structure, special business reporting requirements, security, and educational needs. Information control, should be based on a simplified systems approach with up front control.

Information archiving should be based on limited types with minimal redundancies. Records should be designed for auto purging as they become obsolete. Quick retrieval of current records is an essential requirement of the final system. The easy access to data is a major item in the improvement of response time throughout the enterprise. This also leads to improvements in the decision processes both in time and accuracies.

Managing Technical Change

Another consideration that should be considered by the research team concerns how decisions are made. Managing technical change is not a democracy. Frequently only an expert must make technical decisions that redirect the whole program. These decisions must be identified and fully supported by the management team. The conversion of the typical hierarchy management structure must be understood, so that none essential activities are removed from the design team members. The design team must develop the team skills necessary to divide the work and achieve the final results.

Endnotes

12. Fidoten, R. E., p. 226.

13. Fidoten, R. E., p. 226.

14. Fidoten, R. E., p. 227.

15. Fidoten, R. E., p. 226.

16. Fidoten, R. E., pp. 224-225.

17. Hammer, Michael and Champy, James, "Reengineering the Corporation," Harper Collins Publishers, Inc., New York, NY, 1st Ed., pp. 51.

18. Thomas L. Whisler, The Impact of Computers on Organizations, pp. 142-151.

CHAPTER V

CONSTRUCTION

"By the year 1996, it is estimated that 42% of all microcomputers installed in business will be connected to LANs" (Metcalf, 1993, p. 46). This statistic supports the industries trend toward CIM system developments around the use of microcomputers. It also supports the potential for small to mid-sized companies to fully develop CIM systems. What strategies should be considered with respect to purchase or develop a CIM system?

There is no clear cut answer to the question of purchase or develop a CIM system. Generally the development of any system exceeds all of the original estimates. A simple rule may be of some help: If you can purchase a product that satisfies 85% of the specifications, don't develop your own. With the wide assortment of products available it is amazing how many companies still elect to develop their own software solutions. Even if the estimates of development, maintenance, and documentation are accurate, and yield a net savings, these projects pull critical resources away from the "Mission Critical" projects.

Purchase

Referring to CIM Hierarchy of Services (Figure 13), the seven layers can be grouped into levels as shown in Figure 14. Only one, mission critical applications, should be considered for internal development. All of the other layers are common to many applications and situations. There are numerous potential suppliers, developing numerous alternative approaches, that should exceed the 85% selection level for the purchase of a product. If the requirement specifications are not adequately met, then another look at the requirements is probably in order.

The goal in selecting products in the enabling layers is to build a solid foundation for future applications. The use of existing hardware, software,

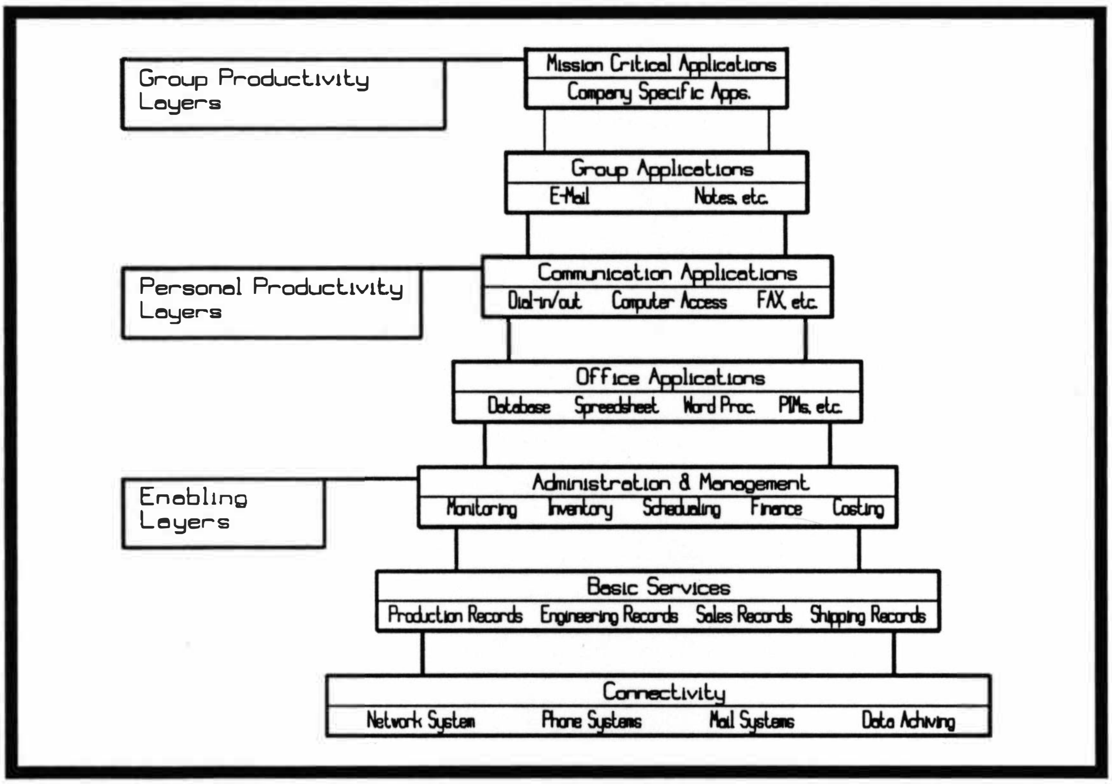


Figure 14. CIM Hierarchy Levels.

manufacturing systems, accounting systems, and all existing equipment is encouraged. It is desirable to spend a minimum amount of time addressing enabling issues without sacrificing performance or productivity. During early stages in the establishment of the CIM system, the enabling levels will probably consume almost 100% of the development teams time. The establishment of simple user instructions, based on the vendors training manuals will usually speed this operation.

The personal productivity level goal is to effectively migrate users from the stand alone systems to the CIM systems. Once a significant number of employees are working on the CIM system, it is reasonable to begin leveraging the overall productivity. The CIM development team should limit their activities to maintaining simple data transfer routines between users and data collection and storage systems. The task of productivity at the personal level should be left to the newly empowered employees. An appropriate rule for the personal level is to standardize office applications for all users to simplify training and support and to encourage peer support and reduce software acquisition costs.[19]

Group application levels are the first levels that may require development or product modification. These applications focus on moving, coordinating, or storing work among multiple people. Careful selection at this level include the application and the roll out to the group. Remember that group productivity provides the most benefit to the overall enterprise. Generally it is advisable to select applications that provide immediate group benefits that require a minimum of application development time. This provides the longest return on investment and does not tie up critical resources that may be used elsewhere.

Mission-critical applications in the group level can be purchased, and should be if prepackaged and debugged products are available that satisfy the requirement specifications. True mission-critical applications are probably well understood, since the business profitability and survival are directly dependent on these issues. Examples of mission-critical applications are: (a) proprietary order entry and information systems, (b) just-in-time inventory management systems, (c) video check-out systems, and (d) work flow automation systems. Because of this detailed understanding, it should be relatively easy to evaluate purchasable products for compliance to the specifications. At this level the purchased product probably needs to satisfy the specifications much closer to 100% rather than the previous 85% level. In fact a product that exceeds the minimum specifications may be a good solution, even if the cost is much greater. According to Max Hopper of American Airlines: "The cost of rewriting software in order to switch from mainframe to smaller machines can be almost inconceivably high."[20] Figure 15 graphically represents this cost increase. This also applies to rewriting software to increase its application to the CIM system.

Develop

If the purchase of the CIM applications are not feasible then the development becomes necessary. Most small to mid-sized companies are not staffed to

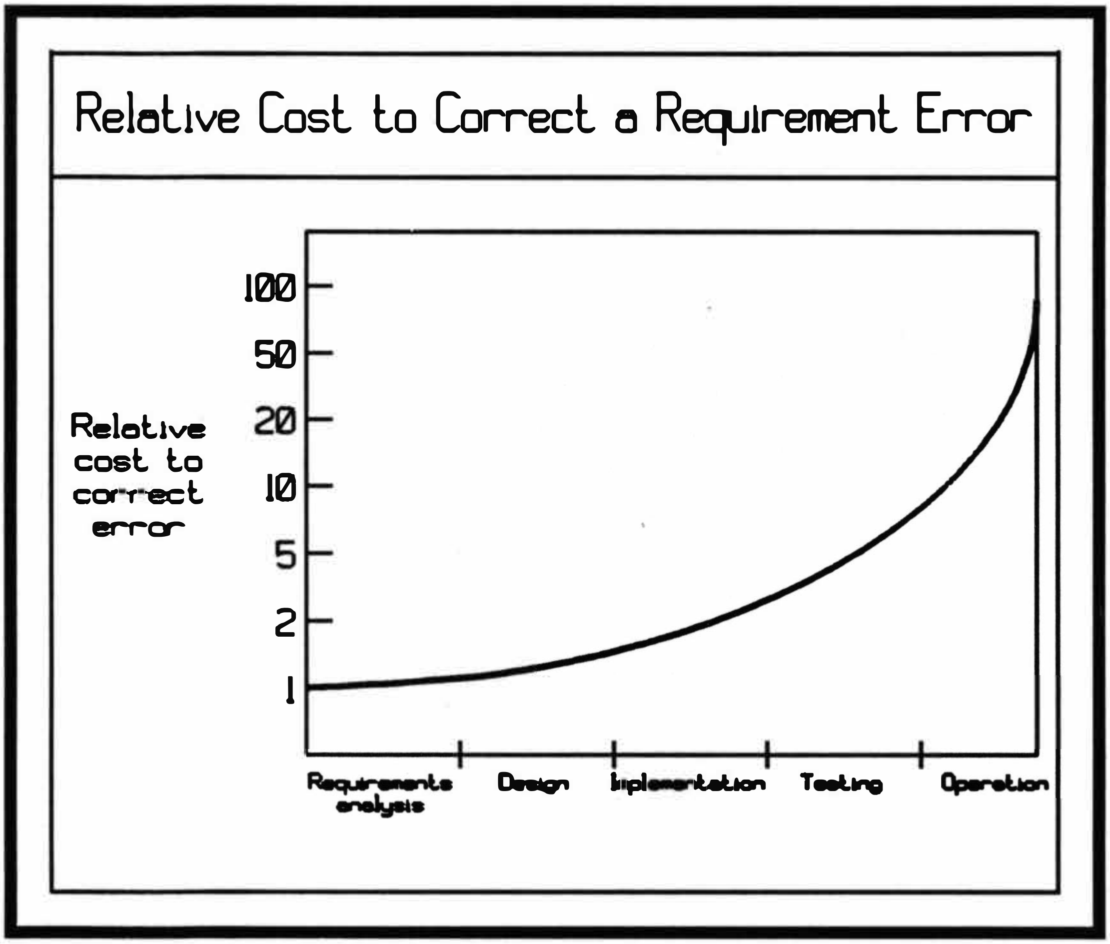


Figure 15. Relative Cost to Correct an Error.

properly develop a new application. The first step is to find additional resources through hiring skilled professionals, or selecting consulting services.

If the choice is to higher additional help Fidoten suggests that you "Hire the smartest person you can get who will be responsive and easy to deal with" (p. 226).[21] The goal of mission-critical applications is to enhance productivity generally through communication between members of the user group. The developer of the application must be capable understanding the specific needs of the group and the requirements of the enterprise.

Another suggestion from Fidoten is to "Hire the strong systems oriented person; this practice has been successful at Engineering Index" (p. 227).[22] Specialists in one field tend to spend to much time learning the details of an operation before they can develop an application. The generalists or the systems person may not develop the most computer efficient software, but they more effectively satisfy the requirements of the overall enterprise. Now that computer hardware is so available, the wasting of computer time is far more preferable for a company than the waste of critical employee time.

If the choice is to utilize contract workers or consultants be considerate of Fidoten's opinion: "Do not use consultants; it is too costly, causes upset to current system and their recommendations are usually similar to those arrived at internally, or they come up with the wrong answers" (p. 226).[23] While not entirely true, this opinion is based on the experience of all to many companies. It is important to remember that consultants like contract workers are temporary employees, and their personal goals do not match those developed by your company. It is important that you manage these short term resources closely. Constant coordination of efforts and progress reports to the internal project team are effective control tools.

Whether the CIM system is developed or purchased, there are common goals. The weight of the enterprises' future success will be based on the final CIM product. The CIM product should be a high quality, reliable, and effective.

Only the users within the company can truly evaluate the ultimate performance of the CIM system, these same users are a valuable asset during the construction.

Special Small Business Requirements

The small business creates several additional problems in the implementation of CIM Technology. The limited resources for building implementation teams. The lack of specialists in critical areas of the basic CIM hierachial levels. The high cost of any new technology with respect to the available cash flow. The long process of implementation compared to the immediate needs to satisfy customers. These are only a few of the problems faced by the smaller sized firms. They are not unique, but are certainly of more importance, when company size is considered.

A technique that should be considered by the small firm is brainstorming. This technique is valuable at any business, the special vaule at small firms is that it can include virtually all of the employees. This larger percentage of employees should virtually minimize any organized resistance to the CIM implementation process.

The reliance on the implementation team suggested earlier is still valid for the overall implementation. The small firm should rely more heavily on individual suggestions. In fact, once the overall plan is developed, Phase 1, each employee should be encouraged to research and suggest those tools and proceedures most appropriate to their own function. No one knows better than employee, the way to improve personnal productivity. By including these suggestions into the overall CIM plan, each job is optimized to use the special skills of the employee.

Limited resource problems, are not unique to the implementation of CIM projects. Small firms are used to facing projects more costly than the budget allows. If the overall economics of the CIM project are valid then there should be a responsible way to fund the project. One of the advantages of PC networks is the the way they can be phased together over time to achive a fully functional CIM environment. Because of the exclusive use of PCs, there are limitations to the available group software. Some office automation packages are also limited, as are advanced CAD systems, and complex material resource planning packages. As technology advances, the software limits are quickly eroding, but for now they are still a significant concern.

Endnotes

19. Farris, p. 18.
20. Hopper, Max, Chief Information Officer, American Airlines.
21. Fidoten, R. E., p. 226.
22. Fidoten, R. E., p. 227.
23. Fidoten, R. E., p. 226.

CHAPTER VI

CONCLUSIONS

The final CIM System implemented by a company is unique to the environment, the enterprise, and to the time of implementation. The environment consists of those external factors surrounding the company at the time of implementation. They include competitive companies and suppliers, the aggregate of external conditions that effect the development of the company. The enterprise is the internal structure of the company and its resources. The time of implementation changes the currently available software and the operating hardware. The rapid changes in both of these systems can radically effect the installed CIM system in as short of a period as one year. The system is not the end product, it is only the vehicle of cultural change. If the system reduces the redundant work and improves the speed and accuracy of the communication, then the goals will be met.

The Western Michigan University CIM Management Center is a demonstration lab designed to satisfy the small to medium sized Company. The hardware and software utilized was chosen to represent typical equipment available to this sized business. The Environment model was taken to be typical of that faced by the western Michigan region. Because of these constraints the WMU CIM Lab details can be used as a suitable model for similar situations.

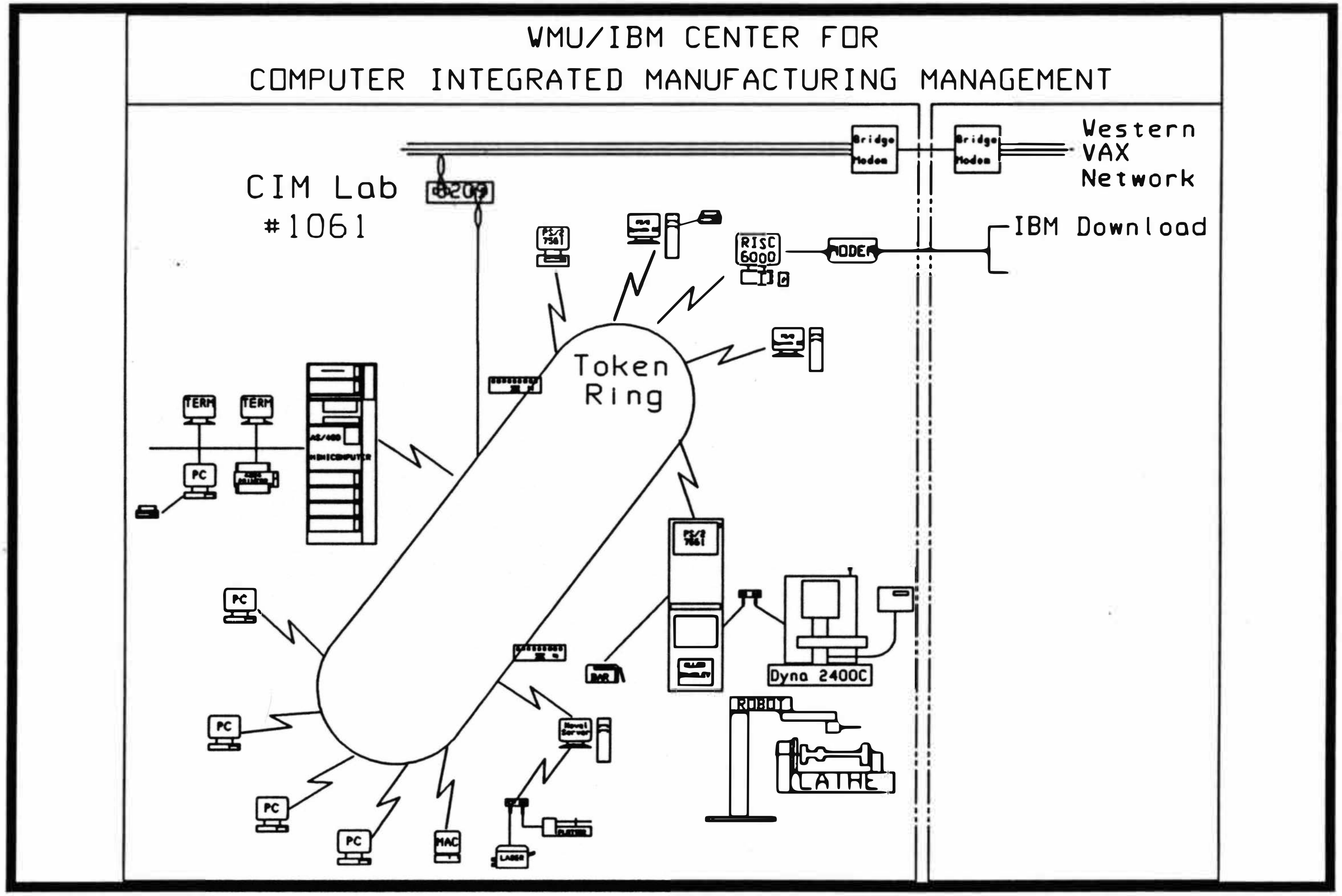


Figure 16. WMU CIM Center Functional Diagram.

The functional LAN figure (Figure 16) represents the Connectivity Layer in the CIM Hierarchy Level diagram (Figure 14). It represents the basic hardware layer of connectivity, the wiring highway used to convey the higher levels of data transfer. The importance of this layer is the ability to carry all types of data from its origination point to all those locations that may need access at later times.

The Basic Services Level (Figure 17), where actual business information is developed and transferred into the shared data of the enterprise. This creation of data is ultimately important to the enterprise, but not until it is compared and contrasted or otherwise manipulated through the formulas and processes of the organization. The basic service layer only collects the data into easily accessible forms that can later be used for decision making.

The third hierarchial layer, Administration and Management (Figure 18), begins the transition of the raw data into enterprise decisions. This layer is practically designed to reduce the raw data into ordered and structured data. The data is processed through standardized processes, computer programs such as Mapics DB, or other scheduling and monitoring software. The organization, and ordering summarizes and reduces the raw data into manageable pieces. This reduced information can be utilized to plan for the future. The first three layers, Enabling Layers, are all essential to support the higher level functional layers.

The Office Application Layer (Figure 19) uses personal productivity tools to provide special analysis of the overall enterprise and environmental data. This analysis is for special cases and is usually not frequent enough to require the

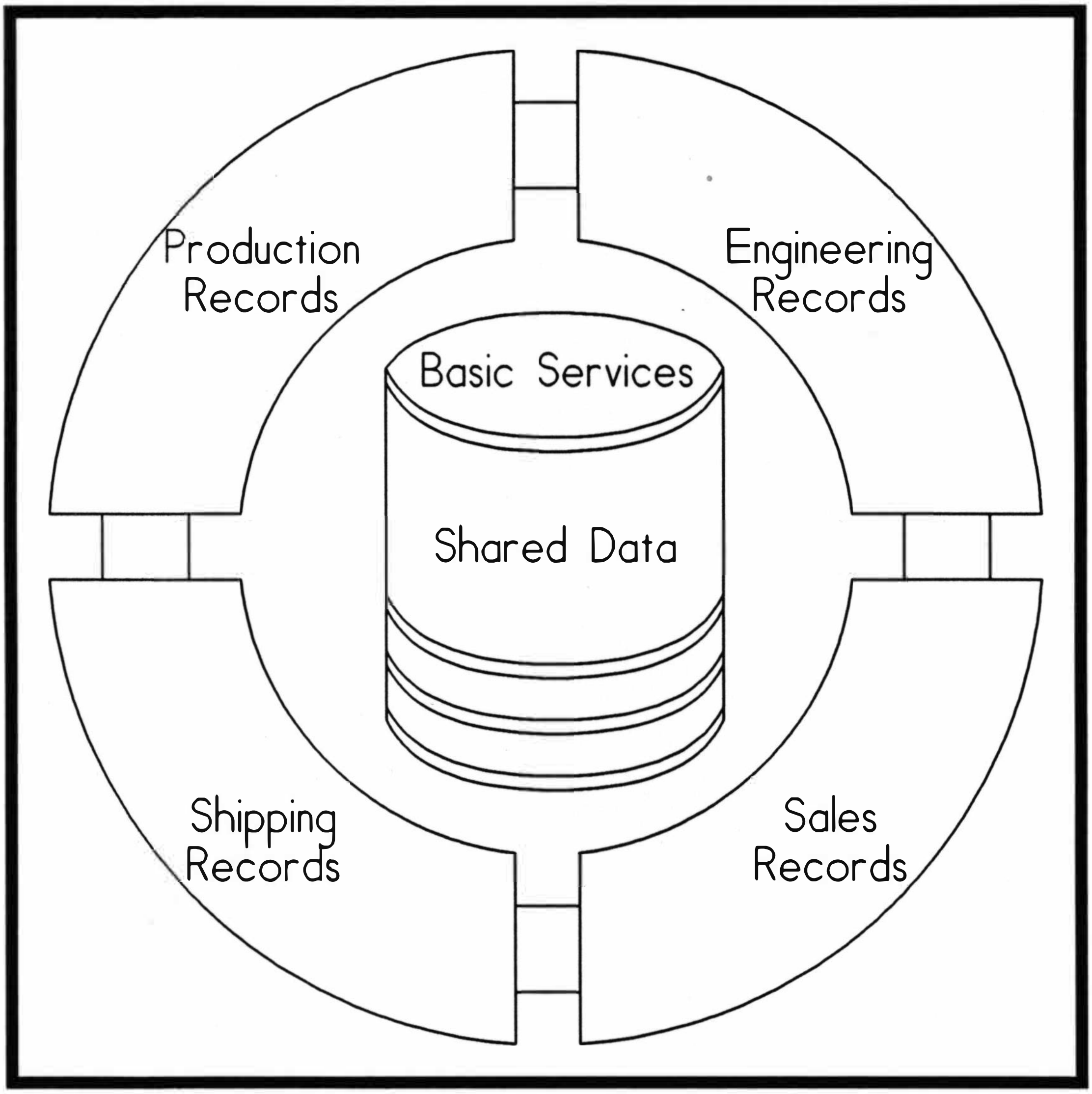


Figure 17. Basic Services Level.

development of an automated process. These personal tools tend to change rapidly, and are subject to the preferences of the operator. They are powerful and extremely valuable to the rapid reaction to changing conditions.

The Communication Application layer (Figure 20) is primarily a computer enhancement of the personal Office Applications layer. This layer allows

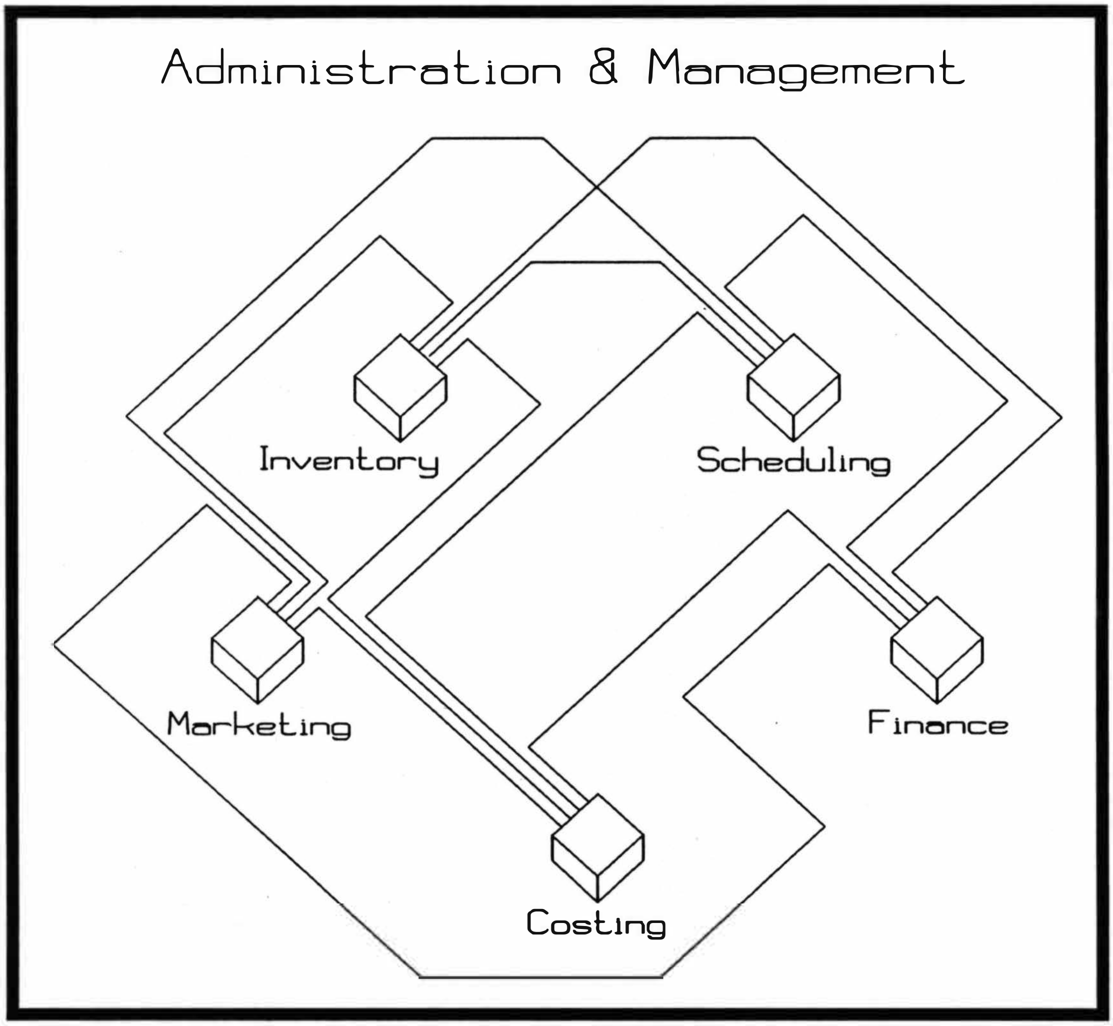


Figure 18. Administration and Management Level.

individual contributors to quickly interact with others on special projects. The transfer of specialized data and analysis trends between individuals or small groups provides for a cross analysis of this specialized data. The resulting information provides inputs to the organizational decisions required to run the business.

The Office Applications and Communication Applications layers make up

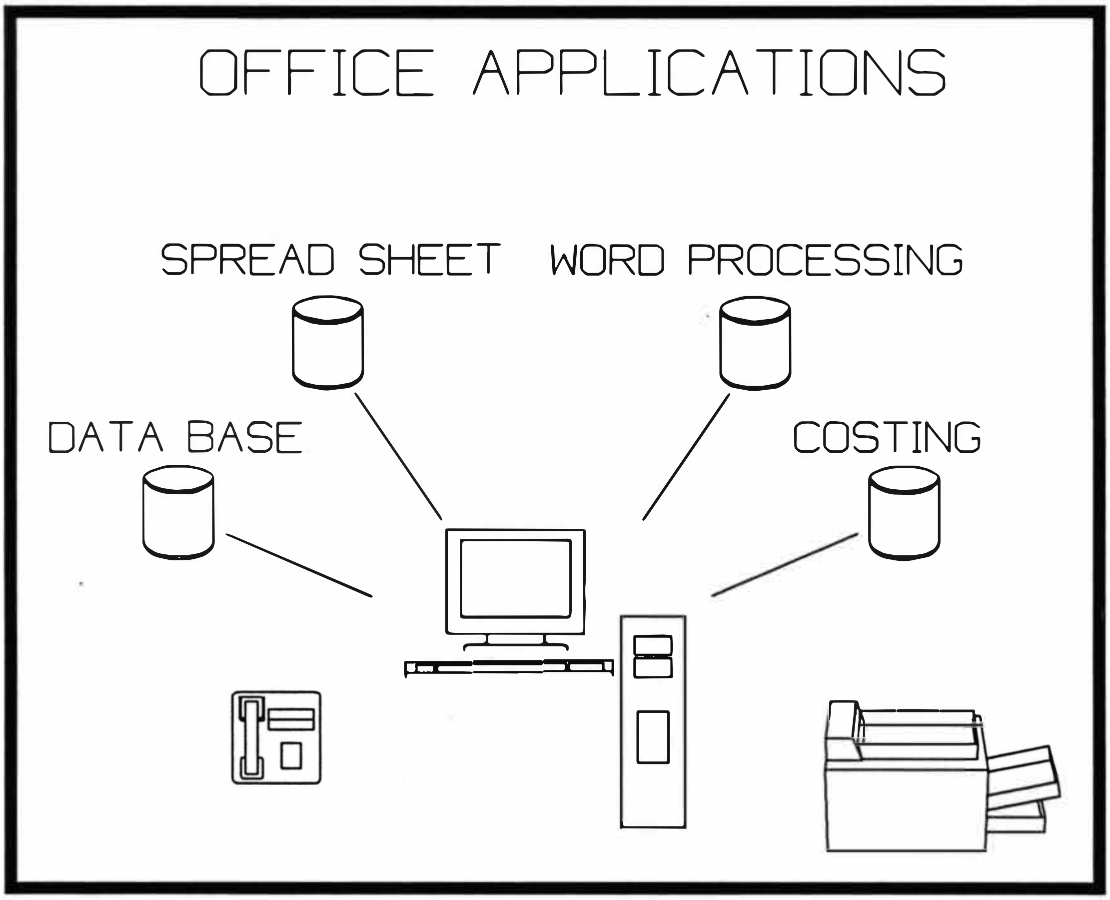


Figure 19. Office Applications Level.

the Personal Productivity Layers. Although they appear to be highly computerized, these layers are primarily cultural in effect. They encourage cross departmental discussions and data sharing at levels never experienced before in traditional business organizations. The blending of departmental functions and the employee empowerment effects are rapidly changing the enterprise.

Group Applications, like E-Mail (Figure 21), are a relatively new layer to the enterprise. The closest group layer functions are probably general meetings. Times when areas of the company came together for a single purpose. Generally

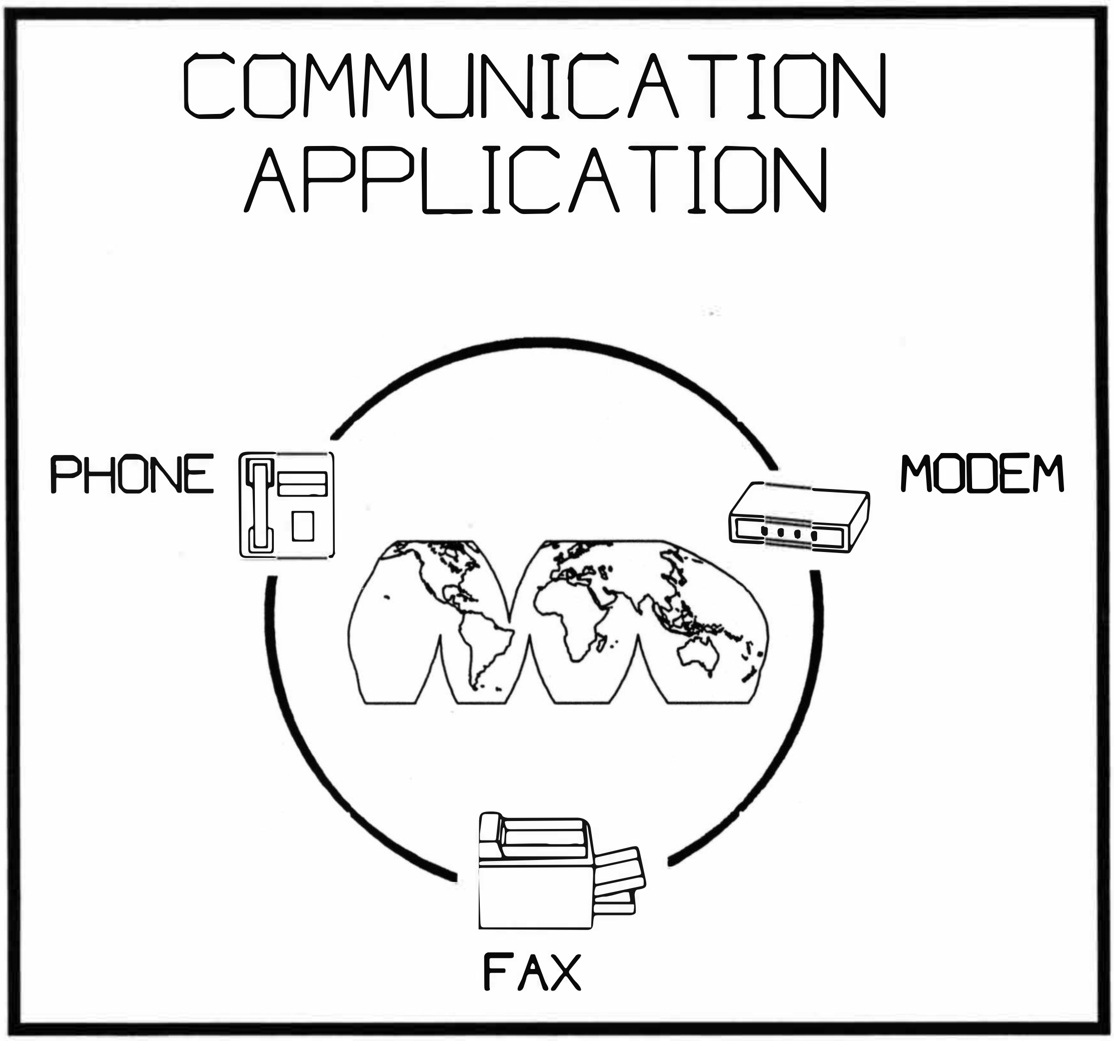


Figure 20. Communication Application Level.

these meetings were very structured and strictly follow a detailed structure. A benefit of E-Mail activities is the unstructured nature. Although much of the E-Mail activity is to respond to specific questions, there is an open route to creativity and the initiation of new concepts. There is also an unprecedented open door from individual to individual in the organization. No idea can be lost through the traditional methods of resistance.

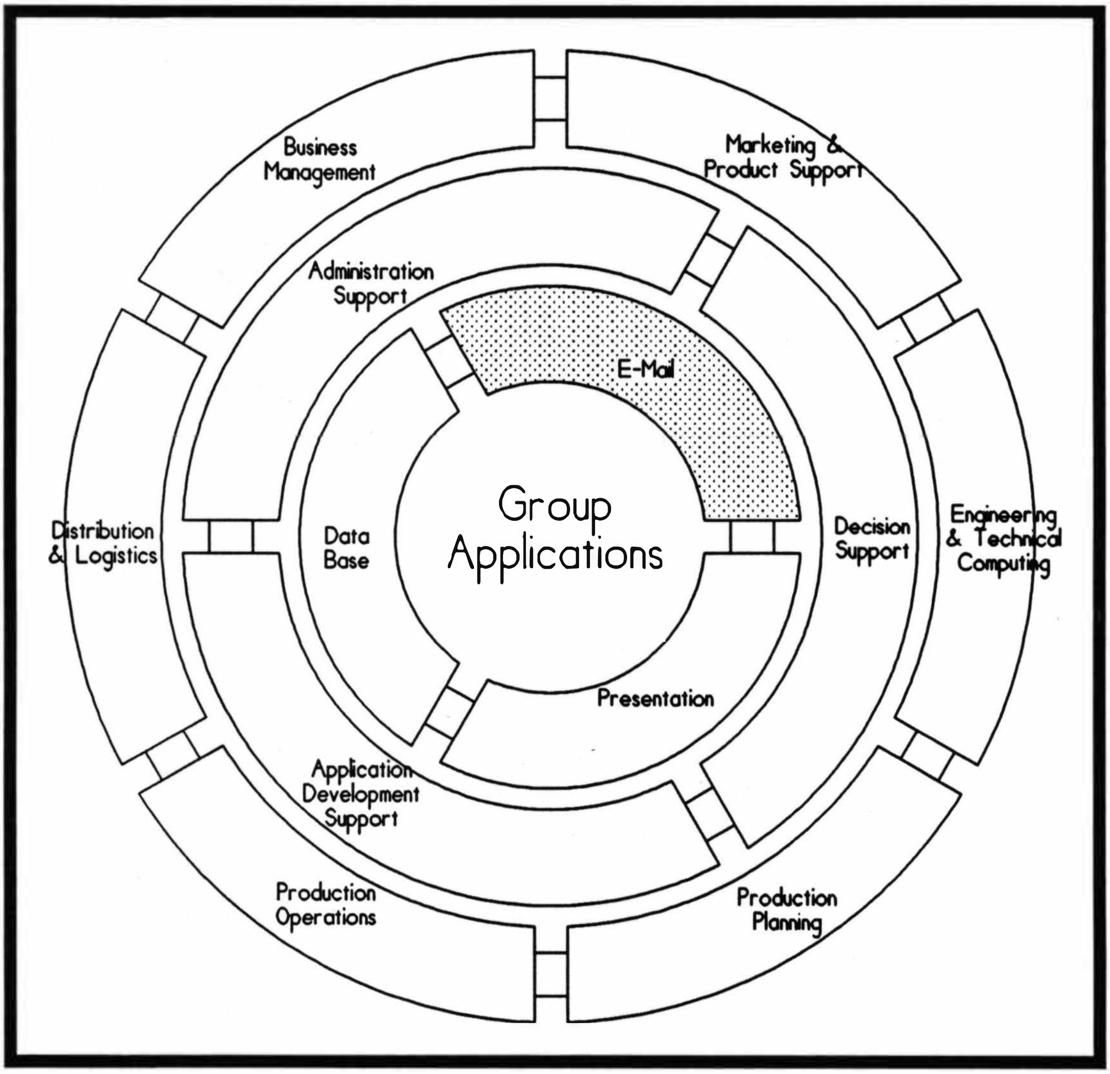


Figure 21. Group Applications.

The main purpose of all of the previous layers is to enable and support the end goal. The Mission Critical layer (Figure 22), those company specific applications that are unique value added features of the company. These applications are by their very nature a highly leveraged group application. They would generally be supported by a broad spectrum of the company, utilizing the

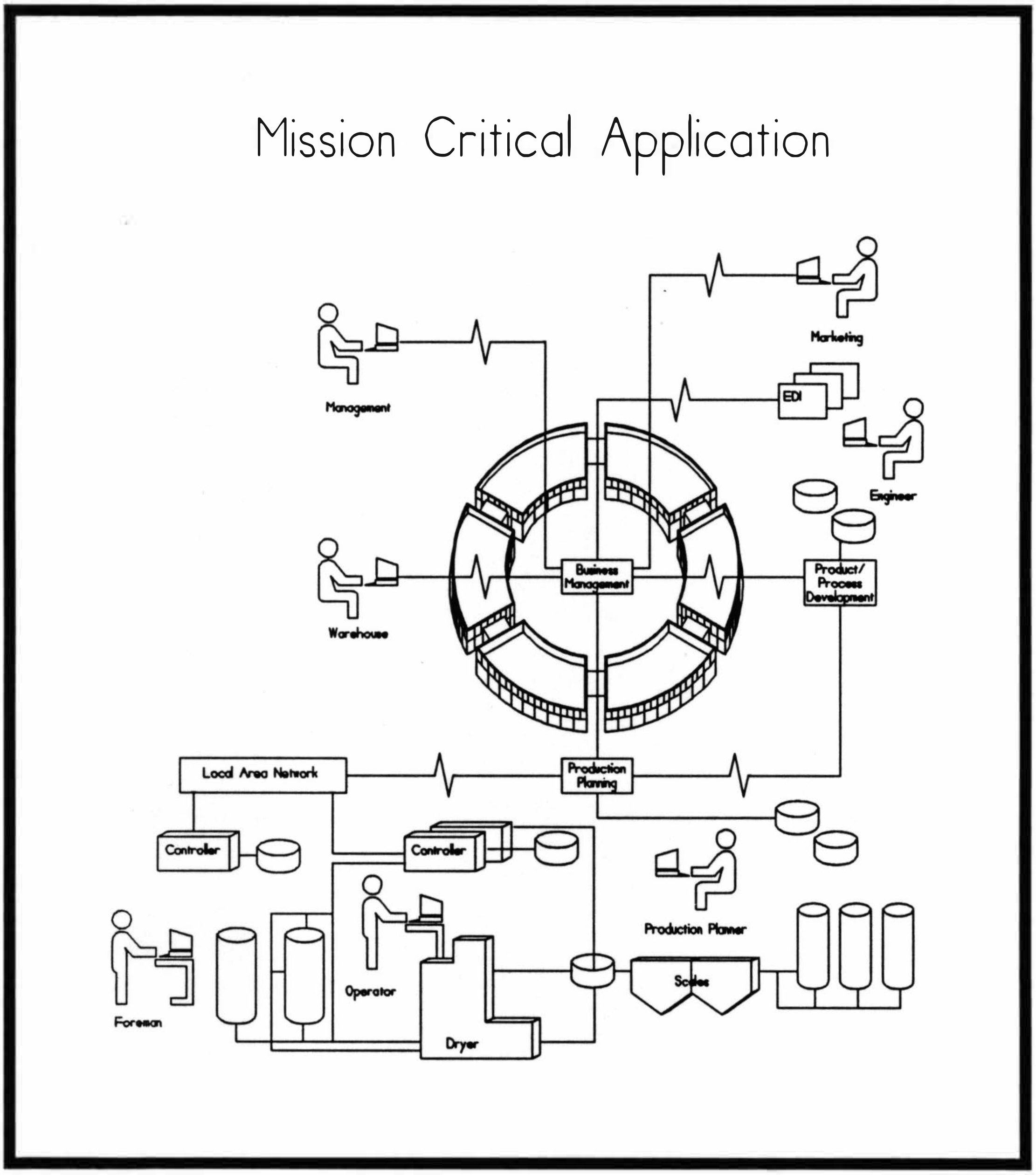


Figure 22. Mission Critical Applications.

companies most specific information, the CIM technology at its apex.

Western Michigan University CIM Management Center

There is no better conclusion to a paper on CIM technology than the description of an operational success. The WMU CIM Lab is just that. With the help of a host of individuals, and the generous contributions of hardware and software from IBM, the CIM Lab has moved from a room full of Islands of Automation to a true CIM environment. It continues to grow and change almost daily, but it represents a practical CIM implementation at either a small or medium sized business.

The fundamental hardware, LAN, and software utilized at the CIM Lab are described for purposes of duplication. No attempt is made to indicate that these configurations are the best or only possible solutions. The most that can be said is that they do work in the proposed environment.

Practical Hardware

The nature of CIM hardware technology is moving to rapidly to develop a complete list of available hardware. Research into compatible hardware is almost impossible on a detailed level, because of the enormous variation and configuration possibilities. The following listing is a general suggestion for small and medium sized companies that have been successfully implemented at Western Michigan University. The listing is not model specific, but should provide the implementation team with direction and limits that are useful in a specific application.

Table 1

Small Versus Medium - Hardware

SMALL versus MEDIUM - Hardware	
CADD Personal Computers 386 or 486 processor Co-processor 16 Meg RAM 250 Meg DASD Tape Backup 1076 x 640 15" Color Monitor Mouse Pen Plotter Laser Printer	CADD Work Station RISC processor 24 Meg RAM 1 - Gig DASD Server - Model Storage 1076 x 1076 21" Color Monitor Tablet Dials Electrostatic Plotter
TOOL PATHING Personal Computers "Can Use CADD system"	TOOL PATHING Work Station "Can Use CADD system"
ENGINEERING SERVICES Personal Computers 386 or 486 processor 8 Meg RAM 250 Meg DASD 1076 x 640 15" Color Monitor Mouse Laser Printer	ENGINEERING SERVICES Server/Work Station RISC processor 16 Meg RAM 1 - Gig DASD Server - Model Storage 1076 x 1076 21" Color Monitor Tablet Server "Use Mapics AS400 Server"

Table 1--Continued

SMALL versus MEDIUM - Hardware	
DECISION SOFTWARE Personal Computers 386 or 486 processor 8 Meg RAM 250 Meg DASD 1076 x 640 15" Color Monitor Mouse Laser Printer	DECISION SOFTWARE Server/Work Station RISC processor 16 Meg RAM 1 - Gig DASD Server - Model Storage 1076 x 1076 21" Color Monitor Tablet "Use Mapics AS400 Server"
MRPII Server Computer 586 processor 16 Meg RAM 2-Gig DASD 640 x 640 14" Monitor Laser Printer Personal Computers 386 or 486 processor 4 Meg RAM 130 Meg DASD 1076 x 640 14" Color Monitor Mouse	MRPII Server/Work Station RISC processor 16 Meg RAM 1 - Gig DASD Server - Model Storage 1076 x 1076 21" Color Monitor Tablet Server AS400 processor 24 Meg RAM 1 - Gig DASD LAN Personal Computers 386 or 486 processor 8 Meg RAM 250 Meg DASD 1076 x640 15" Monitor Mouse

Table 1--Continued

SMALL versus MEDIUM - Hardware	
SHOP FLOOR CONTROL Server Computer 486 processor 16 Meg RAM 2-Gig DASD 640 x 640 14" Monitor Laser Printer Personal Computers 386 or 486 processor 4 Meg RAM 130 Meg DASD 1076 x 640 14" Color Monitor Mouse	SHOP FLOOR CONTROL Server/Work Station RISC processor 16 Meg RAM 1 - Gig DASD Server - Model Storage 1076 x 1076 21" Color Monitor Tablet "Use Mapics AS400 Server" LAN Personal Computers 386 or 486 processor 8 Meg RAM 250 Meg DASD 1076 x640 15" Monitor Mouse

<u>Practical LAN Systems</u>

LAN Technology has stabilized to a few major systems capable of supporting a CIM System. The massive LAN traffic in data exclude all but the most sophisticated LAN technologies. Traffic rates should be capable of 10 to 16 Megabytes per second (MIPs). The disconnection of any device should not shut down the system or cause any notable effects on any other part of the LAN. Error rates must be less than 10^{-6} or lower in a hostile environment like a factory. Cabling should be light and flexible in all but the most hostile environments. Typically twisted pair technology, i.e., telephone cabling, is successful. This technology is relatively cheap and extremely changeable as the enterprise grows and moves.

Two LAN environments are popular and good choices for small companies. The most popular LAN Networking Software is Netware 3.11. It is well documented and available technical support is outstanding. Netware's ability to handle the large file sizes found in CAD environments, and its ability to deal with complex Shop Floor issues has been questioned. Netware 4.0, recently released, apparently has addressed these issues; although this has not been verified in the CIM Lab.

Most of the CIM Lab Network traffic is handled utilizing the OS/2 Network version 1.0. It has been very reliable and relatively stable throughout the experimental process. Working with Windows, DOS, and OS/2 operating systems has not shown any significant weaknesses. Both Networking Systems have operated using Token Ring Adapter Cards and Multiple Access Units.

The Medium Sized Companies might use the Netware or OS/2 Networks, but they probably can support the TCP/IP Network Technology running on either EtherNet or Token Ring. This will provide more consistent connections between all types of hardware and software. In addition the TCP/IP systems seem to be more compatible with the proposed "Super Highway for Technology" currently proposed by the Administration. The CIM Lab has bridged all three of the networks to TCP/IP with good success. In fact most CIM Lab applications can be reached over InterNet, the government sponsored international network utilized

Table 2

Small Versus Medium - LAN

SMALL versus MEDIUM - LAN	
TOPOLOGY Ethernet Token Ring	TOPOLOGY Ethernet
LAN Netware 3.11 OS/2 LAN (Specialty Servers Suggested for Reliability) Engineering Server Eng. Services Server Office Automation Server MRPII Server Shop Floor Control Server	LAN TCP/IP (Specialty Servers) Engineering Server MRPII Server Shop Server

by most universities and research facilities.

Practical Application Software

There is an unlimited supply of software to be applied in a CIM environment. The selection can be daunting, if not impossible. There are a few simple rules may limit the variability in the process:

A. Limit new and unproven software to a few applications that are unique to Mission Critical Success.

B. Select the remaining required software based on broad industrial use

Table 3

Small Versus Medium - Software

SMALL versus MEDIUM - SOFTWARE	
CADD Auto Cadd Generic Cadd IBM Cadd Micro Caddam	CADD Auto Cadd Caddam CATIA Pro Engineer
TOOL PATHING Smart Cam	TOOL PATHING CATIA
ENGINEERING SERVICES Aldus Publisher Word Word Perfect	ENGINEERING SERVICES Interleaf Office Vision
DECISION SOFTWARE Lotus D Base Paradox Excel	DECISION SOFTWARE Minitab SAS DB IV Oracle RDBMS
MRPII Platinum Plus Macola	MRPII Mapics/DB Oracle/JIT Discrete Manufacturing System Oracle/MRPIII
SHOP FLOOR CONTROL ONSPEC SPCEX	SHOP FLOOR CONTROL Shop Floor Control Oracle/Global Enterprise Manufacturing Management System

of the package. This insures both an available supply of experienced users and continued supplier support

C. Select software that is not specifically tied to a single hardware platform type.

D. Select software that can work from a common database of information.

While not trying to specifically recommend software, the experience at Western Michigan University may be of assistance. The software either in use or evaluated is listed below. The basic ingredients necessary to provide CIM support are listed by category and business size. The success of the CIM Lab in interconnecting the packages, while supporting a CIM environment indicates a strong probability that these are good solutions to the general CIM environment.

Appendix A

User Survey

User Survey

User: ____________________
Title: ____________________
Date: ____________________

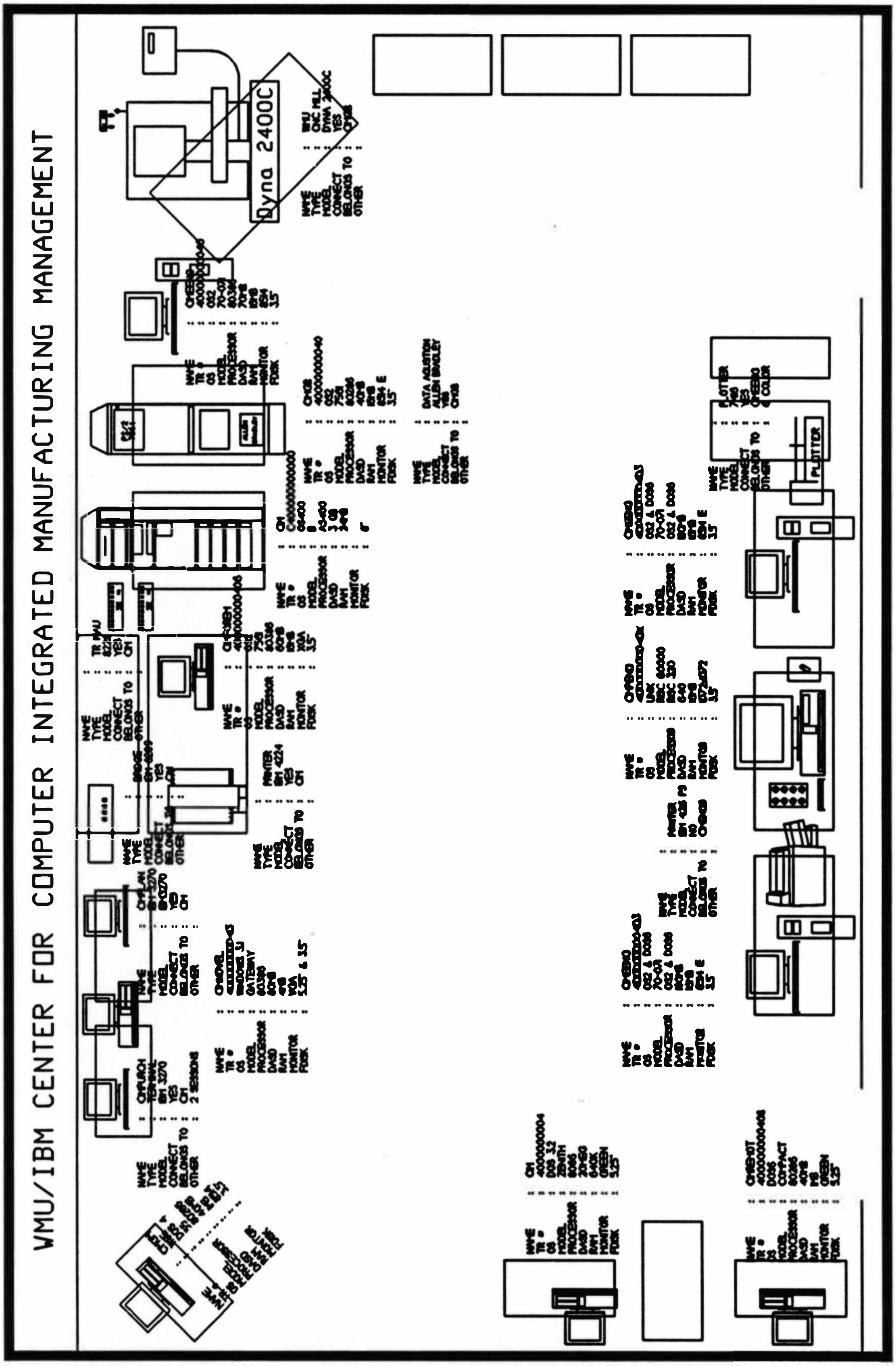
I. User Overview
   A. Job Duties
   B. List each job duty or task.
   C. Deadlines
   D. List specific deadlines the user must meet.
   E. Interactions
   F. List each person with whom the user communicates and interactions necessary to accomplish specific tasks.
   G. Resources
   H. List the resources, such as fax, copier, etc., that the user has access to and uses frequently.
   I. Previous Work-station and Application Experience
   J. List applications and environments that the user is familiar with.

II. Problem Areas
   A. Problems
   B. List each problem as the user has described it.
   C. Perceived Needs
   D. List each fix that the user believes would assist them in meeting their objectives.

III. Quick Evaluation (Complete After the Interview)
   A. Immediate Opportunities
   B. List quick thoughts concerning simple system or procedure changes that could address a need.
   C. Long Term Opportunities
   D. List quick thoughts on systems or procedures that would address problems, but that would require more time and planning to implement.
   E. Areas for Further Exploration
   F. List areas where additional information is needed from other users, management or outside resources.

Appendix B

Western Michigan University Computer
Integrated Manufacturing
Management Center


WMU/IBM CENTER FOR COMPUTER INTEGRATED MANUFACTURING MANAGEMENT
Dyna 2400C
PLOTTER

Design Engineering Function		
Hardware:	**Vendor:**	**Function:**
386 PC @ 16 Mhtz. 16 Meg. Ram Coprocessor 150 Meg DASD Tape Drive 14" XGA Display Token Ring Card	IBM	Product design and engineering Component design Drawing support Engineering analysis
Plotter Model 7372	IBM	Electronic mail
Printer Laser PS	IBM	Develop numerical control paths
Software:	**Vendor:**	
OS/2 ver. 2.0	IBM	
DOS ver. 6.0	Microsoft	
Cad Key ver. 5.1	Cad KEY	
SmartCAM ver 6.0	SmartCAM	
Cadd ver. 6.0	Generic Software	
Token Ring Driver	IBM	
Communications Manager	IBM	
Telnet	IBM	
X Windows	IBM	

<table>
<tr><th colspan="3">Engineering Services Function</th></tr>
<tr><th>Hardware:</th><th>Vendor:</th><th>Function:</th></tr>
<tr><td>386 PC @ 20 Mhtz.
16 Meg. Ram
105 Meg DASD
Tape Drive
14" VGA Display
Token Ring Card

Printer Laser PS
Model 4216</td><td>IBM

IBM</td><td rowspan="3">Publish documents

Update technical documents

Create bill of materials

Create routings

Electronic mail</td></tr>
<tr><th>Software:</th><th>Vendor:</th></tr>
<tr><td>OS/2 ver. 2.0
DOS ver. 6.0
Word Perfect 5.2
Page Maker 4.0
OS/2 Extended Services
PS2 Tape</td><td>IBM
Microsoft
WordPerfect
Aldus Publisher
IBM
IBM</td></tr>
</table>

General Management Function		
Hardware:	**Vendor:**	**Function:**
286 PC @ 12 Mhtz. 2 Meg. Ram 60 Meg DASD 14" VGA Display WSE Card Printer Model MX 80	IBM Epson	Status inquiry Sales presentation Management support Electronic mail
Software:	**Vendor:**	
DOS 4.0 Lotus 2.4 WordPerfect 5.1 Story Board Work Station Emulative	IBM Lotus WordPerfect IBM	

Production Planning Function		
Hardware:	**Vendor:**	**Function:**
3197 Terminal	IBM	Schedule production Release of manu-facturing orders Check availability of parts
Software:	**Vendor:**	Costing parts and assemblies
Direct connect to AS 400		Electronic mail

Plant Management Function		
Hardware:	**Vendor:**	**Function:**
386 PC @ 16 Mhtz. 16 Meg. Ram 60 Meg DASD 15" XGA Display Token Ring Card	IBM	Time & attendence Job scheduling Electronic mail
AS 400 Model B 3 gig, DASP 24 MB, RAM	IBM	Inventory Costing Accounting
Software:	**Vendor:**	Purchasing
OS/2 ver. 2.0 Onspec ver 7.0 FTI Direct connect to AS 400 Mapics DB Office Vision	IBM Heuristics IBM	Shipping Receiving

Operator Station Function		
Hardware:	**Vendor:**	**Function:**
286 PC @ 12 Mhtz.	IBM	Retrieve drawing to guide machine setup
16 Meg. Ram		
Coprocessor		
45 Meg DASD		
14" XGA Display		Retrieve NC code to program mill
Token Ring Card		
IE 232 Card		
		Machine monitoring
CamMate 111	Intercim	
		Inventory location
Data Aquisition	Allen Bradley	
		Time & attendence
Software:	**Vendor:**	Material control
OS/2 ver. 2.0	IBM	
Server 1.3		
Onspec	Heuristics	
Mill Download		
Shop Assist		
Remote access to AS 400		
Mapics	IBM	
Office Vision	IBM	

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