AN INVESTIGATION INTO THE REQUIREMENTS FOR SUCCESSFUL IMPLEMENTATION OF ADVANCED MANUFACTURING TECHNOLOGY (AMT)

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PREFACE

This study sought to identify correlation between the levels of commonly cited success factors in individual AMT project implementations that differentiated successful AMT implementation efforts from unsuccessful ones, by surveying "knowledge workers". In order to classify AMT projects as successes or failures, the survey instrument obtained information from each project regarding the initial expected outcome of the project, and its performance relative to the stated expected outcomes. Scoring schemes were developed, evaluated, and the best methodology was used to obtain the relative performance scores for each project. The scores obtained underwent cluster analysis to define projects as successes or failures. These groupings were used for testing nineteen hypotheses to find out which of the factors commonly listed as success factors in AMT project implementations were statistically significant for distinguishing between the successful and the unsuccessful groups of AMT implementation.

A two tailed t-test for independent groups, indicated that seven out of the nineteen factors addressed in study were statistically significant in differentiating successful and unsuccessful AMT implementation efforts across the spectrum of projects represented. The findings concluded that although all of the factors addressed in the hypotheses tended to contribute to success in individual project implementation, the degree to which they varied between successful and unsuccessful projects was significant for only seven factors. The degree to which these seven factors are present would be indicative of more successful AMT implementations across projects and organizational boundaries. The seven significant factors were: alignment of the core organizational systems with the corporate strategy, strategy formulation process, educational program for employees, top-down planning and bottom-up implementation, pace of implementation, adequacy of technology implemented to its application, and the alignment of AMT strategy with corporate culture.

I am deeply indebted to many people without whose assistance this work would not have been completed. In particular, my sincere gratitude goes to the chairman of my Doctoral Committee, Dr. John W. Nazemetz for his encouragement, support, and guidance throughout my Doctoral program. His constructive critique of several aspects of this study helped me understand the depth of the problems addressed in the research. His insistence on the highest level of professionalism has been very helpful and is reflected in many places throughout this dissertation. It has been a unique privilege to be associated with Dr. Nazemetz for the entire duration of my graduate program, and I am grateful for his direction. I am thankful to Dr. David E. Mandeville who had such a great influence during my doctoral program. Dr. Mandeville's guidance, from a wealth of experience in the application of engineering principles, had such a great impact on the quality of this research. I would also like to thank Dr. Allen C. Schuermann whose dedication to excellence and professionalism has been an inspiration to me for as long as I have been associated with him. I wish to express my appreciation to Dr. Larry M. Hynson for his support, encouragement, and the wisdom that he provided for the duration of this study. I feel fortunate to have been associated with Dr. Joe H. Mize who has been a major resource to me throughout the study. His experience, resourcefulness, and astute dedication to professionalism was greatly appreciated throughout this study. It has been a invaluable experience to associate with such an outstanding individual as Dr. Mize.

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CHAPTER I

INTRODUCTION

Problems of productivity growth and global competition are major concerns of business organizations. Among the many proposed solutions to these problems is the upgrading of process technology in manufacturing sectors of the economy. However, most firms experience at least some problems in their efforts to implement process innovation. Most firms do not get the full productivity benefits of these technologies [24]. Even when firms do apparently achieve acceptable performance levels with the new systems, it often takes longer and uses more resources than most managers anticipated [34]. The challenge now is in the organizing, scheduling, and managing the total manufacturing enterprise, and determining why some companies are successful at introducing new process technologies while others have extreme difficulty, and why some companies that have a history of successful innovations suddenly experience problems with a new one [36].

It is easy to use limited data (one's experience, say, or one's casual observation of others) to construct theories about the secrets of success or failure in process innovation. Unfortunately, few theories have weathered the exposure to large amounts of data because so many variables obscure the picture: industries differ, technologies differ (some are inherently more complicated than others or are at different stages of development), companies differ, their vendors and consultants differ, and the people involved differ [36]. This study attempted to identify some of these factors and based on the data collected across different industries, search for a generalizable patterns of successes. This was done in an attempt to provide some input to address these probing questions relating to the implementation of advanced manufacturing technology (AMT) projects.

Successful implementation strategies address the method of implementing Advanced Manufacturing Technologies (AMTs) such that they produce the expected effects (the desirable outcomes of AMT) on the total organizational posture. Among the desirable outcomes of AMTS are the following: greater long-term profitability, improved competitiveness, improved quality, higher productivity, greater flexibility, shorter throughput time, improved schedule performance, reduced inventories, reduced prices for end products, less parts queue time, and greater value added per square foot and so on [102]. This, of course, is by no means an exhaustive list of the desirable outcomes of AMTS, but a representative set of desirable outcomes, to give only a synopsis of the potential benefits that could be derived from successfully implemented Advanced Manufacturing Technologies (AMTs).

This study reviewed the literature to determine the factors that were predominantly mentioned as success factors in individual project implementation experiences. These formed a basis for developing the hypotheses for the study. Based also on the information from literature, a questionnaire was developed and used to conduct a survey of projects that have implemented AMT. This was done in order to investigate if there were a general set of factors which distinguished successful AMT implementation from the unsuccessful ones. The results of this study are expected to provide some direction and guidelines for successful implementation of AMTS. The development in the following sections will indicate the need for this study, through the statement of the problem, background of the study, and the goals and objectives of the study.

The Advanced Manufacturing Technologies (AMTs) explored in this study fall under the realm of technologies that collectively, comprise Computer Integrated Manufacturing (CIM). "Computer Integrated Manufacturing (CIM) is an approach to the organization and management of a manufacturing firm, in which the functions of design, manufacturing and production management are mutually rationalized and completely coordinated, through the use of computer and information/communication technologies" [63, p. 173].

There are numerous discrete advanced manufacturing technologies under the overall umbrella of technologies that make up CIM. Technologies that are included in this framework include: Computer Aided Manufacturing (CAM), NC/CNC/DNC, Robotics, Vision Systems, Automated Guided Vehicle Systems (AGVS), Automated Storage and Retrieval Systems (AS/RS), Flexible Manufacturing Systems (FMS), Manufacturing Cells, Automated Assembly Systems, Computer-Aided Testing and Computer-Aided Inspection (CAT/CAI).

Other technologies included under the CIM umbrella are: Computer-Aided Design and Computer-Aided Engineering (CAD/CAE), Group Technology (GT), Computer-Aided Process Planning (CAPP), MRP and MRP II, Just-In-Time (JIT) manufacturing, Local Area Networks (LANS), Manufacturing Automation Protocols, and Technical and Office Protocols (MAP/TOP), Initial Graphics Exchange Specification (IGES), Database

Management Systems (DBMS), and so on. As is evident thus far, almost every "buzz word" in modern manufacturing systems can be under this general rubric that comprises CIM. The study investigated how these technologies combine with other systems within an organization to yield the respective levels of Advanced Manufacturing Technology (AMT) implementation success attained by the organization. Figure 1 gives a general picture of how these AMTS fit into the total organizational infrastructure. The model presented in Figure 1 indicates that the external focus of strategy must be balanced by assessment of the internal capabilities - the organization's structure, management process, cultural and political systems, and the technical system - in order to implement strategy effectively. A disciplined approach to implementing these AMT systems is the cornerstone for achieving the full potential of such systems. The questionnaire that was used to conduct the survey for this study was designed to capture the relationships of these systems, and to subsequently test individual factors within each system to find out which of them were differentiating factors between successful and unsuccessful AMT implementation.

Need for the Study

Manufacturing firms throughout the world have invested and are expected to continue to invest heavily in Advanced Manufacturing Technologies (AMTs). As global competition intensifies, American managers are adopting a new battle cry: "Beat'em with technology or move-over there" [44, p. 69]. Indeed, since 1975, the boom in information-intensive processing technologies has been explosive. According to Jaikumar [44], a close look at how U.S. managers are

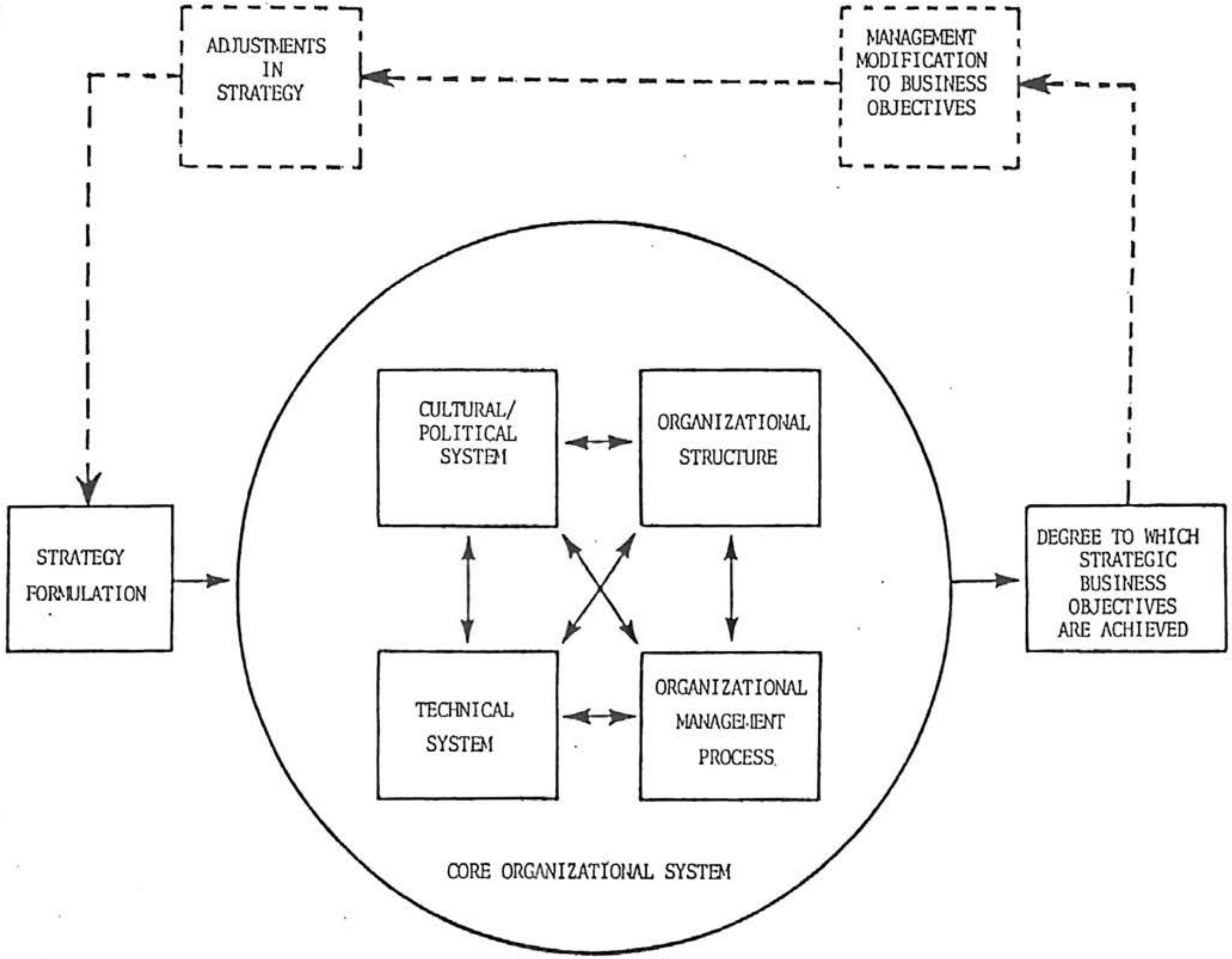

Figure 1. A Model For AMT Implementation

actually using these technologies, however, silences their battle cry in a hurry. He indicated that they are buying the hardware of flexible automation, but in most cases, they are using it very poorly. Information, from Dataquest, Inc., a market research firm, shows that purchases of factory automation has doubled to 18.1 billion dollars over the past five years, and the market is expected to double again by 1990 [67]. Each year, these new technologies, such as CAD, CAM, robotics, etc., are being applied to an ever-expanding list of industry fields with some impressive successes. "No longer are these technologies only for giant corporations, for as they are proven, these technologies are becoming less expensive and within the budgets of smaller companies who must consider these new technologies to remain competitive within their market places" [76, p. 13]. The results of the efforts to implement AMT systems at this stage are mixed, with some alarming failures, but also some notable successes.

To date, the strategy for implementing advanced manufacturing technologies (AMTS) have been developed via trial-and error by each firm as it pursues its first efforts. This approach to Advanced Manufacturing Technology (AMT) implementation may not result in the most efficient operation of the new technology installation. The process by which a strategy is formulated is extremely important to the strategy's success. The appropriate process involves not only developing the right economic answer, but also ensuring that it can be implemented within the particular company [97]. Determining what set of activities needs to be undertaken involves identifying what is needed by the company. There is however, no empirical data currently available, that delineates the factors accounting for success across a spectrum of AMT project implementations. There is therefore a need for such a study in order to provide a general model that is not based on individual project implementation experiences. Such a model would be significant in directing future implementation efforts. Implementing modernization which will not aid a company in accomplishing its business objectives will be a failure. It is imperative that the real needs of the company be determined in order to identify the appropriate modernization activities, and delineation of the requirements for a successful AMT project implementation would assist in that process.

In a number of cases, managers have successfully resolved the issues involved in implementing AMT systems, but their experiences and knowledge is not readily available to assist other managers going through similar experiences. Assessing and documenting the general requirements for successful implementation Advanced Manufacturing Technology (AMT), and evaluating their commonality across several implementation efforts will provide a set of generally accepted factors required for successfully implementing Advanced Manufacturing Technology (AMT). This would be valuable information and also serve as a guide for future efforts to implement AMT systems.

Implementing advanced manufacturing technologies (AMTS) such that the system will achieve the anticipated effects on the total organizational posture is of prime concern to numerous organizations that are planning to implement AMT systems in the future. This study was designed to extract and synthesize the general factors affecting AMT implementation efforts across several different projects. This will provide valuable information for managers who are designing AMT implementation strategies for the future.

Statement of the Problem

The information addressing Advanced Manufacturing Technology (AMT) implementation success or failure that is available in the literature today is predominantly based on reports of individual project implementation experiences. This body of information, currently being used to theorize on the factors accountable for successes or failures of AMT projects are therefore, limited to reports by individuals involved in the implementation of the project being reported on without the benefits of cross comparisons with other implementation experiences. Empirical data indicating the commonality of any set of factors for successful implementation of AMT across several projects is currently lacking. Such information is required in order to give implementation planners and practitioners some direction in their implementation efforts. This research synthesized factors that were commonly cited in literature as being factors for individual AMT projects successes. Subsequently, a study was conducted, to survey AMT projects across the United States, to investigate if there were any discernible pattern in factors that accounted for successes across a spectrum of AMT projects.

Purpose of the Study

The purpose of this study was to conduct a survey of companies across the United States that have implemented advanced manufacturing technologies, to investigate if there is any commonality in factors that significantly differentiated successful AMT projects from the unsuccessful ones. The study was aimed at determining if there are any generalizable patterns in success factors across the myriad of projects represented in the survey sample, or if the success factors addressed in literature are based strictly on individual projects. Assessing and documenting the factors affecting AMT implementation efforts will provide valuable information to managers who are designing implementation strategies for the future, and contribute to the general theory of AMT implementation.

In the efforts to implement Advanced Manufacturing Technology (AMT), identifying attractive opportunities and setting the right strategic direction do not themselves guarantee success. An organization will move most effectively toward its declared objectives when, and only when, all of its complex elements are synchronized. This synchronization concept is frequently referred to as "fit". Successful performance occurs when an appropriate strategy is implemented through the effective rationalization of the basic elements (The core organizational systems) that make-up and drive the organization. Success - the achievement of the declared strategic business objectives desired from the Advanced Manufacturing Technology (AMT) project implementation - is brought about through a complex interaction of strategy and all these elements. The questions addressing each of the hypothesis for this study attempted to focus on the complex interaction required of the core organizational systems (organization's structure, management processes, cultural and political systems, and the technical system) in order to achieve the strategic business objectives specified for the Advanced Manufacturing Technology (AMT) in the organization's strategy formulation.

Theoretical and Practical Framework for the Study

All of the complex elements and actions required to move an organization towards its strategic objectives must be raised to the conscious level, clearly understood, and as much as possible, made to work in unison. A strategic diagnosis is one way to evaluate the fit among them all, and can help the organization move surely towards success [88]. There is no general theory of implementation that would specify how different organizational settings can balance their external focus on strategy formulation with their internal capabilities in order to implement the AMTs included in their strategy effectively.

It seems reasonable that more sophisticated manufacturing systems would require integrated planning of the whole system, but even the largest companies rarely approach the problem this way. It is much more of a trial and error process [34]. There is a disturbing tendency in much of the literature on advanced manufacturing technologies that suggest that every installation is unique and there is no transfer of knowledge gained from experience from one case to the next [24]. The overall thrust of this research was to explore theoretical and practical answers to the question of why some firms that adapt advanced manufacturing technologies are more successful than others. In spite of the importance of this issue, there is no general theory of implementation in existence [24]. This research should eventually contribute to the general knowledge of implementation, as well as provide summary recommendations to practitioners faced with implementation planning in the future.

Scope and Limitations

This study was limited to selected companies that have implemented AMT. The sampling of companies to be included in the study was conducted on a nationwide basis. Information was collected from project managers or team members that have been involved in the actual implementation of their respective AMT systems. This was possible because a purposive sample was used to direct the survey instrument to those who have either volunteered to be participants in the study, and have indicated their involvement in such projects, or have been selected by experts consulted, based on their knowledge of, and interaction with those chosen to be in the survey population.

The responses to the questionnaire have several inherent limitations. One of the major limitations is that the return rate to mail questionnaires is usually very low because the participants are essentially volunteers. In order to increase the return rate, the depth in which questions are designed has to remain somewhat limited to avoid possible concern of respondents as regards revealing confidential company information.

Another limitation of this study is that the questionnaire approach distances the researcher from the sample, somewhat limiting the researcher's knowledge of the respondents.

Assumptions

The study made the following assumptions:

1. All participants had a good understanding of their organization's Advanced Manufacturing Technology (AMT), and the implementation process in their particular organizations. This was

accomplished by using a purposive sample in a deliberate effort to direct the questionnaire to people that are known, though publications or personal contacts, to be involved in their AMT efforts.

2. All participants have played an active part in their organization's Advanced Manufacturing Technology (AMT) implementation, for example, by being members of the AMT project team.

3. All participants understood the intent and purpose of each of the survey questions.

4. All participants answered the questions honestly and accurately.

Definition of Terms

Although most of the terms in the study may be classified as common knowledge in advanced manufacturing organizations. The following definitions are provided to avoid misinterpretation of their use within this study:

ADVANCED MANUFACTURING TECHNOLOGY (AMT) - Individual technologies which, as a group comprise computer integrated manufacturing. Among the technologies included in this category are: robotics, computer-aided design and computer aided manufacturing (CAD/CAM), material handling systems, vision systems, and so on.

KNOWLEDGE WORKER - People who were involved in the planning and/or implementation of their AMT.

CIM - COMPUTER INTEGRATED MANUFACTURING - An approach to the organization and management of a manufacturing firm, in which the functions of design, manufacturing and production management are mutually rationalized and completely coordinated, through the use of computer and information/communication technologies.

SUCCESSFUL IMPLEMENTATION - Attainment of the stated expected outcomes for the AMT project. The level of success of a project is measured by the degree of attainment of the expected outcomes for the project.

FMS - FLEXIBLE MANUFACTURING SYSTEM - FMS consist of a group of processing stations (usually Numerical Control machines) connected by an automated workpart handling system.

JIT - JUST-IN-TIME - This is a Japanese production control philosophy in which there is so little inventory in the system that detailed monitoring of transactions is unnecessary. It is a logistics approach designed to result in minimum inventory by having the necessary material arrive at the necessary place and time.

LEAD TIME (MANUFACTURING) - The total time required to process a workpart through the plant. It includes not only the actual operation times but also the nonproductive dead time that must be allowed.

MRP II - MATERIAL REQUIREMENT PLANNING II also referred to as **MANUFACTURING RESOURCE PLANNING** - Material requirement planning (MRP) is a computational technique that converts the master schedule for end products into a detailed schedule for raw materials and components used in the end products. MRP II represents a significant improvement over MRP. It ties together, the various separate functions of production planning and control system by linking the MRP system and the financial systems in the company.

Null Hypotheses

The hypotheses for this study were derived from an extensive review of literature. In the literature review which is presented in its entirety in Chapter II, a set of factors were identified predominantly by several different sources as being accountable for varying levels of successes attained in AMT project implementations in their firms. Those factors that were most frequently listed were synthesized, and formed a basis for the hypotheses that were tested for the study. Chapter II covers the review of literature which produced the factors addressed in these hypotheses. A summary of each hypothesis formulated, along with the literature supporting them is also provided at the end of the literature review in Chapter II.

This study was designed to test the following hypotheses:

1. The degree of effectiveness in aligning the core organizational systems with the corporate strategy will not be a significant factor in differentiating successful and unsuccessful organizations in their efforts to implement AMT.

2. The degree of effective alignment of employee attitudes with the corporate strategy will not be a significant factor in differentiating successful and unsuccessful AMT implementation efforts.

3. The strategy formulation process will not be significant in differentiating successful and unsuccessful AMT implementation efforts.

4. An organization's position along the organic - mechanistic dimension will not make a significant difference in the degree of success attained in their efforts to implement Advanced Manufacturing Technology (AMT).

5. The nature of the relationship between the technology supplier and the user firm will not be significant in differentiating successful and unsuccessful AMT implementation efforts.

6. The existence of an AMT champion will not make a significant difference between successful and unsuccessful AMT implementation efforts.

7. The position of the AMT champion in the organization will not make a significant difference between successful and unsuccessful AMT projects.

8. The existence of an employee educational program prior to AMT implementation will not be a significant factor in distinguishing between successful and unsuccessful AMT implementation efforts

9. The degree of availability of hands-on training program for employees after the installation of the AMT system will not make a significant difference between successful and unsuccessful AMT implementation efforts.

10. The degree of top-down planning and bottom-up implementation in an organization will not be a significant factor for distinguishing between successful and unsuccessful AMT implementation efforts.

11. The pace of implementation will not make a significant difference between successful and unsuccessful AMT implementation efforts.

12. The degree to which organizations obtained experience with a pilot project prior to implementing a full scale project will not make a significant difference between successful and unsuccessful AMT implementation efforts.

13. The organization and composition of the AMT project team will not be a significant factor differentiating successful and unsuccessful AMT implementation efforts.

14. The degree of management commitment and support in an organization will not be a significant factor differentiating successful and unsuccessful AMT implementation efforts.

15. The magnitude of product redesign or simultaneously designing a new product in parallel with implementing a dedicated AMT will not make a significant difference between successful and unsuccessful AMT implementation efforts.

16. The degree of adequacy of the particular technology to an application in the organization will not make a significant difference between successful and unsuccessful AMT implementation efforts.

17. The degree of information integrity in an organization prior to AMT implementation will not be a significant factor in differentiating between successful and unsuccessful AMT implementation efforts.

18. The degree of availability of qualified systems integrators in an organization will not make a significant difference between successful and unsuccessful AMT implementation efforts.

19. The degree of alignment of an organization's AMT strategy to its culture will not be a significant factor in differentiating between successful and unsuccessful AMT implementation efforts.

The core organizational systems shown in Figure 1 are represented in the nineteen hypotheses stated for this study corresponding to the factors addressed in the literature, and selected as pertinent factors for investigation in this study. A summary of the core organizational systems along with the hypotheses addressing them is presented in Table I.

TABLE I

COUNTERCHECK OF HYPOTHESES' AFFILIATION WITH THE CORE ORGANIZATIONAL SYSTEMS

Core Organizational System	Countercheck Hypotheses #
Strategy Formulation	3
Cultural/Political System	19
Technical System	15, 16, 18
Organizational Management	1, 2, 5, 6, 7, 8,
Process	9, 10, 11, 12, 13, 14
Organizational Structure	4

CHAPTER II

REVIEW OF LITERATURE

This chapter focuses on the review of theoretical and empirical literature most pertinent to this investigation. It also inventoried data pertinent to the adequate assessment of the current knowledge of Advanced Manufacturing Technology (AMT) implementation strategies, and established the practical and theoretical reasoning underlying the AMT implementation process. This aided in identifying the general requirements for successful AMT implementation. These identified factors were then used in the survey design to attempt to establish the commonality of these factors in the companies surveyed. This chapter covers the literature supporting the different core organizational systems, as they relate to the implementation of Advanced Manufacturing Technology (AMT). The topics covered include: the need for understanding of implementation success factors, strategy formulation and implementation, cultural and political systems, technical systems, organizational management processes, organizational structure, implementation success factors, and expected outcomes of AMT.

The Need for Understanding of Implementation Success Factors

Advanced Manufacturing Technology (AMT) is not just groups of equipment or systems such as Computer-Aided Design (CAD), Robotics, Manufacturing Resource Planning (MRP II) or other sophisticated equipment, but significant strategic systems, capable of determining an organization's survival or demise in the face of global competition. AMT represents an opportunity to revise the way companies do business in new and creative ways through more flexible and integrated approaches to manufacturing operations. Modernization includes the set of activities which will improve productivity, quality, and throughput time, among other benefits. Some of these activities will involve purchasing new equipment, but may involve improving how the product is currently being processed and utilizing existing resources to their maximum capabilities without spending money on new equipment [76]. Determining the right set of activities is the cornerstone to a successful modernization effort. Implementing new technologies which do not interface with all required activities will create an island of modernization with disappointing results. For this reason, it is important to identify the needs of the organization, and how the new technologies tie into the strategic direction of the organization. Delineation of factors for successful implementation would be a valuable resource in this needs analysis. This information would provide guidance not only for determining if a modernization activity should be undertaken, but also determine what areas should be considered for such modernization activities.

Most market forecasts reveal a dramatic growth in factory automation. According to Dataquest, Inc.,"... purchases of factory automation has doubled to 18.1 billion dollars over the past five years. The market is expected to double again by 1990" [67, p. 8].

The evolution of global markets and competition are some of the reasons that organizations are adopting AMTs. Because of international competition, companies are being forced to introduce new and better products faster, and at a lower cost. Developments in manufacturing technology are offering new options - options for greater flexibility, better quality, and rapid response to changing market requirements - at lower costs. In addition to market pressures, the rate at which technology itself is being developed and transferred is forcing companies to recognize AMTs as the inevitable alternative in order to remain competitive.

Advanced Manufacturing Technology (AMT) implementation involves more than a technical challenge. It is also an organizational challenge. It requires that the organizations involved redefine traditional roles and responsibilities, organization structure, work content, reward systems, and its approach to education and training [67].

Because of the complexities of all the issues involved in implementing AMT, many companies are ending up with disappointing results, as their attempts to implement AMT fail to yield quick and dramatic benefits, and may even cause problems that are more complex and serious than those they were intended to solve [101]. The enormous amounts invested in AMTs justify the need for synthesizing factors that would indicate the trade-offs and constraints that project managers and/or teams are likely to face in the implementation process, in order to increase the success rate of their implementation efforts. The following sections will address the different components of the general AMT implementation model introduced in Chapter I.

Hayes and Wheelright [36], in their discussion of Implementing Changes in Process Technology, indicate that from examining the data contained in a number of surveys and case histories, one is likely to conclude that much of the advice on "how to succeed in implementing a process innovation" is quite superficial. They assert that the case/surveys indicate, for example, that "top management commitment" and the support of the workforce are essential, that "interfunctional committees" help deal with the pervasive effects of technological change throughout the enterprise, and that it is important to find someone to "champion" the new technology. They noted, however, that in many instances, top management commitment seems to hinder the innovation process (particularly when top mangers force an innovation on an unwilling organization). Similarly, interfunctional committees can complicate, frustrate, and bureaucratize the implementation process as easily as they abet it. They also pointed out that the wrong technological champion can do irreparable damage. They contend that these supposed answers are not really answers, they are more like questions. "How does one obtain the commitment of top management and the support of workers? Who should be on the interfunctional committee, and whom should it report to? Where does one find a technological champion, and how does one know - before it is too late- whether one has found the right person?" [36, p. 324].

Ettlie [23] explores the theoretical and practical answers to the general question of why some firms that adopt new production technology are more successful in utilizing these innovations than others. He notes that despite the importance of this issue, no general theory of implementation currently exists. He further indicated that such a generalized model should eventually contribute to the fund of knowledge on implementation as well as provide summary recommendations to practitioners faced with implementation planning and problems for discrete parts production technology in both the supplier and user organizations. He notes that most firms experience at least some problems in implementing process innovation. He further stressed that "in particular, we are not effectively utilizing discrete parts manufacturing innovation like CAD/CAM Systems, even when they are installed," [23, p. 38] and that most firms do not get the full productivity benefits of discrete parts manufacturing technology. He asserts that even when firms do apparently achieve acceptable levels of performance with new systems, it often takes longer and uses more resources than anticipated. Ettlie notes that "The challenge now is in the organizing, scheduling and managing the total manufacturing enterprise" [23, p. 39]. He further states that it seems reasonable that more sophisticated systems would require integrated planning of the whole system, but even the largest companies rarely approach the problem this way. It is much more of a trial and error process.

Ettlie proposed that the factors which influences implementation success can be divided into three categories. First, the technology incorporated into the innovation can be characterized by attributes (e.g. cost, sophistication). The second broad category of variables is the nature of the organization attempting to install process change. Examples of variables in this category are implementation strategy and availability of slack resources. The third category of variables is the context of the organization. Examples of variables in this category are Original Equipment Manufacturer (OEM) behavior supporting implementation of customers, adoption listing and economic conditions [23].

Strategy Formulation and Implementation

Strategy implementation is not a new concept in business literature and practice. Stonich [97] notes however, that its role has been placed in a secondary position to strategy formulation. The basic premise was that if the formulation process was sound, successful implementation would follow automatically. The consequence of this philosophy is that many managers, who relied heavily on strategy formulation for their companies' survival, end up wondering why their sound strategies do not work as formulated. They are finding out, the hard way, that a more comprehensive and integrated way must be derived to tackle the complex task of implementing strategy.

Stonich [97] asserts that clearly identifying attractive opportunities and setting the right strategic direction - whether at a corporate or division level - do not, by themselves guarantee success. Implementation issues have to be appropriately addressed in order to successfully implement strategy. He adds that as the methods used to formulate strategy become more sophisticated, and the resulting strategies themselves become more precise and fine-tuned, corporate managers need to devote increasing attention to the question of execution. In order to implement strategy effectively, the external focus of strategy formulation must be balanced by assessments of internal capabilities - as depicted in the AMT implementation model presented in Figure 1. The internal components in the model, referred to as the core organizational systems are: the organization's structure, management processes, cultural/political issues, and the technical system.

Eschenbach and Geistauts [22] explored some issues involved in interfacing engineering and strategy in an organization. They point out some problems of conflicting thinking patterns between engineering and management, and conclude that tightening the linkage between engineering and strategy formulation will require changes in the thinking patterns of both engineers and the managements that employ them. They also discussed the differences between technology and strategy, they point out that radical changes in a firm's technology portfolio (adding new technologies) requires top management's support, as only they can accept the risks and commit the resources required. They further state that while top management can and should set the strategic direction, input and support from the functional areas - including engineering - is required. Strategic change becomes difficult or impossible, if the functional capability or the willingness to support change is absent.

Eschenbach and Geistauts [22] also covered several areas of support required for strategic planning. These include: technological, economic, demographic, competitive, political, social, legal, and international. In discussing the technological dimension, they ask several questions addressing some areas of interest. Among these are: whether or not strategy and technology are integrated in the plan; if the strategy fits the firm's technological profile; if there is a concrete program for implementation, if there are there linkages to medium and short-term plans and budgets; if any required changes in organizational structure have been identified and carried out; if the strategy matches the prevailing values and attitudes in the firm; the engineering and design group, as well as other groups participating in its implementation; if the strategy fits the corporate culture, and also whether or not it enhances the firm's image as a technologically strong organization. Other issues raised include whether or not the strategy would increase organizational cohesion, if it will challenge and motivate engineering performance, and finally, if it will it help attract the best engineering talent - both for present tasks, and for future technological growth.

Synder and Elliot [95] indicated that they found several items to be prerequisites for successful implementation of new technology through interviewing several experts and reviewing the current literature. Among the key prerequisites listed were the following. Top management must determine and prioritize company objectives as they relate to manufacturing (cost, quality, delivery, flexibility, positive work environment, increased employee involvement, etc.). They point out that management must continually emphasize these priorities through actions as well as words. They also indicate that in order to support a desired operational change, it is essential that: first, adequate changes be made in performance measures and second, necessary resources be made available. They also point out that management should set a stage for change. A good plan must include communicating the reasons for necessary changes to all employees. Such communication, they indicate, may include: 1) a brief history of events leading to changes, 2) a current state of the business and why change is required now, 3) what changes need to be made for the company to become competitive. The objective of this process, is to set a uniform tone regarding what needs to be done. Everyone should be informed as to the who, what, where, when, how, and why concerning a major change.

Another possible roadblock to successful implementation of automation projects is the fact that frequently, there is a corporate power struggle over the control of AMT projects. According to Herb Halbercht, a Stamford, CT., management consultant, " ... a corporate power struggle is underway over control of CIM. Automation experts in some companies report not to the vice president for manufacturing, but to the head of MIS, who is viewed as the computer czar" [59, p. 9], observed Halbercht. "But an arrangement like that makes no sense. The traditional information service manager is concerned with finance and information and has little to do with manufacturing. Nevertheless, he may resist the suggestion that he surrenders responsibility for CIM. And nothing important is going to happen in the CIM area at a company unless the automation experts report to the top person in either manufacturing or engineering. It's as simple as that. Commitments have to be made now or manufacturing in this country may not survive 1990" [59, p. 9].

In order to remedy a situation like the one described above, it is recommended that an environment conducive for such an enormous undertaking as the implementation of AMT be developed. According to Joseph Hurley, the director of manufacturing systems at Corning Glass, in the early stages of their CIM program, there were three notable problems. First, there was no focus for the efforts - no relation of the technologies to strategic business goals. A second shortcoming was that of island building. He indicated that islands of automation can be beneficial, but if there is no strategy to interconnect them, they will lead to new bottlenecks or problems elsewhere in the manufacturing process. The most serious problem, according to Hurley, was that there was no grand CIM strategy to make it all happen. To remedy this situation, "Four initial steps were taken to build an environment suitable for the undertaking: creation of an advisory board, creation of a systems board of directors, identification of CIM as a key corporate strategy, and creation of a CIM organization [49].

According to Krepchin [49], the advisory board is a diverse group whose role is to communicate the impact and progress of CIM to all areas of the corporation. The systems board of directors was formed expressly to avoid any turf battles with information services that might arise between groups. The groups includes members from manufacturing, engineering, information services, and strategic planning functions. Crucial to success is an internal organization and a set of procedures that enable communication among participants, but also with clear lines of responsibility. Krepchin indicated that previously, the responsibilities for the various components of CIM were spread out in separate groups. Responsibilities for control systems and CAD were in the process area, while robotics and manufacturing systems were under the heading of machines and manufacturing systems. Each group had different priorities. To correct the situation, a new unit was formed that combined all the CIM-related areas under one individual. As an example, at Corning, all the subgroups reported to Hurley who held bi-weekly, one-on-one meetings with group leaders. This helped build consensus and countered some of the provinicialism that still existed. A system of shared objectives made sure that they worked together. If the automation engineer did not like the process engineer's approach, or feels that his territory was being invaded, Hurley reminded them of their common goals and saw that they resolved their differences [49].

Bergstrom [8] points out that in his discussions with Larry Giesel, President and CEO, Carnegie Group, Inc. (Pittsburgh) a point was raised in the segment where they discussed what to automate in the plant, the point, he asserts, is that understanding the needs of the entire organization and the strategic goals is required, and in doing so, one finds that there may be areas where implementation would be - at least at a given point in time - ill advised. One may actually find that some of the objectives in a mission statement, from a CIM implementation perspective, simply should not be acted on [8].

Cultural and Political Systems

Organizational Culture

The word culture has many meanings and connotations. When one combines it with another commonly used word, "organization", there is almost a certainty of having conceptual and semantic confusion. The term culture should be reserved for the deeper level of basic assumptions and beliefs that are shared by members of an organization, that operate unconsciously, and define in a basic taken-for-granted fashion, an organization's view of itself and its environment. These assumptions and beliefs are learned responses to a group's problems of survival in its external environment and its internal integration. They come to be taken for granted because they solve those problems repeatedly and reliably.

Organizations are not easy to define in time and space. They are open systems in constant interaction with their environment, and they consist of many subgroups, occupational units, hierarchical layers, and geographically dispersed segments (Thompson, 1963). Culture should be viewed as a property of an independently defined stable social unit. That is, if one can demonstrate that a given group of people have shared a significant number of important experiences in the process of solving external and internal problems, one can assume that such common experiences have led them, over time, to a shared view of the world around them, and their place in it. There has to have been enough shared experience to have led to a shared view, and this shared view has to have worked for long enough to have come to be taken for granted, and to have dropped out of conscious awareness. Culture in this sense, is a learned product of group experience and is, therefore, to be found only where there is a definite group with a significant history. In summary, culture can be defined as a pattern of basic assumptions - invented, discovered, or developed by a given group as it learns to cope with its problems of external adaptation and internal integration - that has worked well enough to be considered valid, and therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems.

Stonich [8] defines culture as a pattern of beliefs and expectations shared by the members of the organization. These beliefs and expectations, he points out, produce rules for behavior - norms - that powerfully shape the behavior of individuals and groups in the organization. He further explains that different companies have different cultures. The culture of an organization is assimilated by its members, and those who cannot accept the culture often choose or are asked to leave. "Strategy may be brilliantly formulated, well suited to the competitive situation, and supported by adequate financial and human resources. The other core organizational systems may very well be integrated throughout the company. Despite these good mix, the level of fit between strategy and culture will undoubtedly affect the success of the strategy's implementation" [97, p. 5]. In some cases, a corporate strategy matches its culture and helps the firm achieve its strategy. In other cases, corporate culture is a barrier to the successful implementation of strategy. The issues of cultural fit/alignment with the strategy will be explored in this segment.

The analysis of cultural alignment is based on the view that an organization is in part held together by belief in a set of norms which make up the organization's culture. The major concern when evaluating the cultural alignment of an organization is to determine the degree of cultural homogeneity; that is to what extent the organization is dominated by a single culture or multiple cultures.

Schreiber [92] profiles the opinions of some of the visitors at AUTOFACT '86. Those visitors contacted gave some ideas on the keys to successful CIM implementation. "It's a cultural problem", says Philip M. Condit, executive vice president, Boeing Commercial Airplane Co. (Seattle). "Like many other companies, Boeing's history is primarily of functional origins - the engineering department, the planning department, the fabrication department. CIM requires that we cross those boundaries. The impact of such change can be severe, but managing it is critical in the implementation of CIM."

Tichy [100] in his discussion of the dynamic aspects of an organizational model, contends that organizations serve as a social means through which people attempt to accomplish technical, political, and cultural ends. He points out that they are complicated, difficult to design, difficult to manage, and even more difficult to change once they are set in motion. Tichy discusses the different types of adjustments required in order for organization to function properly, focusing on the technical, political, and cultural alignments. Of particular interest to this section is the coverage of political and cultural alignments. Of the three systems, he points out, the cultural aspects are both the most pervasive and the most ambiguous. This is because norms and values are not always as explicit and clearly identifiable as a technical organizational structure or production technology. One of the most important and difficult tasks of top management, says Tichy, is to decide on the conflicts of the organization's culture, that is, to determine what values should be shared, what objectives are worth striving for, what beliefs the employees should be committed to, and what interpretations of past events and current pronouncements would be most beneficial for the firm. Having made these decisions, management's next task is to communicate these values in a memorable and believable fashion which will not be instantly forgotten or easily dismissed as corporate propaganda. He notes that these decisions are not always made explicitly, adding that decisions about culture are often made implicitly, intuitively, and by trial and error.

Tichy further states that there are two critical issues regarding culture. First, the content of the culture and subculture of an organization. Second, the means by which cultural processes are managed, that is, what vehicles are used for molding and shaping culture and incorporating subcultures into the organizations. Katz and Kahn [45] proposed two conditions for cultural congruence among members of an organization: (1) a majority of the active organizational members should accept the beliefs , endorse the values, and abide by the norms; and (2) individual members should be made aware that beliefs, values, and norms have collective support. However, cultural congruence in an organization varies over time. This is, perhaps, because of environmental value shifts, or perhaps because new members bring diversity into the culture. Therefore, organizations must have ways of either reducing cultural incongruence or developing capacities for managing cultural incongruence. There are a set of concepts for analyzing the amount of cultural uncertainty which an organization faces, and there are managerial responses to cultural uncertainty. Tichy [100] provides some guidelines for assessing the cultural alignment of an organization, which can be used to deal with the phenomena. He asserts that organizations vary in their degrees of cultural congruence. Congruence is defined as the degree of consistency among organizational members with regard to values and organizational norms. Congruence varies as a result of environment. Cultural value shifts in the wider environment are reflected within the organization and thus create cultural incongruence. Diversity of backgrounds in the organization along such dimensions as ethnic background, education, professional identification, sex, and age contribute to greater cultural value incongruence. In addition, differences in functional background, such as finance, marketing, R&D, and production also creates diversity; as organizational value/cultural incongruence increases, so does the need for increased amounts of cultural/value adjustment and hence the need for greater organizational capacity for dealing with cultural/value shifts; different organizational configurations (networks, people, processes) have varying capabilities for facilitating cultural/value adjustments; organizations will manage the cultural/value adjustment process and be more culturally effective to the extent that there is a match between the cultural/value incongruencies facing the organization and the adjustment capacity of that organization's components.

According to Tichy [100], when there is a poor alignment between cultural/value congruence and the cultural/value adjustment capacity in the organization, there are two basic options for changing the situation. Option 1 is to change either the environment and the organization's relationship to the environment, or to change the diversity of people in the organization. Option 2 is to alter the alignment between the value/cultural adjustment demands and the organization's value/culture adjustment capacity. This entails making adjustments along the mechanistic to organic dimensions for the organizational components.

Sashkin and Morris [87] present a cultural functions questionnaire (CFQ). "The CFQ is based on the work of the sociologist Talcott Parsons. Parsons built on the earlier work of the founder of modern sociology, Max Weber" [87, p. 168]. Weber observed that an understanding of social systems must be based on an examination of how organized activities - means - are connected to desired end states or goals. According to Sashkin and Morris, Parsons took this a step further by noting that a second key issue centers on how the social system maintains its identity separate from its environment. This, they contend, is done by creating a boundary, which defines an inside and an outside organization. Parsons identified four critical functions that he felt any organization would have to carry out, just to survive for a substantial length of time. These four functions are: adapting, attaining goals, coordinating activities of people, and developing a set of values, beliefs, and norms of behavior, that is, developing a stable culture that defines and maintains the system.

Specific values, beliefs, and norms - cultural patterns - can vary a great deal from one organization to another, and so can patterns of coordination. Specific goals and ways of changing to meet demands of a changing environment can vary almost indefinitely. These variations have led some management researchers to search for oversimplified categories of values, coordination patterns, goals, and adaptive strategies. Some other scholars assert that the complexity is so great as to mean that every organization is unique, and cannot be compared with others in terms of the factors discussed here. "In fact, neither view is correct ..." [87, p. 168]. In order to understand organizations, one must look for fundamental underlying patterns, and not just try to figure out the best way to categorize the great complexity of specific differences. In a sense, Parsons'[87] framework is elegantly simple (although its full and detailed application for the purpose of an in-depth analysis of an organization can become quite complex). The basic idea of the four functions is attractive, and even if they are not the only important set of organizational functions, they are surely an important set. The CFQ presented by Sashkin and Morris [87] is a tool for assessing how an organization is performing in terms of Parsons' four functions. The questions used to solicit the information for testing hypothesis # 19 in the study was extracted from this instrument [87, p. 165].

Organizational Political Systems

The second type of alignment in Tichy's organizational model deals with the political aspects of the organization. For this type of alignment, observed that "a business firm is a political coalition and...the executive in the firm is the political broker. The composition of the firm is not given, it is negotiated. The goals of the firm are not given, they are bargained" [100, p. 129]. Political alignment is based on the view of organizations as coalitions, altering "... their purpose and domains to accommodate new interests, sloughing off parts of themselves to avoid some interests, and when necessary, becoming involved in activities far afield from their stated central purpose" [67, p. 247].

The political test of alignment is similar to the technical test in that the objective is to reduce or manage uncertainty. The difference is that here, the focus is on the uncertainty surrounding the power to allocate resources & decide on the organization's goals. An organization faces political controversies or uncertainties which require political bargaining and conflicts. These requirements should match the organization's capacities for political bargaining and conflict.

Organizations vary in their degree of political uncertainty. Political uncertainties result from controversies regarding the power to allocate resources and to set organizational goals. These controversies express disagreements among coalitions in relation to allocations of resources, power, and prestige. Organizations will manage the political bargaining and exchange processes and will be more politically effective to the extent that there is a match between the requirements of bargaining and exchange and the bargaining capacity of the organization's components. According to Tichy, two options are available to deal with a poor match between political uncertainty and the organization's bargaining and exchange capacity. Option 1 is to alter uncertainty. This can be accomplished by attempting to change the environment by forming political coalitions, or using interworking directorates to maintain control. Another way is illustrated by governmentally regulated firms which have captured the governmental agencies that are supposed to regulate them - by supplying key personnel, by exerting influence through legislators, and by hoarding technological expertise (Kohlmeier, 1969). Option 2 can be exercised by developing a goal and/or means consensus.

Technical System

One of the three dominant traditions explored by Tichy [100] in guiding the thinking about organizations and the practice of change that should be brought together in order to provide managers of change with the necessary strategic tools is the technical view of the system. He asserted that one tradition views organizations and change from a technical perspective and prescribes change strategies based on empiricism and enlightened self interest. He called this the technical view. The technical view restricts itself to organizing most effectively and efficiently [100, p. 16]. Technical system alignment assumes that the components of the organization are to be interrelated in such a fashion as to achieve organizational effectiveness and efficiency in the market place. Some of the elements of the technical system in the organization addressed in this study include: product redesign for dedicated production within the framework of the new AMT implementation, adequacy of particular technologies within the confines of the overall technological scheme of the organization, information integrity, and the availability of qualified systems integrators. This is because these elements were most frequently identified as factors leading to successful implementation of AMT, based on individual projects implementation experiences.

Product/Process Redesign

In the 1970's, GM developed a strategy to combat impending foreign competition by the Japanese. This strategy was in reaction to the gas price fears of buyers. The plan was unveiled in early 1979, and over the next seven years, GM essentially started from scratch to redesign every one of the cars and factories at the cost of $40 billion [33]. In a recent Business Week cover story [33], it was expounded that GM has invested $60 billion in the past eight years: (1) to completely redesign every product line, and (2) to install vast amounts of high technology manufacturing systems. The report indicated that "...many of its expensive new high-tech plants are hardly more efficient than the old ones..." [33, p. 103], and the anticipated results of the installations have not been achieved.

In this particular case, among the impediments identified as affecting GM's initiative were: management misconceptions leading to too much emphasis on high technology and automation rather than on more basic issues like addressing the functionality desired from the AMT installation. GM believed that if it spent enough on computers and robots, increased efficiency would be assured. It found out the hard way that new technology pays off only when coupled with changes in the way work is organized on the factory floor.

Perhaps the most widely reported example of a successfully AMT implementation is the automated assembly line at Allen-Bradley in Milwaukee, manufacturers of industrial controls [1]. The line produces electrical contactors and relays that serve as electromechanical starters and controllers for industrial electric motors. The line currently produces 600 units per hour, and as many as 125 different configurations of the product can be manufactured on any given day, in lot sizes as small as one unit. All products are manufactured to customer order and are shipped within 24 hours after receiving the order. The process is completely automated, including 3,077 built-in inspections. If a component fails one of the inspections, it is automatically rejected and a replacement unit is ordered automatically.

Allen-Bradley executives decided to invest $15 million in a new AMT line that they hoped would make contactors and relays that would meet the standards set by the International Electrotechnical Commission (IEC) at the lowest possible cost. Allen-Bradley says it could not employ traditional short-term Return-on-Investment (ROI) calculations to justify the strategy because the company believed it was making a critical long-term decision. Thanks to its automated line, Allen-Bradley has been able to come late to a highly competitive world market and establish itself as a leader.

J. Tracy O'Rourke, Allen-Bradley's president and chief executive officer (CEO), claims that no competitor anywhere can beat him on price or quality for IEC contactors and relays. Depending on the competitiveness of the market, the going rate for one of the controllers produced on the innovative Allen-Bradley line is anywhere from $8 in Australia to $20 in the U.S. Allen-Bradley's cost is $6.42.

Allen-Bradley's success has been closely linked to the fact that the system development was aimed at specific goals. One of the strategies employed at Allen-Bradley was to simultaneously design a new product along with its dedicated automated manufacturing facility [4]. In a speech at the Integrated Manufacturing Exposition (IMEX '86) in New York in December, 1986 [42], J. Tracy O'Rourke offered an extensive list of advice on how to implement CIM. Based on the successful results at his company, he said the company must have long-term objectives and these should be supported by long range plans. For new products, the product and process should be designed simultaneously, one should not be made a slave to the other. This is because quite often, part designs and new assembly techniques are not practical to automate, but many times a design change can eliminate this problem. The option to redesign must be weighed against the cost of the redesign, and its implementation [105]. The questions of what the impacts of redesigning are on other parts, and whether the redesign would be acceptable to the customer have to be adequately addressed and answered before embarking on such a project. O'Rourke also suggested that companies should seek flexibility to give their facilities a longer life than the products they are producing. He indicated the CIM's economies of scope, the flexibility offered by the system to adequately accommodate dynamic product mix when the general product unit of the companies, makes economics of scale possible [42].

In a study of organizations that have implemented advanced technology, Ettlie [23] noted that product-process dependency was mentioned in 46 percent of the cases. This variable refers to the relationship between products and manufacturing processes, especially its complexity. According to Ettlie [23], one of the great paradoxes today is that "these complex system can usually be justified only when a new product is launched" [23].

Sepehri [91], in his discussion of the automation project at IBM's Lexington plant indicates that because the goal of the automation was a new manufacturing process for new products that were in the design stage, there were no interruptions in the manufacturing process, although some manufacturing floor space was reorganized and cleared up. Some automation elements were tested first in a laboratory environment, but most were designed, installed and tested on the floor.

Information Integrity

According to Merchant [62], the reasons for the appeal of AMT are precisely the same as the reasons for their risk - the extreme interdependence of manufacturing system elements and the number of variables, parameters, and changes that must be dealt with at every step of the process. Loss or distortion of data or information at any point spells disaster for the successful completion of the process. Because of this complexity, not all of the essential technology exists and not all of what exists is perfect for an individual company's applications.

Other companies have attempted to automate existing, inefficient procedures without having in place, the fundamentals required to start such AMTS. Included in this category are: adequate data integrity, and organizational discipline to follow established procedures. According to Jim Harnedy, business, planning, and administrative manager at

Digital Equipment Corp.'s (DEC) Augusta, Maine manufacturing facility, "our MRP II program is a necessary step in our overall CIM effort... it establishes the discipline DEC-Augusta needs to achieve true integration, and provides a good start on setting up the required data base for CIM" [39, p. 107].

Another example of a successful AMT implementation is reported at General Electric's Steam Turbine-Generator Business (STGB) in Schenectady, NY, where the general manager of STGB's engineering and manufacturing department, Randall J. Alkema says, " ...with CIM we are getting the right information to the right people at the right time to make the right decision" [111, p. 72].

Bergstrom [8] presents some critical issues in CIM implementation. One of the issues was: what to automate, emphasizing automation of those areas where the real large costs are, rather than concentrating on trying to eliminate direct labor. The next important issue raised is the knowledge of the cost of implementing CIM. Unless all the costs are known, a successful cost analysis cannot be done. Without a thorough cost analysis, CIM cannot be effectively implemented. This is because without a cost analysis, implementation efforts could be directed towards chasing the wrong symptoms. The object of CIM implementation is to find the points with a real cost payback, and go after them, rather than try to do everything. Some things are simply not worth the effort, and investment. To do that, one must understand the entire manufacturing process and know where all the costs reside - including indirect, or white collar labor.

Adequacy of Technology Implemented

Ettlie [23] also indicated that many firms simply buy the wrong system. What they end up learning in the process is valuable, but the price is high. He indicates that if the technology supplier and users truly have a good working relationship, the system design can be changed once it is ordered. "This change would save some of the systems from failure or greatly reduces the cost of technical success" [23, p. 78].

Savage [88] discusses the "reflections inspired by the CASA/SME round table on fifth generation management." He indicates that it makes little sense to install third, fourth, and fifth generation computer technology in second generation organizations. Yet, he states, this is precisely what many manufacturing companies are doing. Savage offers some reasons why this is happening. Among these were: 1) the focus has been on the computer technology; 2) Computer Integrated Manufacturing (CIM) has, for the most part, ignored the tough management issues; 3) few have effectively understood the new management logic which is required to leverage the full value of the investments that have advanced computer-based systems.

CASA/SME President Wayne Snodgrass notes: very few top executives have begun to move towards Fifth Generation Management [88]. Savage describes Fifth Generation Management (FGM) as assuming a well-developed and flexible infrastructure of networked functions together with their computers and applications, capable of referencing a common data architecture. Each of the functions become a node, or decision point, on the network. These nodes become reference points or knowledge centers, capable of teaming with other nodes in the support of the enterprises business strategy. Rather than being held together by a command and control structure, FGM is coordinated by its shared vision, values, and culture. This arrangement frees the organization from being locked into a management of sequential hands-offs and provides a way of coordinating the iterative dialogue which must go on between functions, such as design for assembly. In short, FGM makes it possible to effectively leverage the information infrastructure for competitive advantage. He further adds that FGM calls for a new leadership style and expects more of all employees in dealing with business variety so windows of business and technical opportunity can be more effectively met. Moreover, it recognizes human interaction is as important a quality issue, as is product quality, if competitive advantage is to be achieved. Finally, he indicates that FGM taps into the power, wisdom and insight of its managers, professionals and employees who have, as a team in nodal network, learned to use computer-based resources to enhance their decision making capabilities.

Savage [88] further indicated that FGM, nodal networking, assumes the Computer Integrative Management of the Manufacturing Enterprise (CIM II). He stated that Fourth Generation Management, digital interfacing, is what should be called Computer Interfaced Manufacturing (CIM I). So much of what is presently called Computer Integrated Manufacturing (CIM) is, in reality, Computer Interfaced Manufacturing). In CIM II, according to Savage, the focus is not just on the manufacturing function, but the entire enterprise. Second, it is integrative, not just integrated, because we are involved in a continually evolving integrative process. Third, each of the departmental functions and sub-functions become nodes, or decision points, on a network capable of bringing their accumulated knowledge to bear in an interactive mode as the functions work in parallel. He emphasizes the fact that interfacing is not the same thing as integrating, and yet the confusion of the two is leading to deep frustrations, and in so many cases a rejection of the idea of CIM itself. CIM I will fail to solve the fundamental problems of the hierarchical organization, because it, like matrix management, is an overlay on second generation management.

Savage defines the five generations of manufacturing enterprises as follows:

- o First: Small/Entrepreneurial
- o Second: Hierarchical/Functional/Divisional
- o Third: Matrix
- o Fourth: CIM I - Computer Interfaced Manufacturing, Smith/Taylor Bottleneck
- o Fifth: CIM II - Computer Integrative Management of the Manufacturing Enterprise

Standard Communication Protocols

Zygmont [115] mentions the fact that a major barrier to exchanging product description data is the lack of a common computer language that permits comprehensive communication among the different hardware and software systems in use. Part of this issue, says Zygmont, has already been addressed by IEEE's Initial Graphics Exchange Specification (IGES), a data standard for communicating geometric product information between computers. Major CAD/CAM vendors subscribe to the IGES standard so their systems can share data with others. IGES does not cover nongeometric data like tolerances, which are also part of a complete product description. The proposed solution is another standard, the more thorough Product Data Exchange Specification (PDES), which is being drawn up by the National Bureau of Standards [115].

Product definition models are usually crucial to the CIM strategies of companies working toward beginning-to-end integration. Here, communication standards like IGES and PDES are also important, but they may be worked around more easily, since a company can limit its equipment selection to compatible systems, or write proprietary software for communication between departments. Therefore, it is not surprising that efforts toward integration within a company have progressed the farthest [115].

Savage [88] asserts that Manufacturing Automation Protocol (MAP), Technical and Office Protocol (TOP), and the Initial Graphic Exchange Specifications (IGES), are helping second generation organizations move toward fourth generation management. They will make possible the digital interfacing of information between functional departments or between organizations. MAP and other networking approaches will play a large role on the shop floor. TOP will help tie together, engineering and manufacturing. IGES provides a neutral file format for passing information between dissimilar CAD systems. By themselves, they will not lead to FGM. They remain technologies and do not begin to address the values and cultural aspects of integration. Efforts to develop a Product Data Exchange Specification (PDES) will support the transition to CIM II, because PDES will provide a neutral reference data architecture for the entire organization.

Qualified Systems Integrators

Rummel and Holland [82] in citing some difficulties involved in installation of CIM systems, identified some common problems. Among the common problems they identified are the following: "The need for well trained workers familiar with the principles of automation, computer technologies, and manufacturing processes has driven many companies to institute comprehensive training programs" [82, p. 36]. Synder and Elliot [95], in their list of suggested implementation steps, point out that proper resources should be allocated to support the new technology once it is in place. The resources include: properly trained operators, and skilled knowledgeable technical resources personnel.

Voss [106] in his discussion of factors accountable for success and failures in advanced manufacturing technology, pointed out that many adopters of new technology, both successful and unsuccessful, commented on the problems of obtaining suitably trained people. White [108] in his list of some of the more commonly expressed reasons for the scarcity of integrated systems pointed out that perhaps the scarcest resource is qualified people. Not only must technical competency exist, but operational, management and financial skills also must be present. Also, one or more individuals must be competent in developing control systems, for it is the control system that will separate successes from failures.

Quantz [77] cited some obstacles to CIM implementation, they include: Critical skills deficiency. Here he indicates that critical skills are often lacking in both the planning and the implementation of broad based CIM programs. He points out that many manufacturing organizations are poorly equipped to deal with new technologies because they do not employ enough people with the requisite skills. Still other obstacles listed in this article are: timing errors, setting of timid goals, and trying to research the benefits of CIM by traditional methods.

Organizational Management Processes

Management process is the set of tools that management has available to implement strategy [97]. These tools are directly related to the other components in the core organizational system - cultural/political system, technical system, and organizational structure. Stonich covers different elements of management process namely: planning, programming, budgeting, and rewards. Together, these elements make it possible for an organization to allocate resources when and where they will produce the best results, and to control performance in a way that drives the firm toward its strategic objectives.

"Planning can be thought of as the communication of strategies to top management. It normally pulls together Strategic Business Unit (SBU) strategies and allows top management to develop corporate strategy and allocate scarce resources. Programming is a process that increases a strategy's chances for success by assuring that the funds are allocated to activities that that drive strategy forward. Budgeting deals with allocating all resources - both those necessary to operate the business on a day-to-day basis and to carry out the strategic programs developed through the Strategic Funds Program (SFP) process" [97, p. 99]. The SFP is an approach designed to enable companies to achieve their strategic goals by selecting and funding those programs with the highest potential impact on the future success of the business. Budgeting is therefore a critical link in the efforts to implement an AMT strategy. Without an appropriate budget, it is unlikely that strategy will be implemented effectively. Management and reward systems involve considerations well beyond salary and benefit packages required to attract and keep people of the caliber needed to implement an organization's chosen strategy. Effective systems also motivate people to work toward the overall objectives established during strategy formulation, and being articulated through the planning, programming, and budgeting processes.

Measurement and reward systems send tangible signals to the organization's people about their performance. Changing the reward system can be a powerful tool in altering the behavior of people in an organization. Some major points have to be considered when examining the effectiveness of a particular reward system. The measurement and reward system should fit with the strategy and the other components in the core organizational system, they should provide incentives to accomplish both the long-term and short-term objectives of the organization. A question should also be raised about incentives available to all divisional or SBU managers. Aligning measurement systems with other parts of a company's strategy and organization is a creative process that should not be overlooked.

Alignment of the Core Organizational System Components

Several discrete components comprise the core organizational system. Strategy formulation process feeds into the core organizational system. The system components considered in this study are: cultural/political systems, technical system, organizational management process and organizational structure. Success - achievement of strategic objectives for the AMT implementation - is brought about through a complex interaction of strategy and all the components that make up the core organizational system [97]. Stonich asserts that attacking a problem in one element of a company's activities can have far-reaching ramifications for the other elements. He further indicates that it has been demonstrated repeatedly that successful performance occurs when appropriate strategy is implemented through effective rationalization of the basic elements that make up and drive an organization. An organization will move more effectively toward its declared objectives when, and only when all of its complex elements are synchronized. This synchronization concept is frequently referred to as "fit".

Effectively implementing strategy requires a constant effort to match and fit the basic elements that drive the organization together. The AMT implementation model (Fig. 1) implies that in order to implement strategy effectively, the external focus of strategy formulation must be balanced by assessments of internal capabilities - these are: the organization's structure, management processes, cultural/political issues, and the technical system.

According to George Meister, senior vice president and general manager, McDonnell Douglas Industry Systems Co. (St. Louis), the promise of CIM rests on three premises: the importance of manufacturing to the nation, the importance of manufacturing to the enterprise, and the fact that the relationship between functions within an enterprise can have major impacts on the effectiveness of the manufacturing process [92]. He further stated that CIM can have a significant strategic effect on quality, lead time, market responsiveness, economics of scope, and flexibility.

Tichy [100] presents an organizational model with three components: technical system, political system, and cultural system. He indicates that the goal of strategic change management is to align the components of an organization technically, politically, and culturally. The argument is made that an effective organization is one in which there is good strategic alignment. That is, the organizational components are aligned with each other and the political, technical, and cultural systems are in good alignment with each other. He offers four strategic alignment tests: (1) a technical one, (2) a political one, (3) a cultural one, and (4) one which tests consistency between the three systems. He indicates that because organizations are dynamic and exist in changing environments, none of these alignments will ever be stable. They reflect ongoing dilemmas for the organization. At different points in time, any one, or combination, may be in need of adjustment. He indicates that achievement of strategic alignment is the responsibility of the leaders of an organization. Tichy further discusses the interrelationships between the components mentioned above. According to Tichy [100], technical alignment is designed to manage uncertainty with regard to the financial, business criteria outputs. Technical alignment, says Tichy, assume that the components of the organization are to be interrelated in such a fashion as to achieve organizational effectiveness and efficiency in the market place. The following principle applies: An organization is technically effective to the degree that the uncertainty it faces matches its capacity to process information and to eliminate the uncertainty." Uncertainty, he claims, arises because the information required to complete tasks exceed the information possessed. He states that as uncertainty increases - from any combination of sources - so does the need for information processing capacity. Different organization configurations - of networks, people, and processes - have different capabilities of processing information. As information processing requirements change, organizational components should be adjusted. He further indicates that organizations will be more efficient and effective from a technical point of view when there is alignment between the information processing capacity of the organizational components. Tichy asserts that two options are available to deal with a poor match between uncertainty and information processing capacity. Option 1 is to reduce the uncertainty. This might be accomplished by changing the relationship with an uncertain environment by formation of foreign articles, lobbying for protective legislation, or withdrawal from certain markets. Option 2 is to change tasks or interdependencies, that is, alter information-processing capacities. Automation is one way of simplifying tasks. He indicates that organizational diagnoses is normally triggered in an organization by an event or activity that creates organizational uncertainty. The object of the diagnoses is normally to gather sufficient information to determine which components in the model needs adjusting.

Tichy [100] stated that the basic task for change managers is to ensure that there is alignment within each of the three systems and then between the systems. A well-designed organization should exhibit harmony between its cultural, political, and technical systems, and each of these systems should be internally aligned. The task of strategic management is to keep the internal organization aligned and aligned with its external environment. This alignment may occur quite unconsciously on the part of the organization and its members, and may be viewed by some as an evolutionary process. On the other hand, it may be a very proactive, planned process. Regardless of whether or not it is explicitly and consciously aligned, organizations are proposed to be effective to the extent that there is alignment with each system, and across the systems.

Ettlie [23] proposed that the congruence, or degree of fit, between an organization and a specific process innovation will predict the rate and degree of successful implementation of that technology. Congruence is a scaled combination or index of any of several important attributes of the technology as perceived by key organization members. He asserts that an organizations implementation strategy and structure are matched or congruent in most successful cases. The implementation strategy that results from a very aggressive technology policy for radical innovation will produce flexible structural arrangements, with a special implementation team usually physically separate from the normal workflow. Less ambitious implementation strategies will use existing structural arrangements.

Krepchin [49], in discussing the CIM efforts at Corning Glass, stated that the concept of CIM at Corning is more than just technology. It is built on an existing commitment to total quality and calls for the integration of strategy and human resources as well as technology.

Other factors related to the alignment of the core organizational system include the alignment of employee attitudes with the corporate objectives. To get managers to support new projects, it is imperative that performance measures adequately reflect the positive effects of the change and provide incentives for managers to support change [95]. In his IMEX keynote address, J. Tracy O'rourke, president and CEO of Allen-Bradley pointed out that each employee is a critical link in the system and these individuals must be properly trained, motivated, and rewarded [42]. Bill Kowalczyk, MRP II project manager at the DEC - Augusta, Maine plant noted that one of the keys to success of the project was that the job plans and reviews of all personnel were in some way tied to the project [39].

The other aspects of organizational management processes discussed in literature and covered in this study include: nature of the relationships between the technology supplier and user firms, availability of AMT champion, availability of educational/training programs, top-down planning and bottom-up implementation policy, pace of implementation, organization/staffing of the project, management commitment, and communication. These aspects will be covered in the following sections.

Technology Supplier/User Relationships

Ettlie [23] noted that in a study of some organizations, the most frequently mentioned factor that accounted for success or failure in the implementation of advanced technology systems was the nature of the supplier - user relationships. The respondents to his survey used terms like marriage or long term mutual commitment to describe these relationships. He indicated that after examining the comments of respondents on this issue, one reaches the tentative conclusions that team building across organizational boundaries is the key. "Based on the importance of this factor, it would make some sense to talk about the implementation strategy of the vendor-user team rather than that of the user organization" [23, p. 78]. One supplier indicated that successful installations are "user driven and vendor guided" [23, p.

77]. In another article, Ettlie [24] explored the theoretical and practical answers to the general question of why some firms are more successful in the adoption of production technologies than others. He indicated that the relation between suppliers or original equipment manufacturers, and their customers, or users of the new technology, will be an important determinant of implementation success. He further stated that the supplier of the technology will also have an important influence on the outcome of the implementation process, especially during the early phases of installation and for the first year of trial operation. The OEM Service policy and other policies covering customer relations will be an important factor not only in implementation but in the initial adoption decision by the user [24]. Suppliers of new technology that allocate sufficient slack resources and sustain a support customer service policy for implementation of especially radical new technologies are likely to substantially promote successful installations of innovations.

Availability of a New Technology Champion

Ettlie [24] pointed out that there were always at least two key people: one from the technology supplier firm and one from the user, who worked hardest at building a team to integrate the technology in the user's plant. Also in the list of factors enumerated by respondents in this study was innovation champion. One respondent described this element of implementation strategy as follows: "A person has to love it - (has to be) a champion, an advocate and they're not the same as a product champion" [23, p. 82]. He indicated that the champions have a characteristic of extreme commitment to the project - sometimes they are also the project managers. "Champion commitment is deep and apparently is a key to success in many applications" [23, p. 82]. He proposed that the more sophisticated the system, the more elevated in the hierarchy the champion must be in order to ensure success - an extension of the hypothesis of top management support [23, p. 83]. White [108] states that where systems integration has occurred successfully, a champion has existed. Brauninger [11] in his list of what was used to spark interest in CIM at Cone Drive noted that they allowed people with ambition and desire to lead in the implementation of new ideas and projects.

Nellemann [67] discussed what is involved in applying CIM to gain competitive advantage in the wake of increasing global markets and competition. He commented that frequently, U.S. managers have traditionally worked toward different, and often conflicting goals, and that the most effective strategies have to balance the differing objectives between the different functional areas. He further indicated that because CIM affects each area of the company, each area must participate in the development of the CIM strategy and understand its role and responsibility within it. " ... as James Baker, GE executive vice president, advises, 'in planning for automation, it is important to develop a close alliance between those who know the business to be automated and those who know the business of automation. It's a long-term undertaking requiring a long-term relationship between functions which previously had only a vague awareness of each other'" [67, p. 9].

He further suggested that if CIM is to succeed, management and labor, where relationships have traditionally been characterized by distrust at best and antagonism at worst, have to change. Management and labor must forge new agreements of cooperation to define the role that each will play in the new manufacturing environment. As many companies have already discovered, it is essential to develop in all employees, including the workers on the factory floor a "sense of ownership" of the new technology. He purports that this can be accomplished by the following: First, companies typically find that they require a "CIM champion," a person who not only understands the technology but also has the ability to sell his ideas throughout the organization [67]. Nellemann asserted that CIM requires that new relationships be forged with suppliers.

Quantz [77] in his coverage of the overall planning for CIM suggests that that one way to develop momentum is to single out potential agents of change and convert them into CIM apostles - this, he stressed, is particularly effective if they are chief engineers, chiefs of manufacturing, or other functional leaders who control real resources. The idea is that when middle managers are convinced of CIM's value, the resources they control can be directed toward implementing CIM and pursuing new application opportunities.

Synder and Elliot [95], in their suggested implementation steps, recommend the development of a strong relationship with appropriate suppliers. A common understanding of the problem should be obtained, as well as the criteria for an acceptable solution. Voss [106] in his report indicated that successful implementers have tended to build close relationships with their suppliers. These relationships, he states, would seem to be characterized by a two-way flow of information rather than an off-the-shelf purchase with installation solely by the supplier or the user.

In discussing the automation of the manufacturing process at RCA's video component and display division in Circleville, OH., Juan Brown, one of the partners of Optimization Systems, Inc, the external consulting company employed to install the new system, indicated that it was important for system integrators deal with implementation issues as a single voice from the start of any project. This would prevent another engineer (who may be associated with the project) from instituting change or giving a command counter to the goals of the system integrator or project objectives. "The whole process has to be a cooperative effort between the systems integrator and the customer. Only the customer can bring his knowledge of product and process into the bargain. We bring our practical experience and knowledge of what is required to implement the job," says Brown [107, p. 122].

Education and Training

Another facet in the successful implementation of CIM involves retraining employees, says John W. Vineyard, a consultant with A. T. Kearney (Atlanta) "I hear over and over again: 'We have 5000 people to train in this process and then another 7000, and then... Training's expensive. But have you priced ignorance lately?' Ignorance is very expensive" [92, p. 31]. One way to address the issue of training is to simplify systems. "Its far more cost effective than training," says Douglas Kahn, President, Interactive Images (Woburn, MA.). "After you've trained your people, they may move on to other roles, new people come in, and you've got to do the training all over again. But if you develop simple-to-use, friendly human interfaces for your shop floor systems, training requirements can be eliminated. This permits the shop floor systems to be easily operated by many different non-technical employees. The broader your employee's functions, the more easily the concepts of flexible manufacturing can be implemented, because you can move your people among a variety of operations" [92, p. 31].

Beck [6] in his discussion of the how a new system can meet the growth and challenges of growth and change, attributes to the success of the new packaging system installation at an IBM plant in Boca Raton, FL. to a comprehensive training program. He indicates that among the reasons for the wide acceptance of the system were the diverse training techniques IBM developed to introduce the system to the operators and other employees. According to Beck, the training program, too, illustrates how interdepartmental cooperation paid off. They are the products of cooperation among distribution engineers, staff programmers, maintenance personnel, and others, he said. For example, maintenance personnel spent the last 4 months before the start-up of the system on the job with the installers. So their training included first-hand knowledge of all parts of the system before they become responsible for keeping it running.

Brauninger [11] indicated that one of the things they used to spark interest in CIM at Cone Drive was training. In that system implementation, he pointed out that they trained employees in the new system before the actual installation. This developed confidence that they could do their jobs using more advanced systems and equipment. "We also promised people they would be trained in a new (and probably better) job if their current job was eliminated. This gave them security and a reason to look for time savings" [11, p. 22].

In a survey of organizations that have implemented advanced technologies, training was frequently mentioned as a factor in a successful strategy [60]. According to Ettlie [23], it involves both education of the organization and training in specific technical skill area- for example, operation, programming, and maintenance. Early commitment to training and education is important, and perhaps it is a factor in establishing a readiness for change and participation. He indicated that a respondent suggested an interesting combination of the training and vendor-user elements of implementation strategy; that vendors (technology suppliers) and users jointly conduct training schools after the initial group of user personnel has been trained. The user could then pace the training to the strengths and weaknesses of the personnel involved in the implementation [23, p. 79-80].

Among the milestones that lined the path to a class A status in the MRP II project at the DEC -Augusta plant was education and training. Education was provided for top-level managers so that they would understand the importance of their efforts. A training program for operations personnel was developed in house and was accomplished just prior to cutover to the new system. By developing their own training methods, DEC was able to tailor training to the policies and procedures it had devised. Workers received training as close as possible to the time the new system was brought on line, to make sure that new techniques were fresh in their minds and that the training reflected the most current state of the system [40]. Synder and Elliot [95] recommend that proper training be provided to all stockholders in the project, including management and supervisors as well as individual operators. They also recommend that proper resources be allocated to support the new technology once it is in place, including - properly trained operators, and skilled, knowledgeable technical resources personnel.

In the CIM efforts at Corning Glass [49], Joseph Hurley, the director of manufacturing systems, in the efforts to remedy the problems encountered at the initiation of the program, began a education campaign, first for himself and then for the corporation. He utilized consultants, vendors, societies, trade shows, literature. Once he began to come to speed it become apparent that it is just as important to involve others. A high-level sponsor in the corporation is critical, and early in Hurley' s efforts, the corporation's vice-chairman for technology, Dr. Thomas C. MacAvoy, become the CIM sponsor [49].

Nellemann [67] points out that one of the factors for success in implementing strategic directions of CIM is that education and training need to take place to enhance skills and to convert replaced personnel to the next generation of computer operators, technicians, programmers, and maintenance personnel. He asserts that education is one way that organizations can fight resistance to technology in their factories and offices. Management needs to be part of the training process. Nellemann pointed out that " ... we can make significant gains by scrapping outmoded work rules, managing and training the workforce better and handling parts inventories more efficiently. By having just the right amount of technology and by initiating new procedures to prepare our companies for a new system of operation, these companies can end up with higher productivity for less investment" [67, p. 3].

Kowalczyk described the experiences of the team responsible for implementing the MRP II software as an example of the kind of dedication required [39]. Twenty individuals spent 3 months full time, and 6 months part time, in training with the new software. "But we didn't have to hire extra people to carry the load. Many of them worked 60 and 70-hour weeks to perform their regular tasks as well as come up to speed on the software" [39, p. 109].

Pearson [72] provides some techniques for reporting CIM successes to personnel. Included in his list are: getting employees involved in planning and implementation, internal news reporting, periodical business results meeting, encouraging and allowing technical publications, rewards for technical accomplishments, and employee training programs. He indicates that training programs provided within a business structure offer further opportunity to stimulate employee involvement and interest. A well organized training session will not only provide needed exposure to individual operations for employee participation, but can also expose the employee to current and planned enhancements in the business that will affect or involve the employee. The training process can be used to create and stimulate a climate of receptiveness to a changing business. There is opportunity for the business that is receptive to using training as an additional tool to motivate employees. Rummel and Holland [82] identified the common problems associated with the installation of CIM systems. One of the difficulties they cite is the need for well trained workers familiar with the principles of automation, computer technologies, and manufacturing processes has driven many companies to institute comprehensive training programs.

Sepehri [91] in a discussion of the highly successful automation project of IBM's Information Products Division in Lexington, Kentucky, gives some attributes for successful implementation of the automation project. One of the factors listed was that prior to introducing the automation, every manager participated in a seminar about what was being done in manufacturing. It covered aspects of automation business strategies and product directions. The managers took information back to their groups and started preparing for job and responsibility changes. According to Sepehri, the skills required to make the old Selectric typewriter, with its many mechanical parts, are clearly different from those needed to run an automated factory. The employees had to learn about electronic technologies and automated assembly. They were candidly told that their jobs would be profoundly affected. Hundreds of Lexington employees were retrained as computer programmers and robotic system technicians. Extensive retraining and redeployment enabled IBM to maintain full employment. It also helped build a skill base in automation technology to carry the company into the future. Employees morale, as measured by the annual opinion survey, actually went up at Lexington during the automation project.

According to Zygmont [115], TRW's investment in training underscores the importance of personnel in computer integration. "The failure of new systems is much more psychologically based than technologically based," says George J. Hess, vice-president of Ingersoll Milling Machine (Rockford, IL). "We can change that dramatically by more effective training" [115, p. 28]. One of the causes of failure in AMT efforts that is addressed frequently in literature is the fact that companies realize late in the game that training workers to handle the new technologies takes longer than anticipated.

Top - Down Planning and Bottom - Up Implementation

According to Bill Kowalczyk, MRP II project Manager, one of the factors responsible for the success of the MRP II effort at Digital Equipment Corp. - DEC - Augusta, GA plant was the commitment, from the top down, of all plant personnel [39]. O'Rourke stressed the importance of the process of planning from the top down and from the bottom up [42].

Nellemann emphasizes that "The success of CIM requires top down planning and participation" [67, p. 3]. He further states that the issues connected to CIM - and those that determined its success - are strategic - and significantly impact the survival of the company. They require management's attention at all levels.

Krepchin [49] explains that one of the outputs of the corporate CIM effort is a project plan that serves as a guideline for individual plant programs. Planning begins with the setting of business objectives which in turn lead to a set of manufacturing goals. Before any further work is done, an audit of the existing configuration is performed. The audit serves several purposes. It indicates where shortcomings are, and is a basis for comparison once the CIM project is underway. One result of the audit is a firm understanding of current plant practices. This assists in the development of a computer simulation model which is used in the next step - simplification. "Why automate a process that has hundreds of steps when the same product can be produced with half the complexity?" "First we simplify, then we automate", says Hurley [49, p. 94]. He indicated that simplification also applies to information systems. After procedures are simplified, the automation and information systems plans can be developed. After the plans have been developed, a computer simulation is again performed. Once the simulation has confirmed the plans, priorities for implementation can be set. The speed at which a project proceeds depends on the cost and the ability of the plant to receive the project.

Snyder and Elliot point out that top management must form a corporate business plan and determine a specific plan for manufacturing which will serve as a road map for future change. Management must also determine and implement the specific changes necessary to support the plan [95]. "Get users involved up front to gain understanding and take ownership. If applicable, ground work should be laid for any union negotiations - Have users participate in the design, explain reasons for contract changes needed" [95, p. 45]. Voss [106] stresses workforce involvement and human factors, and continual management involvement to stay up to date.

Three distinct strategies for implementing CIM are emerging, says Peter Marks, vice president of Automation Technology Products (Campbell, CA), a supplier of CAD/CAM systems. One approach is to integrate inside to outside, creating a computer network for data exchange between a manufacturer and its suppliers and/or customers. A company may also integrate from beginning to end of a product's development cycle, creating a data continuum from earliest design and planning through engineering and production, and even tying in support departments like marketing and technical publication (to aid in the preparation of operator manuals and repair guides). Finally, a company may decide to integrate from top to bottom in order to disseminate information downward for better control of manufacturing operations and to feed information upward from the shop floor for use in business management and planning [115].

Pace of Implementation

One of the reasons cited for failure at advanced manufacturing technology (AMT) implementation efforts is the rate of implementation. Driven by an enthusiasm for the promise of AMT, executives often fail to pace the implementation of the sophisticated systems and equipment. GM's Jan Tannehill, who oversees Hamtramck and several other GM assembly plants acknowledges that "...GM is rethinking its plans...we are going to phase in automation slower than we had planned" [101, p. 1]. If GM scales back its automation plans, it will be concluding what many experts already believe: High technology, like strong medicine, must be taken in carefully measured doses. Automakers are having enormous problems both in coordinating sophisticated advanced manufacturing technologies, and in training their workers to handle it. Only by a carefully planned and systematic approach can these corporations be confident that each investment in AMT will be successful. In GM's Hamtramck plant, they tried to do too much too fast, and they are now planning to scale back their automation plans.

One of the reasons for failures of CIM implementation efforts, says Nellemann , " ... is that management underestimates the magnitude of moving toward fully automated operations. The complex myriad of technologies that work well is isolated pilot projects are not always easily coordinated in the real word of high volume manufacturing" [67, p. 3]. Another reason for failure, according to Nellemann, is the rate of implementation. Driven by an enthusiasm for the promise of CIM, executives often fail to pace the implementation of the sophisticated systems and equipment. He also pointed out that rather than have automation as a goal, for example, we should think in terms of systematically upgrading ... incorporating only a portion of the many options now available. He stated that because of the rapidly changing technology, a step-by-step approach makes the most sense over the long run. He further gave a prescription for an approach that works. According to Nellemann, "To succeed in implementing CIM, we need to restructure our factories in a systematic, three-stage process: Simplify, Automate, and Integrate" [15, p. 3].

Putnam [76] points out some traps that smaller companies should be aware of and must avoid when considering modernization activities one of the traps to avoid is trying for a home run in implementing new technology. "Learn to walk", he says, "before running, because no matter how much analysis is conducted prior to implementation, when the technology is implemented, a long learning curve may be necessary" [76, p. 13]. He further states that when designing a modernization project, it should be kept simple, and implemented in an incremental manner. According to Putnam, "always start with a first step that is easy to implement and that will show good results. This will convince doubters and gain support for the modernization project. It will better allow time for a difficult part of the project to be implemented and proven without pressure for immediate results" [76, p. 14]. Early successes, he indicates, will provide momentum for the project, and the momentum will be necessary.

AUTOFACT '86 visitors gave some ideas on where the keys to success with CIM are [92]. According to Douglas Kahn, president, Interactive

Images (Woburn, MA), a lot of companies are "studying" new technologies, which he says he encourages, but that they should learn by doing, because they are losing the opportunity to get hands-on experience, which is the best way to know what works and what does not. Jack H. Schron, Jr., vice president, Jergens, Inc. (Cleveland), agrees. "Don't be afraid of using current level technology today rather than waiting for what's over the next horizon. At some point along the way, you've got to make a decision and say - 'Today is when we're going to start - we can't afford to wait for the next improvement...' Then take it in bite sized chunks with a goal of always moving toward improvement" [92, p. 32]. The best way to make the transition from a conventional compartmentalized manufacturing operation to an integrated one, say most CIM analysts, is to break up the under taking into small, manageable pieces. For many manufacturers that are unable to commit vast sums to new equipment, an effective CIM strategy many require little more than creating an atmosphere that encourages integration [115].

Ettlie recommended that an incremental implementation strategy be used. He cautioned: "Don't try too much too fast" [5, p. 80]. It was indicated that it is wise to take a strategic approach to phased adoption and implementation of the new technology allowing sufficient time (equal in importance for people and financial resources) to implement. He recommends that firms implementing advanced systems do so in stages or gradually in phases. Brauninger [11] points out that despite the early success indicators in their CIM project, their " ... challenge now is to manage our future programs so that we do not attempt to accomplish too much at one time" [11, p. 22].

A pilot project to test the systems is also recommended. A pilot project to test out the systems before implementation was also essential according to Kowalczyk of DEC - Augusta. This was not a full-scale test, but included real products, real parameters, and an actual data base [39]. Dr. Daniel L. Shunk, Director, Center for Automated Engineering and Robotics, Arizona State University (Tempe), urges companies to use prototyping techniques before committing themselves to a particular CIM program. "Prototyping is a way to understand the technology, minimize the risk, and maximize exposure to upper management, middle management, and shop floor personnel", he explains. "I think it's the only way to assess the impact a technology will have on a company. It doesn't have to be the first place of a multiphase installation it may be a small-scale demo using actual data. The important thing is that it allows you to get feedback from the users in terms of whether it's going to work" [92, p. 31]. Hurley of Corning recommends that once implementation is accomplished, a post-project audit should be performed. This can be used to justify similar future projects, or to reassess the directions taken on the work just completed [49].

Organization/Staffing of the Project

In his discussion of the critical issues in CIM, Bergstrom [8] stressed the CIM project team. He indicated that among the key members of a task force investigating the implementation of CIM should be a technologist, or a futurist. This person is key to the success of the task force. Further, he pointed out, a member too easily overlooked is the human resource specialist. According to Larry Geisel, president and

CEO, Carnegie Group, Inc. (Pittsburgh), "more than half the problems in CIM installations have to do with people related issues. The human resource thinker has to be involved in the CIM planning team. If you consider him or her not as important as the technologist, you make a serious mistake" [8, p. 25]. CIM planning must be done with participation at management levels high enough to carry the broad perspectives of the business.

Brauninger [10], in defining the roles of the different levels of management in the organization implementing CIM, states that the managers must assign the most capable people to the project. "Ideally, the person will be someone respected by the rest of the group, have leadership skills, and be experienced enough to understand how things are accomplished in this particular enterprise" [10, p. 17]. He further points out that the key ingredient in managing the CIM project is the project leader. He indicates that the chief executive must ensure that there is a team approach but must also ensure that the responsibility for getting things done is given to one individual. This individual will be one that oversees the project, ensures that each group is meeting its particular milestones, and advises the chief executive on the progress, lack of progress, or problems requiring attention. He also points out that people with ambition and desire should be allowed to lead in the implementation of new ideas and projects [4].

Pearson [72] states that when the climate is right, an effort should be put forth to generally define what goals and benefits are expected by introducing CIM. When some idea of what is desired has been formulated, a multi-disciplined team should be formed to further define the goals and generalize on how the goals can be accomplished [72, p.

30]. In forming the team, members with a variety of training and experience should be included. Using a single discipline can seriously limit the effectiveness of the team in developing plans that will address all aspects of operating the business. "The actual number of participants will vary with business complexity and size and business objectives" [72, p. 31]. Pearson urged that generally, the team should include persons that have knowledge of manufacturing operations, production control, facilities engineering, factory planning, and information systems development. For complete integration of the CIM functions, the team should also include members from the computer-aided design and production engineering segments of the business. Other support organizations may be tapped as needed for additional contributions.

Voss [106] recommends cross functional implementation teams. He stated that new manufacturing technologies are characterized by both their cross functional impact and by the involvement of a new discipline - computer software. Successful implementation appeared less likely to occur, says Voss, when relevant functions or skills are missing from the implementation teams. He further stated that successful teams are likely to have active members from: manufacturing, software engineering, and product engineering/development. According to Knill [50], the Allen-Bradley system discussed earlier, is a textbook example of how automation should be planned and executed. Larry Yost, vice president of operations, Industrial Control Division at Allen-Bradley pointed out that " ...the challenge in planning was to integrate the input of all the specialties that would be involved namely - marketing, quality control, management information systems, product development, manufacturing, packaging, cost/finance, etc. All these functions were represented on a planning task force by the best people available. They wrote the specifications for the system" [50, p. 62]. "They need to set the goals, says Manor, "to provide the multidisciplinary project teams, to set the focus on the processes of the business rather than the functions of individual departments, and to ensure that there is an environment where change is possible, and is in fact desired" [92, p. 32]. The need for a multidisciplinary team approach to CIM is stressed by many. The problem says John W. Vinyard, Principal, A.T. Kearney (Atlanta), is that we've "incentivized" individuals, not teams. "I'm convinced that people perform in the manner they perceive they're being judged," he explains, "If they perceive they're being judged on how successful engineering is, they'll make engineering successful - even if it cripples manufacturing. But if they understand they're being judged for the total benefit of the company, they'll make serious, dramatic strides." [92, p. 31].

On a more basic level, manufacturers experienced in CIM emphasize the need to utilize employees through the transition from a company's former operating procedures. To unite an array of independent computer systems with CIM, says Philip N. Condit, president of Boeing Commercial Airplanes, a lot of classical boundaries have to be violated. And when that happens, the cultural impact can be severe, but managing it is critical to the implementation of CIM. To forestall turf wars, Boeing's product design, engineering, production, and support are brought together from the outset of a program to foster communication and a unified effort [115].

Geisel of the Carnegie Group, Inc. warns of a few problem areas associated with the organizational aspects of CIM planning. First, CIM planning must be done with participation at management levels, high enough to carry the broad perspective of the business. "Most people," Giesel says, "understand only part of an organization - the part they are in. They may understand one level up or down, but not much beyond that. So, the selection of the task force becomes very important" [8, p. 25]. A second pitfall pointed out involves skewing the task force one direction or another by simply over-representing one area's participation. If the task force is heavy on engineering, the resultant CIM plan is likely to have a strong engineering flavor. The third area of concern for Giesel is planning in obsolescence. According to Giesel, "People doing CIM planning tend to look at process and equipment technology as static far more often than they should. Technology is absolutely dynamic, and any plan that fails to take that into account will inevitably lead to an implementation five years out that is obsolete" [8, p. 26].

Putnam [76] pointed out some of the traps smaller companies should be aware of and try to avoid when considering modernization activities. He stated that the scope of modernization will vary depending upon the resources the company has to apply. Some companies have extensive engineering staffs dedicated to modernization projects while other companies' entire engineering staffs remain committed solely to daily operational requirements. Some companies have limited time for engineering staffs to work exclusively on modernization projects, while many other companies do not have the luxury of dedicated modernization departments. He indicated that these companies that do not have dedicated CIM project group, when confronted with the need to engineer a modernization project, must pull engineers of on-going projects and assign them to the modernization project. Great pressure will be exerted to complete the job quickly so the engineers can resume their regular duties. He suggested that to ensure that the engineer's time is spent productively, it is necessary to know what functions need to be improved in order to modernize an operation. The functional analysis, he claimed, will describe how the operation is being performed, and this information facilitates the generation of requirements. Once the requirements have been determined, specific solutions can be recommended and justified. By directing the engineers' efforts to specific functional areas for consideration, a great amount of engineering time will be saved. More time will be spent on solving problems, not just trying to define the problems.

Ettlie [24] emphasized employee participation through implementation teams. He indicated that the greater the participation of production personnel in implementation strategy formulation, the more successful the installation of manufacturing process innovation. According to D'Angelo of IBM's Boca Raton, FL. plant, "We included in the system's design and implementation, those who will use it, maintain it, or be affected by it. So we are confident that they understand the system's purpose, its operation, and how it will serve their needs today and tomorrow" [6, p. 5]. Ray Reichenbach, Automation Manager, New Products, at IBM's Lexington plant noted that the system is the key to IBM's success. He points out that employees are are such an integral part of the company that IBM and the employees basically have to look after each other [41].

Witt [111] in the discussion of the automation of the manufacturing process at RCA's Video component division located in Circleville, OH., indicates that an important factor to the success of the project was the designation of a project manager by the customer - RCA.

Management Commitment and Support

Despite all the upbeat talk about Automated Manufacturing Capabilities, the "factory of the future" has met considerable resistance from senior executives at many companies, according to Herb Halbercht, a Stamford, CT., Management Consultant. "Unions are usually blamed for opposing automation," said Halbercht. "But the true culprit is top management itself ... senior executives reluctant to take risks or block projects that may not have any payoff until five or ten years in the future" [60, p. 9]. According to Halbercht, the big breakthrough are only going to come when there's an across-the-board commitment to CIM technology. This, he indicated, is not just CAD/CAM and Computer-Aided Engineering (CAE), but also vision systems, robotics, factory data networks (MAP), artificial intelligence...and the entire process controlled by computers.

Quantz [77] covers the overall planning for CIM. He cites some obstacles to CIM implementation. He indicates that although capital shortage and senior management complacency are often cited as the major obstacles to implementing CIM, inertia and middle management reluctance to change often prove to be the real problems. Quantz states that middle managers usually have limited knowledge of computers and their applications. These managers are often the most reluctant to support CIM because they are directly responsible for company resources and productivity. Synder and Elliot [95] recommend top management involvement in the formation of corporate objectives. This would aid them in assigning adequate resources to analyze the technology and the application in adequate detail to create a detailed functional specification.

Rummel and Holland [82] state that some of the common problems in implementation come from a lack of commitment from management or labor groups. Either of which may perceive new technology as a direct threat. Management must recognize that new organizational structures may be necessary to allow more employee participation in design and planning, as well as in some decision making processes. Managers and engineers will need more finely honed human management/interaction skills to provide necessary motivation and enthusiasm and inspire employee's cooperation.

Ettlie [24] suggest that the most important predictor of utilization success is likely to be the strategy formulated and implemented that firms use to integrate new manufacturing equipment into their organizations. He indicated that he found management's commitment to the philosophy of the new approach to manufacturing to be the second most significant correlate of utilization rate of equipment, with the largest correlation being the degree of workflow integration achieved with utilization. Gerwin [34] strongly suggests that a firm has to have strategic commitment to CAM systems in order for integration to be possible. Ettlie proposes that organizations that have an explicit, long term commitment to a new manufacturing process, a commitment that is promulgated and understood by key organization members as the implementation strategy of the firm - will be more successful implementing the new technological process.

Brauninger [10] gives the roles of the different management levels in the organization implementing CIM. At the highest level, he indicates that the CEO must clearly communicate to subordinates, the CIM objective and ensure that continual motivation is applied in all areas. The next layer in the organization, he states, is the functional manager. He points out that this level of management is the most critical element to the overall success of implementation and the overall program. If the functional management level is not solidly committed to the program, their subordinates will sense this and they, in turn, will be against the program.

In discussing top management's role in CIM implementation, Bergstrom [8] points out that the obligation for successful CIM planning and implementation begins at the top of an organization. He, however, indicates that this is also the seat of many hurdles and bottlenecks. The major difficulty, according to Giesel, as reported by Bergstrom [8, p. 26], is that all too often, top management not only is not directly involved in CIM planning, but also it does not clearly communicate corporate strategic goals and objectives. When that happens, the CIM planners' hands are bound by lack of information - or worse, a body of misinformation. A second area of concern with respect to top management is the tendency to delegate away CIM planning. "This is done", Geisel indicates, "because top management may not be familiar with the technology involved, and may be intimidated by it so it delegates this critical decision-making process to a lower level which is something that should never be done" [8, p. 25]. Geisel points out that top management does not need to understand the technologies of CIM to make informed and successful decisions - decisions, for example, that involve what kind of factories one might have in the future, what their capacities might be, and where they might be located. These decisions, Geisel believes, can be made only at the uppermost level of organizational management. A more severe case of this delegation as addressed by Putnam [76], is the failure to internalize the modernization undertaking by hiring consultants to do all the work. He noted that hiring consultants is an easy way to design and implement a modernization project, but eventually the consultants will leave, placing burden of making the modernization project work on the company. Putnam indicated that consultants are good as technical advisors, but if a company fails to be a leader in selecting the technology and working hard to implement the technology, problems will occur when the consultants leave, as it would be too expensive to retain consultants for helping to manage day-to-day operations. Management commitment to CIM is vital to its success. Says Donald I, Manor, P E Division Manager, Design Systems, Deere & Co., "We need dedicated management to get the process started and to keep everyone moving ..." [92, p. 31].

A good example of a successful AMT implementation is demonstrated at Unimation, Inc., a subsidiary of Westinghouse Electric Corp. (Danbury, CA) in the strategy designed to maintain Unimation's position as a world leader in high technology robots and robotic systems [5]. Unimation built its program on solid ground. It started with top management support and the dedicated participation of every employee. According to Unimation's President Paul Ockerman: "Like most businesses, we have to constantly change or fall behind. Each of our employees has made a personal commitment to deliver the high product quality, technology, and service our customers deserve" [5, p. 4]. This program is working for Unimation. A sampling of the results include: An increase in purchased material acceptance rate from 60% to 92% over a two years period, a 183% increase in incoming material turnaround time, a 165% improvement in on-time shipping, 50% decrease in cycle time (the period between receipt of an order and shipment), 56% reduction in operating expenses over the same two year period, and an increase in value added of 26% in the first year.

Sepehri [91] explains that, in managing automation, senior management at IBM's Lexington plant supported the project actively with financial and resource commitments. At a lower management level, all control, reporting and business management responsibilities for each product or process - including product design, logistics, manufacturing process and CIM- were located under one person.

Voss [106] indicates that the impact of new technologies is cross functional, and top management support may be needed to ensure that a cross functional approach is taken, and that cross functional problems can be overcome. Implementation requires adequate resources, both money, and more important, people and time. Without top management support, these often evaporate. In addition, the choice and implementation of technology must be matched to a company's business requirements, and top management's input is required to accomplish this.

Organizational Structure

Organizational structure is the unique arrangement of reporting relationships and responsibilities found within a particular firm [97].

In order for an organization to successfully implement its AMT strategy, its structure must match or "fit" the firm's strategy. It must also be in tune with the other systems within the core organizational system, required to move the firm toward its stated objectives for implementing the AMT. When properly done, changes in organizational structure, if needed, can be a powerful tool with which to successfully implement such strategies.

"An organization's success depends on its ability to define strategy and respond to important forces operating in its external environment, and on having the appropriate structures required to manage the complex internal activities that will move the organization towards its strategic goals" [97, p. 48]. Some aspects of structure of particular interest in the efforts to implement AMT include: how the structure fits with the organization's strategy, how the people fit the organization's structure, the aspects of structure that could possibly frustrate or foster desired behavior such as communication, and how structure can be used as a strategic weapon.

The choice of structure directly involves the choice of strategy. The first step in making a decision about structure is to understand what the selected strategy requires of the organization. A formal strategy should provide specific and detailed information on its effects on all aspects of the business. If the company defines its strategy as "continued growth in revenues and profits", for instance, the definition does not contain information about what is required of the organization's structure. However, if the firm defines its strategy as "continued growth of 10%, with an emphasis on developing better market penetration and marketing programs through quality products" [97, p.

163], the strategy begins to focus on the need for appropriate structures to implement the strategy. When structure does not fit with the organization's human resources - its people - the result may be significant resistance to change from managers who are critical to the organization's functioning. Some may even leave the organization. The reward structure must be designed to stimulate and encourage the perpetration of the organization's structure. The dilemma of whether to adjust structure or strategy is not easily resolved. Ideally, a firm chooses a structure that fits with its strategy. When strategy is being formulated, the firm must view its structure as both a basis for - and constraint on - the range of strategies possible. Conversely, when contemplating a change in an organization's structure, the fit with its strategy - as well as its people, its culture, management processes, and the technical system must be carefully considered.

Ettlie [23] makes several propositions regarding the subject of implementing strategy for manufacturing innovations. He proposes that organizations that have more complex structures are more likely to initiate and adopt innovation, but are more likely to encounter problems in implementation, regardless of innovation type. Other propositions related to structure are that: Organizations that are more formalized and more centralized are less likely to adopt incremental innovations but are more successful at implementing incremental process innovations when they do attempt change. The opposite is true for radical innovation, less formalized and centralized firms adopt; organizations that use special structural arrangements like implementation teams for radical process introduction and organizations that use existing structural roles and relationships with expanded duties for incremental process introduction, will be most successful [23, p. 13].

Tichy [100] notes that organizations will manage the alignment/adjustment processes required to provide the needed balance in the organization to the extent that there is a match between each incongruency facing the organization and the adjustment capacity of the organization's components. Sashkin and Morris provide a sample questionnaire which can be used to assess an organization and place it along the organic - mechanistic continuum. Pertinent portions of this questionnaire have been incorporated into the survey instrument developed for this study. The questions used to solicit information for testing hypothesis # 4 were extracted from this source [87, p. 101].

Implementation Success Factors

There are a wide variety of issues of significant importance to AMT implementation addressed in literature, but do not fit into any the sections already covered in this chapter. This section explores some of those issues.

Voss [106] states that most organizations believe that they have successfully implemented new operating technology when two conditions are met. First, when all the bugs have been ironed out and it is working technically. Second, when the operation is working reliably and there is little down time, and/or the new technology has a high utilization rate. According to Voss, getting the technology to work may be only half the battle. The full success can only be considered to have been realized if the benefits sought are realized, and ideally realized in the market place through increased competitiveness. Full benefits, he says, may include increased productivity, reduced lead time, improved quality, increased flexibility, customer responsiveness, reduced cycle times, reduced labor costs, increased throughput, reduction in work-in-process (WIP), and common database [106, pp. 159-172]. Voss proposes two levels of success in implementation of AMT: Technical success - the bugs have been ironed out and the system is working technically and Business success - realization of anticipated benefits.

Zygmont [115] points out that CIM is not a single technology but a global concept, encompassing nearly all efforts to streamline a company's manufacturing and support activities. It may mean, for example, tying together product design and production engineering so that the same product data created on a CAD system are also used to program computer-controlled machine tools to cut the parts. It may also entail automatic communication between control computers in the factory, so that production is smooth and coordinated. Because no two manufacturers have the same needs, says John J. Clancy, president of McDonnell Douglas Manufacturing industry Systems (St. Louis), "CIM solutions are not generic; they have to be tailored to individual companies" [115, p. 29]. A manufacturer's approach to CIM depends on such variables as its size, the age and number of its facilities, the volumes and varieties of its products, the kinds of arrangements it has with vendors, and the changeability of its market, to name a few [115].

Bergstrom [8], in an article which covered his discussions with Larry Geisel, president and CEO, Carnegie Group, Inc. (Pittsburgh) covering the notion of CIM, pointed out that any organization contemplating CIM should know itself first, what it is and where it is going, before seriously entertaining the idea of CIM. According to Geisel, "First of all, you have to know the nature of your business, like products and markets, businesses have life cycle, and it's critical to know what kind of life cycle your business has." He was also indicated that "CIM planners who start without a clear notion of business type will find the going difficult" [8, p. 25]. Furthermore, the CIM plan is going to be radically different depending upon the business.

The notion of understanding one's own business and understanding CIM, and the progressing one step at a time, is an important one. "CIM requires tremendous support, both in terms of engineering and maintenance," says C. Sean Battles, senior staff engineer, strategic manufacturing planning, Deere & Co. (Moline, IL). "We ask whether CIM is going to improve the total cost of manufacturing. Careful evaluation before application is important to ensure that we've thought through both CIM's strengths and weaknesses" [92, p. 31]. According to Marcus A. Clarke, Jr., Engineering and Manufacturing Staff, Manufacturing Planning Department, Ford Motor Co. (Dearborn, MI), "The key to the implementation of all this new manufacturing technology is going to be how well you think it through and how well you utilize your people" [92, p. 31].

Nellemann [67] indicates that CIM is more than a technical challenge, it is also an organizational challenge. "It requires that we redefine traditional roles and responsibilities, organization structures, work content, reward system and approach to education and training" [67, p. 4]. He further states that CIM changes the nature of manufacturing by making it a process system which affects many functional areas of the company, and for a system to work at its peak, the parts must work together. Beside having implications for the factory floor, it also means that the various functional areas - finance, marketing, engineering, production, human resources and data processing - must work together to an unprecedented degree. Nellemann also gives some reasons why some companies fail in their CIM efforts. He indicates that because of the complexity of combining the technology, organization and supplier relationships in a fashion that would make them work together, many companies are disappointed as their attempts to implement CIM systems fail to yield quick and dramatic benefits, and even cause more complex and serious problems than those they were intended to solve. He further pointed out that in many cases, sophisticated equipment sits idle while technicians try to debug the software that controls its movements, the number of products made by a new system is only half its capacity, costs and scrap rates are higher than anticipated and productivity suffers.

Kowalczyk, in describing their experiences with the MRP II project at the DEC - Augusta plant noted that one of the elements responsible for their success, striving for an effective system rather than elegance, helped keep the project moving. The idea was to get procedures that worked first, and worry about improving them later [39].

Putnam [76] points out some of the traps that smaller companies should be aware of, and try to avoid when considering modernization activities. He states that the scope of modernization will vary depending upon the resources the company has to apply. Some companies have extensive engineering staffs dedicated to modernization projects while other companies' entire engineering staffs remain committed solely to daily operational requirements. The first restriction affecting modernization efforts, according to Putnam is limited capital funds for such projects. He warns that modernization should not be equated with buying new equipment, that modernization includes the set of activities which will improve productivity, quality, and throughput time. With this limitation, he indicates that determining what set of activities needs to be undertaken involves identifying what is needed by the company. Implementing modernization which does not interface with all required activities will create an island of modernization with disappointing results. For these reasons, it is imperative to determine the real needs of the company to best identify the appropriate modernization activities. The needs analysis will then determine if a heavy capital investment is necessary or if just improving a process will be the best solution.

Beck [6] discussed how a new system can meet the challenges of growth and change. In this case, the discussion is specifically directed at a new packaging system at an IBM plant at Boca Raton, Fl. He indicated that between securing management approval for the new system and selecting a systems integrator (Jervis B. Webb Co.) about 16 months had elapsed. "The business was busy changing while all this was going on," says J. Robert Brokaw, advisory engineer. "That's why we decided we had to make the system generic," adds Larry A. D'Angelo, Manager of distribution engineering. By "generic", D'Angelo means "designed for a range of probable future products in addition to existing ones" [6, p. 5]. To IBM, making the system generic meant including flexibility among the general design criteria. Beck mentioned that planning to handle future products in unknown quantities presented more difficulty. It requires ongoing cooperation between distribution engineers and personnel responsible for new- product development. Other cooperative successes included consultations between distribution engineering with personnel responsible for facilities engineering, safety, maintenance, and manufacturing at every step of the project planning and implementation. Concerning flexibility, O'Rourke also suggested that one should seek flexibility to give the facility a longer life than the product it is producing. He said that CIM's economics of scope make economics of scale possible [42].

Brauninger [11] discusses how Cone Drive became initially interested in CIM. He indicated that what started their interest was customer demand and competitive pressures. They realized that they had problems with their delivery integrity and project lead times. He indicated that they originally attempted to solve this problem over the years by hiring additional people, building more inventory, and extending lead times, but achieved limited or poor results. Top management realized that something had to be done and provided the personnel and financial resources to get started. Brauninger pointed out that the primary method to spark interest in CIM is to get everyone involved. He provided a list of what they used at Cone Drive to spark interest in CIM. Included were the fact that they developed expectations that things were going to get better, remained open to suggestions for improvement whether it related to specific tasks or the system as a whole, allowed people with ambition and desire to lead in the implementation of new ideas and projects, and showed everyone the results as projects were successfully completed.

Ettlie [24] indicates that incremental and radical innovation change ought to be distinguished when we study the innovation process in organizations, because the causal model for the two general types of innovation is different. He defines radical change as involving more risk, often because of the large magnitude of the proposed innovation, the lack of certainty of outcomes when using the innovation, and the degree to which the change is discontinuous with past experience. It stands out as a real difference in the normal day-to day, year-to year routine of patterns of behavior of an organization. He makes several propositions regarding implementation of process innovations. Among these are incremental process innovations failing for economic reasons, or if demand is insufficient at the selling price. Radical process innovations fail primarily because of insufficient human resources, especially during implementation; organizations that have aggressive technology policy are more likely to adopt and formulate a successful implementation strategy for sophisticated production process innovations; the more sophisticated the new production innovation, the more important technology and implementation strategy will be in determining successful integration of the innovation; sufficient slack resources consisting of people, money, facilities, support systems, and time will be allocated in successful innovation implementation cases. One of the most important causes of failure of innovation is the implementation stage will be lack of sufficient resources, especially when the technology is a radical departure from existing practice in an industry.

Synder and Elliot [95] provide suggested implementation steps. Some of the vital points discussed include the fact that firms should obtain a clear understanding of what the new technology can do and how it will satisfy a need that exists and develop a strong relationship with appropriate suppliers. They further indicated that firms should obtain a common understanding of the problems as well as the criteria for an acceptable solution and learn from the installation, perform analysis. The analysis should ask questions like "What did we say we were going to do?, What did we actually accomplish?" [95, p. 48], and find reasons for deviations from the plan. They caution, "do not expect instant results" [95, p. 48].

White [108] provides a list of some of the more commonly expressed reasons for the scarcity of integrated systems. Among the reasons given were the following: It is not easy to design and implement integrated systems. Design complexity tends to grow with the number of operations involved. Many details are involved and nothing can be left to chance; they are radical departures from tradition; few apparent rewards exist. Few, if any, incentives exist for team performance, instead of individual performance, group performance should be recognized and rewarded. Many believe that integrated systems provide little cushion for error. They think that a finely tuned integrated machine will experience considerable downtime, and that many organizational barriers must be overcome. The organization chart creates boundary lines that are difficult to transcend; the concept of integrated systems is not well understood. The term means different things to different people, depending on their background and experience. An integrated system is viewed as being tightly connected, inflexible and very risky; a leadership void exists. Where systems integration has occurred, successfully, a champion had existed. A strong leader emerged and made a commitment to systems integration. Few success stories and numerous horror stories exist. In general, the concept has been oversold and overpromised. Rather than having a dramatic impact on direct labor, integrated systems will have their greatest impact on indirect labor. Many of the indirect jobs in manufacturing, for example, fill the "gaps" between workstations; integrated systems eliminate such gaps.

While many other specific cases of successful or less than successful AMT related implementation endeavors could be cited, the author believes that those covered thus far in this literature survey will adequately serve the purpose of illustrating the possible results that can be achieved from these technologies, as well as to provide proper input as far as the factors desired in order to attain successful implementation, as well as those to be avoided in order to attain such status. This will, in turn, serve as input to the design of the survey instrument tailored towards achieving the goals of this study.

Desirable Outcomes of AMT

There are several factors identified in the literature as desirable outcomes of advanced manufacturing technologies. This section provides a synopsis of the expected/desirable outcomes provided in the literature based primarily upon individual AMT implementation experiences.

In a report of the committee on CAD/CAM interface released by the National Research council (NRC) (Washington, D. C.), it was indicated that there is a requirement for a substantial shift in manufacturing management as a result of market pressures, which demands greater manufacturing flexibility, improved quality and performance, and faster delivery. The study further indicated that based on visits to five leaders in implementing CIM, the following benefits were documented: reduction in engineering design costs, reduction on overall lead times, reduction in work-in-process (WIP), reduction in personnel costs, increase in productivity, and increase in productivity of capital equipment [30, p. 57]. In a similar study conducted by Frost and Sullivan, Inc . (New York), and focusing on companies using flexible manufacturing systems (FMS), the following benefits of FMS were documented: better machine tool utilization, reduction in direct labor, increased machine efficiency, reduced processing time, reduced floor space requirements, reduction in product cost, and reduction in the number of setups [70, pp. 34-35].

Jaikumar [44] indicated that one of the new imperatives in the management of FMS technology is that of making flexibility and responsiveness the mission of manufacturing. Other opportunities that exist in CIM are enumerated by Merchant [62]. These include: ability to reduce manufacturing costs, increased manufacturing productivity, flexibility in automation and operations, assurance of high reproducible quality, and increased job satisfaction.

"The driving force for modernization comes from factors such as customer demands and expectations which are increasing rapidly in terms of product performance, product quality, cost, serviceability, and responsiveness to schedule delivery requirements" [65, p. 34]. Mize, Seifert, and Berry [65] also indicated that the global marketplace is increasingly competitive, requiring manufacturers to improve their capabilities to satisfy customer demands for higher quality products at prices that are extremely competitive.

Kirton and Burnham [47, p. 45] presented some case studies involving the operation of integrated manufacturing. They pointed out some of the pressures that made the companies that they studied to consider integrated manufacturing. Among these were: a changing marketplace demanding greater responsiveness and flexibility, and also international competition demanding improved quality and lower costs. Some of the benefits that the companies experienced upon changeover to integrated manufacturing included: reduction in manufacturing lead times, reduction in product introduction times, improved machine utilization, reduced manufacturing costs, reduced inventories, better quality, and improved workflow.

In a description of the implementation of MRP II system at DEC - Augusta, Maine manufacturing facility, the benefits of the implementation experienced at the plant included: fifty percent reduction in WIP inventory, faster identification of problems on the shop floor, fifty percent reduction in production time for some products, reduced paperwork, and reduced overhead [39]. In a discussion of another case study, Knill [50] described the goals set for the CIM system implemented at Allen-Bradley. Among these were the following: lowered production costs through a reduction in the amount of materials required; total elimination of direct labor costs with the exception of four automation attendants; elimination/reduction of indirect labor costs in inspection, quality control, production and inventory control, data processing, supervision, and material handling; reduction of scrap and rework because of automated manufacturing; higher production rates from manufacturing cells and computer directed material movement; elimination of WIP inventory; reduction in warranty expense due to enhanced product quality; improved market position due to fast turnaround in order filling: just 24 hours from the entry of a customer order to shipment of that order; and the ability to automatically manufacture a lot size of one among the 125 variations of motor starters available.

Dutton [19, p. 38], in a discussion of the modernization program undertaken at John Deere's Harvester Works in 1982, pointed out that the program's directive was to reduce the parts cost and improve quality. She indicated that with over 15000 part profiles recorded in Deere's computerized state-of-the-art Group Technology (GT) database, it seemed obvious that the project's goal of reducing costs had a great potential for savings, increased productivity, inventory reductions, and other efficiencies. Above all else, quality also had to be improved.

Udoka and Nazemetz [102, p. 40], presented a list of driving forces for AMT implementation, based upon an earlier research. Among the factors enumerated were: improved product quality; increased flexibility; improved responsiveness to changing market demands; improved on-time delivery; increased productivity; improved information flow; shorter product life cycles; reduced manufacturing costs; improved system performance; reduced prices for end-products; and reduced raw material inventory. Other factors listed were: reduced purchase parts inventory; reduced WIP; reduced material cost; reduced lead time; reduced throughput time; reduced floor space requirements; reduced direct labor costs; reduced white-collar content; and reduced scrap, rework, and non conforming materials.

In a discussion of the MRP II and Just-in-Time (JIT) program at E. I. DuPont de Numours and Co.'s Eagle Run, Delaware assembly plant, it was indicated that prior to implementation of the systems, their "schedule performance was a dismal 40% and inventory accuracy was less than 60%" [40, p. 73]. The following benefits were projected for the MRP II program: an increase in inventory accuracy of 97%; an improved master production schedule performance of better than 97%; a decrease in raw materials lead times from a half year to less than two months; a doubling of annual inventory turns from 3.5 to 7; and a productivity increase of 35%. The benefits if the JIT effort included: an additional increase in productivity of 25%; cycle time and WIP reductions from 6 weeks to 2 days; a reduction in required floor space; and an overall increase in quality [40, pp. 74 -75].

From the list of desirable/expected outcomes provided in the literature, those that were most frequently mentioned were compiled and used as the list of expected outcomes of AMT in the implementation success diagnosis (ISD) section of the questionnaire described fully in Chapter III. A summary of the selected expected outcomes of AMT used in the questionnaire, along with their literature support is presented in Table II.

The respondents to the survey were given the opportunity to provide some input to this list of desirable/expected outcomes of AMT. In a section of the questionnaire where open-ended questions were asked, the respondents were asked to list the top three specific benefits of their AMT implementation. Their responses to this question are provided in Appendix F, and a relationship to this section is made in the section dealing with the analysis of the data in Chapter V.

TABLE II

LITERATURE SUPPORT FOR EXPECTED OUTCOMES OF AMT USED IN THE STUDY

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1. Product Quality

   SUGGESTED IN: (Voss, '87, p.165; MHE. Feb. '87, p. 52; Merchant, '84, p. 8; Mize, '85, p. 175; Mize, Seifert and Berry, '84-85, p. 34; Kirton and Burnham, '87, p. 45; Knill, '85, p. 62; Dutton, '86, p. 38, Udoka and Nazemetz, '88, p. 40, MMH, Dec. '86, p. 74).

2. Flexibility to accommodate dynamic product mix changes

   SUGGESTED IN: (Voss, '87. p. 166; Jaikumar, '86, p. 76; Merchant, '84, p. 8; Udoka and Nazemetz, '88, p. 40).

3. Productivity

   SUGGESTED IN: (Voss, '87, p. 165; Majchrzak, '86, p. 197; Merchant, '84, p. 8; Knill, '85, p. 62; Dutton, '86, p. 38; Udoka and Nazemetz, '88, p. 40; MMH, Dec. '86, p. 74).

4. On-time Delivery

   SUGGESTED IN: (Vondembrese, '87, pp. 34-35; Udoka and Nazemetz, '88, p.40; MMH, Dec. '86, p. 73).

5. Information flow

   SUGGESTED IN: (Voss, '87, p. 165; Vondembrese, '87, p. 62; Udoka and Nazemetz, '88, p.40).

6. Manufacturing cost

   SUGGESTED IN: (Majchrzak, '86, p.197; Merchant, '84, p. 8; Kirton and Burnham, '87, p. 45, Knill, '85, p. 62; Udoka and Nazemetz, '88, p. 40)

7. Inventory turnover

   SUGGESTED IN: (Kirton and Burnham, '87, p. 45; Knill, '85, p. 62; Dutton, '86, p. 38).

8. Work-in-process (WIP)

   SUGGESTED IN: (Voss, '87, p. 168; Majchrzak, '86, p. 197; Kirton and Burnham, '87, p. 45; MMH, Nov. '86, p. 107; Knill, '85, p. 62; Udoka and Nazemetz, '88, p. 40; MMH, Dec. '86, p. 74).

TABLE II (continued)

9. Material cost

   SUGGESTED IN: (Knill, '85, p. 62; Dutton, '86, p. 38; Udoka and Nazemetz, '88, p. 40).

10. Lead times

   SUGGESTED IN: (Voss, '87, p. 165; Majchrzak, '86, p. 197; Kirton and Burnham, '87, p. 45; Udoka and Nazemetz, '88, p. 40; MMH, Dec. '86, p. 73).

11. Floor space requirements

   SUGGESTED IN: (Vondembrese, '87, p. 34; Udoka and Nazemetz, '88, p. 40; MMH, Dec. '86, p. 74)

12. Direct labor cost

   SUGGESTED IN: (Majchrzak, '86, p. 197; Vondembrese, '87, pp. 34-35; Knill, '85, p. 62, Udoka and Nazemetz, '88, p. 40).

13. Indirect labor cost

   SUGGESTED IN: (Majchrzak, '86, p. 197; Knill, '85, p. 62; Udoka and Nazemetz, '88, p. 40).

14. Responsiveness to shifting customer expectations

   SUGGESTED IN: (Voss, '87, p. 168; Jaikumar, 86, p. 76; Mize, Seifert, and Berry, '84-85, p. 34; Kirton and Burnham, '87, p. 45; Udoka and Nazemetz, '88, p. 40).

15. Long-term profitability

   SUGGESTED IN: (Mize, Seifert and Berry, '85-85, p. 35; Knill, '85, p. 62).

16. Stockholder benefits

   SUGGESTED IN: (Mize, '85, p. 175).

17. Overall system performance relative to system objectives

   SUGGESTED IN:(Udoka and Nazemetz, '88, p.40).

Similar Studies

There have been several discrete reports of successes and failures in efforts to implement AMT. Actual studies in the literature are mainly directed towards showing the benefits of CIMS or its subsystems. This can be attributable to the tendency towards reporting only the successes in AMT implementation efforts in open literature. No studies have been found that has dealt with delineating the factors required for successful implementation of AMTS.

In a study conducted by the Manufacturing Studies Board, National Research Council, Washington, D.C., the benefits of CIMS were shown to include: reduction in engineering design cost of 15-30%, reduction in overall lead time of 30-60%, increased product quality as measured by yield of acceptable product of 2-5 times its previous level. Another benefit listed was increased capabilities of engineers as measured by the extent and depth of analysis they could perform in the same or less time. Increases of 3-35 times the previous levels were recorded. Other benefits of AMT reported include: increased productivity of production operations (complete assemblies) of 40-70%, increased productivity (operating time) of capital equipment of 2-3 times, reduction of work-in process of 30-60% and reduction in personnel costs of 5-20%. The companies studied expect further benefits as full integration is approached [58].

In a similar study of companies using Flexible Manufacturing Systems (FMS), Frost & Sullivan, Inc., New York, using a sample of 20 U.S. operating systems, found some range of improvements for the total sample in the different areas of FMS [70]. The benefits of FMS along with the range of improvements that they found is presented in Table III.

TABLE III

BENEFITS OF FLEXIBLE MANUFACTURING SYSTEMS

AREA	RANGE OF IMPROVEMENT
Machine Tools	60-90%
Direct Labor	50-58%
Machine Efficiency	15-90%
Processing Time	30-90%
Floor Space	30-80%
Product Cost (reduction)	25-75%
Setups	10-75%

Source: [70, p. 34].

Frost & Sullivan forecasts that the total U.S. market for FMS and flexible assembly systems will be about $2 billion by 1990.

Another study related to the implementation of Advanced Manufacturing Technology (AMT) was presented by Jaikumar [44]. In the study cited in this literature, the author, in 1984 conducted a focused study of 35 Flexible Manufacturing Systems (FMSs) in the United States and 60 in Japan, a sample that represented more than half the installed systems in both countries at that time [44, p. 69]. The kinds of products they made were comparable in size and complexity, and required similar metal-cutting times, numbers of tools, and precision of parts. The U. S. systems had an average of seven machines to the Japanese six.

"Here the similarities end. The average number of parts made by an FMS in the United States was 10; in Japan the average was 93, almost ten times greater. Seven of the U. S. systems made just three parts. The U. S. companies used FMSs the wrong way-for high-volume production of a few parts rather than for high-variety production of many parts at a low cost per unit. Thus the annual volume per part in the U. S. was 1,727; in Japan, only 258.... For every new part introduced in the U. S. system, 22 parts were introduced in Japan. ..." [44, P. 69]. In this study, the author indicated in the comparison of the two countries' systems that the Japanese were better able to realize the strategic promise - the flexibility aspects of their FMS installations by more adequate management of their implementations. The study cited here shows the benefits of some advanced manufacturing technologies. The aim of this research study will be to gather information from those companies that have reported such benefits from AMT, about what factors led to their successful (or otherwise) efforts in AMT implementation, in order to formulate some general requirements for successful AMT implementation.

Voss [106] reports on an 18 month study into the success and failure in Advanced Manufacturing Technology (AMT) in England. He concluded that success and failure of the implementation can be considered a two stage process: achievement of technical success, and achievement of business success. Voss further indicated that at that point, few firms had gotten far enough into full implementation of AMT, and thus there was a clear scope for further research to validate and extend his findings. His study indicated that the benefits of AMT, are achievable but many companies have yet to achieve them. This study essentially showed as an output, the percentages of the companies studied that achieved some productivity increases or some other benefits as a result of AMT implementation.

Ettlie [23] in a related study, surveyed 41 organizations to determine the causes of the relative degree of implementation success of advanced programmable manufacturing systems in the United States. The general hypothesis of his study was that a successful implementation strategy is matched with the characteristics of the manufacturing innovation being introduced. He noted that one of the most important of these characteristics is the degree to which the new technology represents a radical, as opposed to an incremental, departure from existing practice. This study essentially tallied the responses of respondents to interview questions, and reported on the percentages of responses in each category. It also gives frequency counts of the different measures of success suggested by the respondents.

Majchrzak [52] interviewed manufacturing managers in plants with AMT equipment varying in degree of computer-based integration. The interviews were conducted to identify those components of management infrastructure which are related to plant performance. The components of the management infrastructure that they covered included: practices for managing human resources such as AMT operator responsibilities, training, job designs, and organizational design factors. Their results indicated that plant performance can be significantly enhanced by attention to management infrastructure variables; that as plants progress from stand-alone CAM equipment to integrated CIM cells, the management infrastructure will need to change; and that management will need to prioritize achievement of the different dimensions of manufacturing performance since management infrastructure likely to achieve low waste is different from that likely to achieve low work-in-process inventory.

In another related study, Majchrzak [52] examined training requirements for CAD/CAM. Plant representatives were surveyed concerning the use of various CAD/CAM technologies. The study suggested that at a minimum both shop floor supervisors as well as machine operators need to be trained. The study also suggested that in addition to machine operation, supervisors need to be taught information about manufacturing processes at the plant and an understanding of where the technological advances fit with the corporate strategy and manufacturing process. Moreover, skills taught to the operators of CAD/CAM also must go beyond specific machine operation. Offering training in safety procedures as well as general knowledge of technological advances in manufacturing provide the employee exposed to CAD/CAM a better understanding of proper expectations for the new equipment.

Summary of the Review of Literature

The review of related literature has attempted to examine the need for successful Advanced Manufacturing Technology (AMT) implementation rating. Investigative research was conducted to find information on how the complex elements that comprise the core organizational systems and the organizational strategy formulation are synchronized or aligned for successfully implementing AMT. From the literature, issues relating to each of the system elements were extracted. The review of literature was also directed at the companies that have been successful in their efforts to implement AMTS, as well as those with dismal results in their implementation strategy. The aim has been to extract information on how the factors covered in the AMT implementation model (Fig. 1) combine to contribute to the relative levels of implementation success attained by organizations that have implemented AMT. These issues were used in designing the questionnaires. The questionnaires were, in turn, used to establish, from the survey of participating companies that have implemented AMT, the commonalty of these factors as success factors or detriments to AMT implementation. This information comprise the results of this study. This information is expected to be useful in giving an overview of the complex interaction of strategy with the basic elements that make up and drive the organization, and how the more successful organizations differed form the less successful ones in the levels interaction of the different systems within the core organizational system.

The factors identified from the review of literature as factors predominantly accounting for successful implementation of AMT comprise the hypotheses formulated for this study. The null hypotheses stated for this study, along with their literature support, and the questions formulated from the literature to support and solicit information for testing each hypothesis are presented later in this section. The reader should note that all the questions used to collect the data to test hypothesis number 3 listed in the section below, were extracted from Stonich [97, pp. 6-10]; the questions used to collect the data to test hypothesis number 4 were extracted from Sashkin and Morris [87, pp. 101-102], the questions used to collect the data to test hypothesis number 19 were extracted from Sashkin and Morris [87, pp. 165-168]. All other questions in the instrument were formulated by the author from a combination of the references listed under each hypothesis.

The following are the hypotheses that were tested for the study. Under each hypothesis, a list of literature references that were used as a basis for formulating both the hypothesis and the questions are provided. The questions listed under each hypothesis were used to solicit information from survey respondents for testing the hypotheses to which they pertain.

Hypothesis #1

The degree of effectiveness in aligning the core organizational systems with the corporate strategy will not be a significant factor in differentiating successful and unsuccessful organizations in their efforts to implement AMT.

Suggested in: (Ettlie, 1984, p. 31; Thompson, 1967, p. 124; Krepchin, 1987, p. 93, Synder and Elliot, 1988, pp. 48-51, Zygmont, 1987, p. 28; Eschenbach and Geistauts, '87, p. 62).

Questions Used:

1. This organization had an overall corporate statement of objectives for its Advanced Manufacturing Technology (AMT) efforts, within which the plan for this particular AMT implementation was specified.

2. This organization adequately assessed the prevailing values and attitudes in the firm, in selecting its methodology for achieving the desired goals from this Advanced Manufacturing Technology (AMT).

3. This organization's scheme of events directed at achieving the desired outcomes of this Advanced Manufacturing Technology (AMT) fits the general technological patterns that I am familiar with.

4. In its plans for achieving the desired goals from this Advanced Manufacturing Technology (AMT), this organization adequately assessed its organizational structure, and made the adjustments required in order to reach those goals.

5. This organization made any organizational structure changes necessary for transition to the Advanced Manufacturing Technology (AMT) environment prior to implementation.

6. This organization had a strategic focus for its Advanced Manufacturing Technology (AMT) which increased cohesion within the AMT implementation organization.

Hypothesis #2

The degree of effective alignment of employee attitudes with the corporate strategy will not be a significant factor in differentiating successful and unsuccessful AMT implementation efforts.

Suggested in: (Synder and Elliot, 1988, p. 44, MHE, Feb.'87, p. 109, MMH, Nov. '86, p. 109).

Questions Used:

7. The reward system in this organization recognized individual efforts to attain the desired goals from this Advanced Manufacturing Technology (AMT).

8. The reward system in this organization recognized group efforts to attain the desired goals from this Advanced Manufacturing Technology (AMT).

9. This organization's top management provided continual motivation, and rewarded compliance with the Advanced Manufacturing Technology (AMT) philosophy.

10. Top management's evaluation of middle management considered performances that reflect the positive effects of change resulting from the Advanced Manufacturing Technology (AMT) implementation.

11. This organization's top management provided adequate incentives for middle and operational management staff to support the Advanced Manufacturing Technology (AMT) program.

12. This organization's top management provided adequate incentives for labor groups to support our Advanced Manufacturing Technology (AMT) efforts.

Hypothesis #3

The strategy formulation process will not be significant in differentiating successful and unsuccessful AMT implementation efforts.

Suggested in: (Thompson, '67, p. 451; Bergstrom, '87, p. 251)

Questions Used:

13. This organization's strategy formulation process explicitly includes consideration of implementation issues such as required reorganizations, staffing changes, modifications to systems and policies.

14. The key middle managers in this organization usually have a chance to review and comment on proposed strategies before resources are allocated.

15. Strategic proposals are usually critically discussed and consensus reached prior to acceptance in this organization.

16. There is a corporate staff support group for strategy formulation within this organization.

17. This organization usually has a formal system for internally reviewing strategic proposals.

18. This organization's Advanced Manufacturing Technology (AMT) efforts were designed to support its strategic business objectives.

Hypothesis #4

An organization's position along the organic - mechanistic dimension will not make a significant difference in the degree of success attained in their efforts to implement Advanced Manufacturing Technology (AMT).

Suggested in: (Ettlie, '86, p. 31; Sashkin and Morris, '87, p. 101).

Questions Used:

19. This organization has clear rules and regulations that everyone is expected to follow closely.

20. Policies in this organization are reviewed by the people they affect before being implemented.

21. Everyone in this organization knows who his/her immediate supervisor is. Reporting relationships are clearly defined.

22. Jobs in this organization are clearly defined; everyone knows exactly what is expected of him/her in any specific job position.

23. All decisions in this organization must be reviewed and approved by upper level management.

24. Standard activities in this organization are always covered by clearly outlined procedures that everyone is expected to follow.

Hypothesis #5

The nature of the relationship between the technology supplier and the user firm will not be significant in differentiating successful and unsuccessful AMT implementation efforts.

Suggested in: (Ettlie, '86, p. 77; Nellemann, '87, p. 8, Snyder and Elliot, '88, p. 50; Galbraith, '78, p. 116).

Questions Used:

25. This organization formed an implementation team with the Advanced Manufacturing Technology (AMT) supplier at the project site during its AMT project implementation.

26. This organization established a long term, mutual commitment with the Advanced Manufacturing Technology (AMT) supplier to support the integration the new technology in our plant.

27. There were key people from the Advanced Manufacturing Technology (AMT) supplier firm who worked very closely with our project team in the efforts to implement the AMT in our plant.

Hypothesis #6

The existence of an AMT champion will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Suggested in: (Brauninger, '86, pp. 21-23; Ettlie, '86, p. 83; Hayes and Wheelright, '84, p. 324; Nellemann, '87, pp. 8-12, Qunatz, '84, pp. 38-44, White, '86, p. 23).

Questions Used:

28. This organization allowed people with ambition and desire (regardless of their rank in management) to lead in the implementation of this Advanced Manufacturing Technology (AMT) project.

29. There was a key person from this organization who worked extremely hard at building a team to integrate the Advanced Manufacturing Technology (AMT) in our plant.

30. There was a key person from the technology supplier firm who worked extremely hard at building a team to integrate the Advanced Manufacturing Technology (AMT) in our plant.

31. The project leader for the Advanced Manufacturing Technology (AMT) implementation had a deep commitment and desire to succeed in the AMT implementation.

Hypothesis #7

The position of the AMT champion in the organization will not make a significant difference between successful and unsuccessful AMT projects.

Suggested in: (Ettlie, '86, p. 21; Quantz, '84, p. 39, Krepchin, '87. p. 95).

Questions Used:

32. The project manager was the key person who "championed" this organization's Advanced Manufacturing Technology (AMT) efforts.

33. The person who directed our AMT implementation efforts was in a key management position.

34. The person who directed our Advanced Manufacturing Technology (AMT) efforts, controlled the resources necessary for implementing the project.

Hypothesis #8

The existence of an employee educational program prior to AMT implementation will not be a significant factor in distinguishing between successful and unsuccessful AMT implementation efforts

Suggested in: (Beck, '86, p.5; Krepchin, '87, p. 94; Ettlie, '86, p. 78; MMH, Nov. '86, p. 109, Pearson, '86, p. 8; Rummel and Holland, '88, p. 36; Sepehri, '87, p. 73; Snyder and Elliot, ' 88, p. 47).

Questions Used:

35. This organization had a comprehensive educational program to communicate to all employees, the reasons for necessary changes related to the Advanced Manufacturing Technology (AMT) prior to actual installation of the system.

36. This organization had an educational program for top-level managers, focusing on the Advanced Manufacturing Technology (AMT) to be implemented prior to the actual installation of the system.

37. This organization had an educational program for middle managers, focusing on the Advanced Manufacturing Technology (AMT) to be implemented prior to the actual installation of the system.

38. This organization had an educational program for operations personnel, focusing on the Advanced Manufacturing Technology (AMT) to be implemented prior to the actual installation of the system.

Hypothesis #9

The degree of availability of hands-on training program for employees after the installation of the AMT system will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Suggested in: (Beck, '86, p. 5; Brauninger, '86, p. 21; Ettlie, '86, p. 78; MMH, Nov. '86, p. 109; MHE, Feb. '87, p. 32; Krepchin, '87, p. 93; Nellemann, '87, p. 8; Pearson, '86, p. 80; Putnam, '87, p. 14; Sepehri, '87, p. 73, Snyder and Elliot, '88, p. 44; Voss, '87, p. 159; White, '86, p. 23; Zygmont, '87, p. 28).

Question Used:

39. This organization had a comprehensive hands-on training program to introduce the Advanced Manufacturing Technology (AMT) to the employees after the actual installation of the system.

Hypothesis #10

The degree of top-down planning and bottom-up implementation in an organization will not be a significant factor for distinguishing between successful and unsuccessful AMT implementation efforts.

Suggested in: (Brauninger, '86, p. 17; MMH, Nov. '86, p. 109, MHE, Feb. '87, p. 32; Snyder and Elliot, '88, p. 47; Voss, '87, p. 163, Zygmont, '87, p. 29).

Questions Used:

40. This organization has a broad corporate plan for its Advanced Manufacturing Technology (AMT) scheme, which provides guidelines for individual projects.

41. The process for developing this organization's Advanced Manufacturing Technology (AMT) implementation plan incorporated employee participation to feed information from the shop floor back to upper management.

42. The overall plan for integrating this Advanced Manufacturing Technology (AMT) into the organization was carried out by upper level management, and the information was passed downward.

Hypothesis #11

The pace of implementation will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Suggested in: (Brauninger, '86, p. 86; Ettlie, '86, p. 80; Ettlie, '84, p. 37; Nellemann, '87, p. 10).

Questions Used:

43. This organization took a step-wise approach to adapt and implement the Advanced Manufacturing Technology (AMT) project incrementally in programmed phases.

44. This organization rushed the implementation of each phase of its Advanced Manufacturing Technology (AMT) program.

45. The pace at which our Advanced Manufacturing Technology (AMT) was implemented was so slow that the initial zeal that pushed the project along in its earlier stages was lost.

Hypothesis #12

The degree to which organizations obtained experience with a pilot project prior to implementing a full scale project will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Suggested in: (Putnam, '87, p. 13, MMH, Nov. '86, p. 109, Schreiber, '87, p. 33).

Questions Used:

46. This organization started its implementation push with a pilot project that was easy and had high probability of success, and then followed it up with successively more complex ones.

47. This organization obtained experience with a manageably-sized (Pilot) project prior to a full scale implementation.

48. The pilot project used to obtain experience in this organization was of similar technology to the full scale Advanced Manufacturing Technology (AMT) project.

49. This organization hired individuals who were familiar with the type of Advanced Manufacturing Technology (AMT) to be implemented to aid in its implementation efforts.

Hypothesis #13

The organization and composition of the AMT project team will not be a significant factor differentiating successful and unsuccessful AMT implementation efforts.

Suggested in: (Beck, '86, p. 6; Bergstrom, '87, p. 18; Brauninger, '86, p. 26; Ettlie, '86, p. 83; Ettlie, '84, p. 39; Knill, '85, p. 64; Nellemann, '87, p. 10; Voss, '87, p. 165).

Questions Used:

50. All the key functional areas were represented in the project team(s) for this organization's Advanced Manufacturing Technology (AMT) implementation.

51. This organization assigned its most capable people to the project.

52. This organization had an in-house project leader, who coordinated the efforts for the Advanced Manufacturing Technology (AMT) implementation.

53. The individual team members of this organization's project team were dedicated to the Advanced Manufacturing Technology (AMT) project on a full-time basis for the entire duration of the project.

54. The staff that worked on this organization's Advanced Manufacturing Technology (AMT) project were involved with the project only on a part-time basis while still performing their regular duties.

Hypothesis #14

The degree of management commitment and support in an organization will not be a significant factor differentiating successful and unsuccessful AMT implementation efforts.

Suggested in: (Bergstrom, '87, p. 25; Brauninger, '86, p. 17; Ettlie, '84, p. 34; MS, March, '86, p. 9; Quantz, '84, p. 40; Rummel and Holland, '88, p. 38; Schreiber, '87, p. 32; Snyder and Elliot, '88, p. 44; BW, March, '87, p. 102, MHE, Feb. '87, p. 32).

Questions Used:

55. This organization's top management was directly involved in its Advanced Manufacturing Technology (AMT) planning.

56. Top management understood/supported the implementation effort, and committed adequate financial resources to the Advanced Manufacturing Technology (AMT) efforts.

57. This organization's top management actively supported our Advanced Manufacturing technology (AMT) efforts with adequate human resource commitments.

58. This organization's top management directed its strategic planning efforts towards the successful implementation of this Advanced Manufacturing Technology (AMT).

59. Top management in this organization clearly communicated the corporate strategic goals and objectives driving the AMT implementation to the implementation planners.

60. Corporate planners in this organization clearly communicated the corporate strategic goals and objectives driving the AMT implementation to the implementation planners.

Hypothesis #15

The magnitude of product redesign or simultaneously designing a new product in parallel with implementing a dedicated AMT will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Suggested in: (BW, 'March '87, p. 102; MHE, Feb. '87, p. 32).

Questions Used:

61. This organization redesigned existing products for dedicated production on the Advanced Manufacturing Technology (AMT) facility, after the system was implemented.

62. This organization simultaneously designed new products along with a dedicated Advanced Manufacturing Technology (AMT) facility.

63. Product redesign concurrent with system implementation contributed significantly to the attainment of the desired levels of performance from our AMT system.

Hypothesis #16

The degree of adequacy of the particular technology to an application in the organization will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Suggested in: (Synder and Elliot, '88, p. 46).

Questions Used:

64. This organization attempted to apply some technologies that are not compatible with the rest of the Advanced Manufacturing Technology (AMT) in the overall technological scheme.

65. This organization purchased/installed some of the Advanced Manufacturing Technology systems without a clear understanding of what the technology could do, and how it would satisfy the needs that exist.

Hypothesis #17

The degree of information integrity in an organization prior to AMT implementation will not be a significant factor in differentiating between successful and unsuccessful AMT implementation efforts.

Suggested in: (Savage, '88, p. 2; Zygmont, '87, p. 28).

Questions Used:

66. The existing database configuration in our organization was too awkward for compatibility with the Advanced Manufacturing Technology (AMT).

67. This organization had a standard data communication system for adequate exchange of product description data, prior to attempting to implement the Advanced Manufacturing Technology (AMT).

68. This organization had adequate interfacing of information between the necessary functional departments, prior to attempting to implement the Advanced Manufacturing Technology (AMT) project.

Hypothesis #18

The degree of availability of qualified systems integrators in an organization will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Suggested in: (Rummel and Holland, '88, p. 39; Snyder and Elliot, '88, p. 47, Voss, '87, p. 164; White, '86, p. 23).

Question Used:

69. This organization had enough people possessing the technical competency required to integrate the Advanced Manufacturing Technology in our plant.

Hypothesis #19

The degree of alignment of an organization's AMT strategy to its culture will not be a significant factor in differentiating between successful and unsuccessful AMT implementation efforts.

Suggested in: (Sashkin and Morris, '87, p. 165; Schreiber, '87, p. 87; Thompson, '67, p. 124).

Questions Used:

70. In this organization, conflicts and differences in values, beliefs, and norms about coordinative activities, primary goals, and approaches to change are quickly dealt with and effectively solved.

71. When changes are necessary, everyone in this organization has a clear idea of what sort of changes are and are not acceptable.

72. In this organization, people do the best they can; there is little pressure to strive for specific goals.

73. People in this organization are very successful in dealing with and resolving ambiguity, and can effectively coordinate the actions of individuals and units.

74. This organization has a long history of maintaining stable patterns of shared values, beliefs, and behavioral norms.

75. In this organization, the pressure to maintain the status quo is so great that if a major change were required for the organization to survive, it might not.

76. There is little consensus in this organization with regard to goals, practices, or needed changes.

77. This organization handles problems of adapting to change with a high degree of effectiveness.

78. Most people in this organization have their own goals that may or may not be compatible with one another.

79. People in this organization have clear concepts of their own roles and how they relate to the roles of others.

80. This organization has shown that it is able to set and reach important goals.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this research is to assess and generalize on the common factors required for successful implementation of Advanced Manufacturing Technology (AMT) projects. From the review of literature presented in Chapter II, those factors that were common success factors across several individual AMT implementations were tallied, and they formed the basis for the factors investigated in the research hypotheses. This chapter describes the procedures used to conduct the study, including the research design, selection of the survey sample, design of the instrument that was used to collect data, the data collection process, and the procedures for analyzing the data.

Research Design

The most desirable research design to be used with a particular research problem depends upon a combination of sampling techniques, the characteristics of the population, survey costs, the allowable complexity of questions, and numerous other factors. The sample for this research represented companies throughout the United States that are known to have implemented Advanced Manufacturing Technology (AMT). Given the available time to complete the study, limited funds, and geographical distribution of the respondents, a mail survey research design was considered to be the most feasible. This research was designed to conduct a survey of organizations in an effort to determine any possible generalizable patterns of success factors occurring across the population surveyed that would tend to move an organization toward its strategic AMT objectives.

The survey was conducted to investigate and obtain information concerning the general lessons that have been learned to date, from the efforts directed at implementing AMT systems in the United States. These lessons could serve as guide posts for future attempts to implement Advanced Manufacturing Technology (AMT) projects. The goal of the survey was to collect data from manufacturing managers and project team members with AMT implementation experience, concerning their views of the resources needed for successful implementation, and the problems facing the implementation process in the different areas addressed within the core organizational system, in alignment with its strategy, and with particular reference to the experiences in their respective organizations. The author believes that the survey sample was representative of the AMT implementation experiences in the United States, and will provide some consensus of experts on the commonalty of factors accountable for successful implementation of AMT. The survey participants were asked to complete a questionnaire with two major sections tailored towards obtaining quantifiable data for subsequent analyses to test stated hypotheses. A detailed discussion of the questionnaire that was developed and used for this study is presented in a separate section later in this chapter.

Wallace [107] presents a discussion of some major weaknesses of the mail questionnaire. Among these are the following: the problems of non-returns, leading to a biased sample; validity of data depends on the willingness of the respondent to provide accurate information; questions may be misinterpreted by respondents without the opportunity for the researcher to offer clarification. Despite those drawbacks, there are several advantages of mail questionnaire. Wallace presents the following advantages: it provides the ability to obtain a large sample with minimal expense; there is an opportunity for wider contact in dispersed geographical locations; it offers the ability to reach people who are difficult to locate and interview; more consideration is permitted in answering questions; there is greater uniformity in the manner in which questions are posed; respondents are given a sense of privacy; and the interviewer effect is lessened, promoting honesty and frankness.

It is commonly believed that the most effective technique for gathering data is through interpersonal contact between an interviewer and a respondent. Dillman [18] points out, however, that face-to-face interviews may not be as successful as they once were, and are becoming prohibitively expensive. He indicates that there is evidence that response rates to face-to-face interviews are on the decline [17], and that refusal rates, especially in connection with research organizations operating from university settings, are on the increase [81]. Due to the problems of locating prospective respondents for face-to-face interviews, costs of conducting research in this mode has skyrocketed. According to ASA [81], in order to raise a 65 percent response rate to 85 percent rate, it would cost about seven times the amount of the original survey. Dillman [18] also points out the difficulty of finding competent interviewers.

Suggestions abound in research literature on how to improve response rate in mail questionnaire design and administration. Among these are: Preliminary contact with members of the sample population [57], an attractive questionnaire design [93], keeping the questionnaire brief [28], using colored stationery [35], official sponsorship of the research [57], personalization of cover letter and other correspondence [17, 28, 29, 57], anonymity and confidentiality [14, 93], incentives (rewards), including return postage along with other token rewards [18, 57], 1983), and follow-up reminders [57].

In designing and administering the questionnaire for this study, the various suggestions for improving response rate were incorporated as much as possible. Efforts were made to minimize the length of the questionnaire, the questions were pretested for clarity, and a pilot study was conducted to further test comprehension of the questions. A complete discussion of the pilot study is presented in a section, later in this chapter. A cordial cover letter that accompanied the questionnaire indicated sponsorship, in this case affiliation with the School of Industrial Engineering and Management in Oklahoma State University (see Appendix C). The cover letter accompanying the questionnaire was printed on the departmental letterhead. Token rewards of tea-bags accompanied the questionnaires, return postage was provided for convenience in returns. A plan was also established for sending follow-up reminders to respondents. As a result of these steps, many problems associated with inadequate sampling frames in mail-out research designs were avoided [18].

Selecting the Survey Sample

The survey sample for this study was selected to be representative of the companies within the United States that are known to have implemented Advanced Manufacturing Technologies (AMTs) as at the time of this study.

A purposive sample was used in a deliberate effort to obtain representative samples [46], by including typical groups of companies that are known to have implemented AMTS. The author believes that a purposive sample represented a more knowledgeable sample for the scope of this study than a randomized approach would. The sample was selected based on the knowledge derived from published literature regarding a variety of AMT project implementation pursuits. Other sources of survey participants were experts who have some "...experiences in assisting several large manufacturing firms in developing their factory modernization programs..." [64, p. 25]. Another source for selecting participants for the study was a list of individual volunteers that has been obtained from presentations relating to this study, made in professional seminars and conferences around the country. In those presentations, the seminar or conference attendees who have operating AMTs were asked to volunteer to participate in the survey for this study. A list of award winners from the Computer and Automated Systems Association (CASA) of the Society of Manufacturing Engineers' (SME) industry Leadership and Excellence in the Application and Development (LEAD) of CIM was also complied for use as a source for selecting companies to be included in the survey sample. The LEAD awards which was first awarded in 1981 is presented yearly to teams that have exhibited outstanding performance in the development and/or use of CIM technology. "It is the highest honor awarded by any organization in the CIM field" (SME News, Oct. 1987, p. 2). One more major source of survey participants selection was the roster of CIM Teams seminar attendees at SME's AUTOFACT '88 conference and exposition held in Chicago in October, 1988.

The individuals that were selected as respondents to the questionnaire were known to have at some time, been actually involved in their company's AMT efforts. It was possible to select these individuals through information in the sources listed above. Participants were selected from organizations that are in business to make profit. A purposive sample of twenty-eight (28) companies was selected for the study. For each company selected to be in the survey sample, efforts were directed at obtaining responses from at least two different individuals, preferably of different academic disciplines, and functions in the implementation group. The intent of this replication was to provide more diverse perspectives to give a more robust picture of each organization's implementation efforts.

Development of the Instrument

The purpose of this study was to conduct an investigation to determine if there common factors across several different AMT projects that tended to account for successful implementation. In order to accomplish the purpose and objectives of the study, a proprietary survey instrument was developed. This section covers the procedures that were carried out in order to develop the questionnaire used to conduct the survey for this study. The factors that were cited by a preponderance of the literature surveyed as success factors were summarized, and formed a basis for the research hypotheses that were tested in this study. The factors selected to be tested in the hypotheses for study were justified based on the strength of literature support. A summary of each hypothesis along with the reference literature support for them and the questions from the questionnaire that were used to collect the information for testing each hypothesis were presented in Chapter II. Once the hypotheses were selected, a set of questions, also supported by referenced literature were formulated tailored toward obtaining information for testing each hypothesis stated. The questions were also backed from appropriate literature sources. Instruments used in surveys of similar magnitude provided significant input into the structuring of the instrument. The questions were designed to solicit the respondents' views of those factors in their organizations that contributed to the level of success attained in their organizations' Advanced Manufacturing Technology (AMT) implementation. The last section of the questionnaire seeks information required to establish the respondent's qualifications to evaluate their AMT implementation. The data obtained by means of the questionnaire are valid when the respondents' qualifications are established. The questions in the questionnaire were a combination of open and close-ended type, designed to permit the respondent to answer with some feeling of confidentiality.

In designing the questionnaire, information was obtained from the review of literature to support the different factors addressed in the hypotheses. The issues delineated from literature concerning each hypothesis made up a general list of questions that became the master list for planning the instrument. The actual questions were then developed from this list. Items from the general list were grouped into the major sections that addressed each of the hypothesis stated for this study. After the questions were written in the desired format, it was necessary to cross-check with the general list, and write in the numbers of the questions that would make up the set addressing each hypothesis. This set would solicit quantifiable information for testing the hypotheses that the set addresses. Comparing the draft copy of the questionnaire with the general list helped to identify and eliminate the gaps and overlaps in the initial questionnaire. This initial document was subjected to a series of tests and revisions to arrive at the final questionnaire. Two stages of questionnaire pre-test and a pilot study were for the revision and testing processes. These processes are discussed in the section on pretesting the questionnaire later in this chapter.

In the final instrument, the opening section asks for general information about the project. This was designed to provide project-specific information for classification of the projects represented in the survey sample on receipt of completed questionnaires. Section II is the Implementation Success Diagnosis (ISD). This section provided the respondents with a list of possible expected outcomes of an AMT project derived from literature search and experience. This list was considered a comprehensive set for the purpose of this study. For each of the outcomes, the respondents were required to indicate with an answer of Yes or No (Y/N) in the space provided whether it was an expected outcome of the particular project being rated or not. The respondents were then expected to proceed to rate all the factors listed, by checking [✓] in the spaces provided, how each factor was affected by the AMT implementation. The rating system was based on the a five-point Likert scale, with the low end indicating that the performance level of that factor actually declined after AMT implementation, and the high end indicating that the expected performance level of that factor was achieved or exceeded. The respondents were given the opportunity to write-in and rate any other factors which they considered important, but were not included in the instrument. The responses to this section was used primarily for clustering the respondents into groups that would be identified as either Successes or Failures depending on the relative levels of accomplishment of strategic objectives set for the project evaluated. A complete discussion of the scoring of the ISD responses for the purpose of clustering the respondents is presented in the following chapter on data analysis. The next major part of the questionnaire (Section III) dealt with the questions addressing the issues concerned with the hypotheses to be tested. The issues in this section dealt with the strategy formulation process, along with the components of the core organizational system - cultural/political system, organizational structure, organizational management process, and the technical system - and how they affect the level of success attained in a given project. As mentioned previously, each hypothesis was represented by a set of questions. These sets were not explicitly shown on the questionnaire. Rather, all the questions were grouped in a single section. The separation of questions into sets representing each hypothesis were done during analysis. Each of the questions in this section was rated on a seven point Likert scale, with the low end being "Disagree Strongly" with the statement addressing an issue relating to AMT implementation in the respondents' individual experiences, and the high end being "Agree

Strongly" with that statement. Given the clustering of respondents as successes or failures using the scores obtained from the ISD, the data collected from this section was used to test if there were significant differences between the two groups in how they approached the issues identified by the questions. This thus enabled data analysis to show what approaches tended to be present successful AMT implementation, as opposed to the less successful efforts. The next section (Section IV) asked some open-ended questions, mainly to allow the respondent to back-up or expand on the issues already covered in the previous sections, and to solicit further input and general AMT implementation related opinions. The last section of the questionnaire (Section V) asked for demographic information on the respondents.

Pretesting the Questionnaire

The questionnaire was pretested twice, and a pilot study was conducted after the second review of the document, and prior to the development of the final form. Participants of the pretest/review group included three professors and seven graduate students, all with some knowledge in different areas of AMT. Two other professors also served as outside consultants providing input regarding the general structure of the instrument. Each question was critiqued using a standardized form (Appendix A) adapted from Leedy [32] and Van Dalen [33]. The participants were asked to give ideas or suggestions for improving the questionnaire. After the necessary adjustments were made, the questionnaire was revised as necessary. The same process was repeated for the second critique and revision. After the second revision, the questionnaire was printed in its final form. Some of the revisions that were prompted by the testing process included rewriting some questions for clarity, rewriting some sectional instructions, and in some areas combining or completely eliminating some questions. Once the necessary editing was completed, the questionnaire was then used in its revised form to conduct a pilot study designed to sample a small group that is somewhat similar to the population to be surveyed. The pilot study group consisted of graduate students who are currently working in the Center for Computer Integrated Manufacturing (CIM Center) at Oklahoma State University, as well as others with some work experience in some area of AMT. The responses to the pilot was analyzed using the methodology described in the data analysis section. Based on the responses and comments from the pilot study, final revisions were made on the instrument, and the final design format adopted and completed prior to sending the questionnaires out to the industrial participants in the study.

Collection of the Data

The collection of data was accomplished through the use of questionnaires mailed to a purposive sampling of manufacturing managers and project team members with AMT implementation experience in selected companies in the United States. A personalized cover letter (Appendix C) to the respondents identifying the purpose of the study as well as its sponsor accompanied the questionnaires. This letter also assured the respondents of confidentiality. Return postage was provided as an incentive for response. A token reward of a one cup pack of tea-bags were enclosed, to symbolize the appreciation of the respondents' time for completing the survey.

McGhee [57] points out that timing of the mailing of the instrument is important in influencing returns. He recommends that the instruments be timed to arrive early in the week. This principle was applied in this study. The questionnaires were initially mailed on a Thursday to ensure that they were received early in the following week. As pointed out earlier, the questionnaires were addressed to the individuals rather than "positions", for example it was addressed to "Tom Smith, The CIM Manager" rather than addressing it simply to "The CIM Manager" in the company. This was expected to show more personalized approach to make sure that the subjects felt more like a part of the study, and stimulate higher response rates [57]. The first follow-up letter (Appendix D) along with a second mailing of the questionnaires were mailed to non-respondents two weeks after the first mailing. The second follow-up (Appendix E), as needed were mailed three weeks following the first follow-up mailings. For the purpose of obtaining the required replications for each project evaluated, in the cases that no more than one respondent was located and contacted initially, the contact persons were asked to further support the study by providing names of other possible respondents from the project evaluated when returning the completed questionnaire. In the cases where the names were sent along the completed questionnaires, those people were contacted following the initial procedure already described, and similar time lines were kept from one set of mailings to the next for the purposes of any required follow-ups. In the instances where no names were supplied as requested, the respondents were contacted, mainly by phone, to obtain the other names, and the mailing procedure was duplicated.

Procedures Used to Analyze the Data

The data collected by the mail questionnaires was tabulated and analyzed statistically. The first section of analysis was the Implementation Success Diagnoses (ISD) section of the questionnaire. The data collected from this section was used in classifying the projects represented in the survey sample as either successes or failures, in order to test the hypotheses for significant differences between the groups. These tests of hypotheses led to conclusions on the factors that were common to successful projects across the spectrum represented by the survey sample. The final output from this section was weighted scores based on the performance of the project, relative to each project's expected outcomes. A detailed coverage of the scoring process is presented in Chapter IV. The projects were grouped into clusters of two and three, and tests were conducted using two groups (successes or failures) in both cases to determine which clustering technique differentiated successes and failures better. Both methods produced similar results, and the two cluster grouping was chosen for the analysis presented in Chapter V. The analyses was performed using the SYSTAT statistical software. Again, a more detailed coverage of the procedure for analyzing the ISD data and clustering is presented in Chapter IV.

Each of the hypothesis stated was then tested using the information obtained from the questions in Section III of the questionnaire. A t-test was appropriate for testing for significant differences in the responses to the set of questions addressing each of the hypotheses. This type of test was adequate because only two groups - two clusters (successes and failures) were dealt with in testing each of the hypothesis. Salsow [85, p. 256] provides a decision tree for selecting suggested statistical tests to meet the requirements of the data to be analyzed. The tree indicated that a two-tailed t-test for independent groups would be appropriate for testing the hypotheses stated for the study, given the fact that the scales used for the questions were specified by the author as interval scales, and only two samples, defined by the author as successes and failures according to the mean scores obtained for each cluster as obtained from a cluster analysis, were used in the tests. Bodwitch and Buono [9, pp. 157-158] indicate that a t-test is appropriate for situations where there are only two samples. They pointed out that this test is one of the most common techniques used for comparison of two groups, by using group means as a basis for comparison. The t-test would indicate whether or not the difference between the two groups is statistically significant. Wilkinson [109] when a sample is small enough (less than 30), a t-test is preferred to a Z-test. A statistical significance level for this test was set at $p < .05$. This significance level was selected to reduce the probability of making type II error. A type II error is the failure to reject the null hypothesis when it is false (Jaccard, 1983). The presentation of the findings, summary, and conclusions were based on the analysis of the data received from the respondents to the survey.

In order to facilitate the complete data analysis, information from the questionnaire was extracted and put into tally sheets, using LOTUS 1-2-3 to facilitate analysis. The questions were mostly rank-ordered, and open-ended. Each possible answer to the rank-ordered question was assigned a weighted number on a scale of one to seven, based on the degree of agreement or disagreement with each question. The total score for each section of the questionnaire, representing a hypothesis was given as the normalized mean of the scores obtained from each question from the set. The scores were then normalized. The normalized score was complied for each project, and the tests conducted established whether or not there were significant differences between the groups for each null hypotheses stated. The response to open-ended questions was grouped by content into categories and presented in its raw state in the appendix (see Appendix F).

CHAPTER IV

EVALUATION AND VALIDATION OF PERFORMANCE SCORING PROCEDURE

Introduction

One of the major tasks that was required in order to test the hypotheses stated for this study was to classify the projects into groups based upon their performance on their projects, relative to the goals set for the project. The aim of this grouping was to differentiate the more successful projects from the less successful ones. This grouping was subsequently used for testing the effects of each of the factors addressed in the hypotheses.

Section II of the survey instrument (Appendix B), Implementation Success Diagnoses (ISD), was designed specifically for collecting the data for use in accomplishing this task of grouping the projects represented in the survey sample into clusters. In this section of the questionnaire, survey participants were asked to respond to a set of questions addressing the desirable outcomes of AMT. For each of the expected outcome listed, the respondents were required to indicate whether or not it was an expected outcome for their project, and then proceed to rate, on a five point Likert scale, their performance on all the expected outcomes listed, indicating how each factor was affected by their AMT project. The task to be accomplished in this chapter is to develop a weighted score of the performance of each project, for use in clustering the projects into groups of either successful or unsuccessful projects.

Weighting, Scoring, and Results of the ISD Data

The data obtained using the Implementation Success Diagnoses (ISD) section of the questionnaire was used for the purpose of classifying projects as either successes or failures based on their performance against the list of possible outcomes for the project. This grouping is required in order to test each of the hypotheses stated for the study. The interpretation of the data in this section involved developing a weighted score for each project in the sample. The score gives an indication of performance against the total scores possible, and thus the relative levels of successes can be assessed for the projects. The projects were then clustered into groups based on the scores obtained. Several scenarios for assigning weights and scoring the projects were tested, using representative test data, in order to come up with an acceptable scoring technique. The test data used was formulated to be representative of the possible combinations of situations that may be encountered when analyzing the real data. This took into account, performances in extreme conditions, as well as ratings factoring in achievement of successes from those factors that were expected outcomes along with those that were not expected outcomes for the project. The scoring methods that were developed/evaluated, along with the reasons for preference of one over the other are covered in the following sections.

Evaluation of Scoring Methodologies

In order to consistently evaluate the scoring methodologies and schemes developed for assessing the performance of the projects represented in the survey, a set of test data was compiled to provide a two-stage test of performance based on scores obtained. The first test, known as the "ordering test", was the primary test, and was used to check conformance of each scheme or scenario attempted to a pre-tested, ordered ranking of data points. This was accomplished by compiling the first ten (10) data points (representing the first ten respondents or projects) such that they would logically rank in descending order from one (1) to ten (10). This data set should rank as described here because they were deliberately chosen to give the achievement levels in percentages that would rank them logically when scored correctly. The achievement level distribution for this data set is presented in Table IV. The percentages are presented in Table V. The scores obtained from each scoring technique was then checked for consistency with this ordered ranking of the first ten data points as a primary criterion for further consideration.

For the purpose of obtaining this rank order for the first ten data points, the possible achievement levels attainable by respondents was restricted to either the highest level of goal attainment available - level 5 (Expected outcomes achieved/Exceeded), and the neutral level - level 2 (No changes in levels after AMT implementation). The reader is referred to Section II of the questionnaire in Appendix B for the complete scales used. These two dimensions of the scale were used so that any proportion of the total expected number of expected outcomes that was not achieved at level 5 was assigned to level 2, and a percentage of the total number of expected outcomes attained at level 5 was obtained. This percentage provides the required ranking for the ordering test. The respondent numbers (R#) with higher percentages based on their actual expected outcomes for the project, should always rank higher than the one with the next lower percentage. The rules for this ranking was such that respondents would score higher points based solely on their actual achievement levels regardless of the number of expected outcomes sought. The scores were normalized such that those who had more expected outcomes did not have an advantage in scoring over those with a lesser number of expected outcomes and vice-versa. A distribution of achievement levels for the first ten data points of the test data, along with their respective total number of expected outcomes is presented in Table IV. The complete listing of the achievement level distribution for the test data is presented in Table V. An illustration of the percentages of factors for which success was achieved at level 5 is presented in Table VI. The first ten data points of the test data were used for the primary "ordering test" for each alternative methodology explored. This was done in order to enable the researcher to inspect each alternative for the right ordinal ranking of those ten points, based on the percentages of expected outcomes obtained at level 5, established by the author.

TABLE IV

DISTRIBUTION OF ACHIEVEMENT LEVELS
FOR TEST DATA

R#	Total # of Expected Outcomes	Levels of Achievement 5	4	3	2	1
1	17	17	0	0	0	0
2	8	8	0	0	9(9)*	0
3	17	15	0	0	2	0
4	8	7	0	0	10(9)	0
5	17	13	0	0	4	0
6	8	6	0	0	11(9)	0
7	17	9	0	0	8	0
8	8	4	0	0	13(9)	0
9	8	2	0	0	15(9)	0
10	17	4	0	0	14	0

* The number in parenthesis represent the number of expected outcomes achieved at the level under which they appear that were not expected outcomes for the project. For example, for R# 4, out of the eight expected outcomes, seven were attained at level 5, and ten were attained at level 2. Nine out of ten expected outcomes attained at level 2 were not expected outcomes for the project.

TABLE V

DISTRIBUTION OF ACHIEVEMENT LEVELS
FOR THE COMPLETE TEST DATA SET

R#	Total # of Expected Outcomes	Levels of Achievement 5	4	3	2	1
1	17	17	0	0	0	0
2	8	8	0	0	9(9)*	0
3	17	15	0	0	2	0
4	8	7	0	0	10(9)	0
5	17	13	0	0	4	0
6	8	6	0	0	11(9)	0
7	17	9	0	0	8	0
8	8	4	0	0	13(9)	0
9	8	2	0	0	15(9)	0
10	17	4	0	0	14	0
11	17	0	17	0	0	0
12	17	0	0	17	0	0
13	17	15	2	0	0	0
14	17	14	0	0	0	3
15	17	13	4	0	0	0
16	17	13	0	4	0	0
17	17	13	0	0	0	4
18	17	13	1	1	1	1
19	17	12	5	0	0	0
20	17	12	0	5	0	0
21	17	12	0	0	0	5
22	17	11	0	0	6	0
23	17	10	0	7	0	0
24	17	9	8	0	0	0
25	17	8	8	1	0	0
26	8	17(8)	0	0	0	0
27	10	12(2)	2(2)	2(2)	1(1)	0
28	12	9	2	2(1)	2(2)	2(2)
29	1	17(16)	0	0	0	0
30	17	4	3	10	0	0

Note:

R# = Respondent/Project Number

Levels of Achievement = Level of Achievement for each ISD Factor as Indicated by Respondent (1 - 5)

*The Number in Parenthesis Represent the Number of Factors Achieved at the Level Under Which They Appear that Were Not Expected Outcomes for the Project.

TABLE VI

PERCENTAGES OF EXPECTED OUTCOMES OBTAINED AT LEVEL 5

R#	Total # of Expected Outcomes	Number Achieved at Level 5	Percent (%)
1	17	17	1.000
2	8	8	1.000
3	17	15	0.882
4	8	7	0.875
5	17	13	0.765
6	8	6	0.750
7	17	9	0.529
8	8	4	0.500
9	8	2	0.250
10	17	4	0.235

With the ordering test established, the scores obtained from each of the scoring methodologies described below was first checked for conformance to this expected ordering for the first ten data points (the "ordering test"). If any scoring scenario failed this test, it was no longer explored as a scoring technique, and was dropped from further consideration. Any scoring technique that passed this test became a candidate for acceptance, and was further tested for consistency with other, intuitively selected, expected ordering of scores. Beyond the first ten data points that were used for the primary ordering test, an additional twenty data points were incorporated, covering a variety of situations. These remaining data points thus served as the secondary testing parameters for checking the consistency of the scores obtained for certain performance ranking combinations relative to the intuitive ordinal ranking of the data points compared. The intuitive ordering were based on the author's intrinsic feeling about how the R#'s should rank based on inspection of the achievement levels between the chosen points. For example, check of scores from Table VI between respondent/ project number (R#) 12, with a total expected outcome of 17 all scored at the third level, and R# 23, with a total expected outcome of 17, with 10 of them scored at level five and 7 scored at level three indicates that intuitively, R# 23 should score better than R# 12. If on inspection, this order was not preserved, that particular combination in the scoring scenario was dropped, and others explored for possibly entering as a candidate for acceptance. Other points of particular appeal were also explored for possible inconsistencies. If a candidate scoring scheme passed all of the tests, it remained as a candidate, and eventually the one that presented the best spacings between comparison points was accepted. The accepted methodology became the one used for scoring the actual survey data for the purpose of clustering the projects represented in the study as either successes or failures.

For all the scoring schemes attempted, the scores were normalized to a maximum normalized score of five for the purpose of equitable cross comparisons across all the methodologies evaluated.

Scoring Scheme Using Every Factor Listed in the ISD as a Comprehensive Set

The first scoring scheme explored involved using all of the factors listed in the ISD as a comprehensive set of desirable outcomes of AMT implementation. With this premise, every respondent would be scored based on all of the factors listed, directly from the ranking (1 - 5) of factors from the questionnaire (Appendix B), regardless of whether or not they were expected outcomes for the project or not. The obvious flaw in this approach was that it would be inconceivable that all the factors would apply to every project equally. Secondly, if the indication of what the expected outcomes for each project were, was considered, the respondents who listed more expected outcomes, even with rather dismal performances in many of the factors listed, tended to always have higher scores as compared to those with fewer expected outcomes, attained at higher performance levels. The following is an example of this situation. The reader is referred again to Table V. From this table, by adding up the scores directly from the questionnaire rating on the Likert scale ranging from one to five, respondent numbers (R#'s) 3, 5, and 7 obtained scores of 79.000, 73.000, and 61.000 respectively; although their percentages of goals achieved at the highest level (5) were 88%, 77%, and 53% respectively, all obtained better scores than R# 2 who had a score of 58, but attained 100% of his/her goals at the highest level. This scoring scheme was dropped because of these flaws.

Scoring Scheme Using Only the Indicated Expected Outcomes

The second scoring methodology considered used only the items that the respondents indicated as expected outcomes for their respective projects. The scores obtained using this scheme was more appealing because it ranked the respondents on the expected outcomes, in agreement with the pre-set ordering of the test data used, as illustrated by the percentages in Table V. One limitation of this approach was that it would tend to favor those projects with a limited number of expected outcomes. For example, a project with five expected outcomes, all achieved at the highest level would always score higher than one with more goals with the same number of expected outcomes or more obtained at the highest level, along with others attained at other lower levels of improvement. A specific case in point is illustrated in scores obtained by taking the mean of the ratings obtained for R#'s 2 and 5 (Table IV) for only those factors that were indicated as expected outcomes. R# 2, by attaining all eight (8) of his/her expected outcomes at level 5, obtained a mean score of 5; whereas, R# 5 attained 13 out of 17 expected outcomes at level 5 and obtained a mean score of 4.294 $(((5 * 13) + (2 * 4))/17)$. One other problem with this approach was that no consideration was given for more ambitious efforts. There would thus be a missing component addressing the "other factors" that may be attributable to successful AMT implementation efforts in this approach.

Establishment of Weights for Different Performance Levels Using the Preference Matrix

The third methodology for scoring the performance of respondents involved establishing weights to be assigned to the different performance level rankings (1 - 5), taking into consideration whether the achievement level attained by a particular fact or was based on a planned expected outcome or on serendipity. A preference matrix was established, on which the user/decision maker can indicate his/her preference of one performance level over the others in a given row. The preference of one performance over others were based on the author's intrinsic placement of values for each performance achievement level, and may differ between users of the matrix. The preference was then recorded as either a one (1) for the preferred level on that row, or a zero (0) for others. In the cases where the author was indifferent between two or more performance achievement levels, as was the case for X_{13} and X_{04} (Table VII), each of the achievement levels were given a score of 1, and all others a score of 0. After all the possible choices had been made, the points in each column representing a performance level were added up and the sum divided by the total points possible for each column (45). The number obtained from this exercise constituted the weight of the performance level represented by that column. The weights from all the columns would sum to one (1) if there were no ties anywhere within the matrix, or a little greater than one in the event of at least one tie. The weights obtained were then used to compute the scores, incorporating all the factors rated in the ISD section. The complete preference matrix used to obtain the weights that was utilized in scoring respondents' performances with this technique is presented in Table VII. The notations used in Table VII are presented below:

X_{1i} = An expected outcome attained at level i, (i=1-5)

X_{0j} = A non-expected outcome attained at level j, (j=1-5)

TABLE VII

PREFERENCE MATRIX

X_{15}	X_{14}	X_{13}	X_{12}	X_{11}	X_{05}	X_{04}	X_{03}	X_{02}	X_{01}
1	0								
1		0							
1			0						
1				0					
1					0				
1						0			
1							0		
1								0	
1									0
	1	0							
	1		0						
	1			0					
	1				0				
	1					0			
	1						0		
	1							0	
	1								0
		1	0						
		1		0					
		0			1				
		1				1			
		1					0		
		1						0	
		1							0
			1	0					
			0		1				
			0			1			
			0				1		
			0					1	
			1						0
				0	1				
				0		1			
				0			1		
				0				1	
				0					1
					1	0			
					1		0		
					1			0	
					1				0
						1	0		
						1		0	
						1			0
							1	0	
							1		0
								1	0
0.2	.1778	.1333	.0444	0.0	.1556	.1333	.0889	.0667	.0222

From Table VII, it can be seen that the maximum weight attainable from this scheme was 0.2 since this value is the sum of scores obtained for X_{15}. In order to scale the weights up to the maximum level of five (5) used in the alternatives already discussed, all the weights were multiplied by 25, bringing the maximum weight to 5, and upscaling all others by the same factor. This was done for the purpose of parity in comparison between the alternatives as explained earlier. The weights that were derived from the preference matrix presented in Table VII, and used for the analysis are summarized in Table VIII.

TABLE VIII

WEIGHTS GENERATED FROM PREFERENCE MATRIX

ISD Score	Weight (if Expected Outcome)	Weight (if not Expected Outcome)
1	0	0.5555
2	1.1111	1.6675
3	3.3325	2.2225
4	4.4450	3.3325
5	5.0000	3.8900

The weights obtained from this weighting scheme, when used in scoring performances, was consistent with the expected ordering of the test data and was thus an acceptable choice for application in scoring the actual survey data.

Establishment of Weights Using a Linear Programming Formulation Based on Rating Equivalence

The fourth and final methodology used for scoring each project's performance based upon ISD rating also involved assigning weights to the factors based on the performance level, and on whether or not the factor was an expected outcome for the project. The only difference between the previous approach described and this one was in the methodology used for assigning the weights. The assignment of weights for this method was based on the establishment of equivalence between an anchor value for a given performance level, and the other levels of performance. In this process, an anchor value for one level of performance was set, and from that value, different distances were established to the other respective levels of performance in order to equate them to the anchor value. For the weights generated using this method, the anchor value was set at 1 for a factor that was an expected outcome of the project and rated at level five is given the notation, (X_{15}). The other levels of performance were then related to this benchmark with coefficients to indicate their distances. Several distances from the anchor value were attempted, based on the intuitive evaluation of the required distances. These were subsequently tried on the equivalence matrix (Table IX) in order to come up with distances that would provide a reasonable scoring of performances. Several trial runs using different combinations of coefficients representing the distances from the anchor value were attempted, and for each trial run, the Linear Programming (LP) formulation was run, and the resulting output examined for consistency with the logical weighting of performance levels. Each run then served as input for further evaluation, and subsequent improvement on the assigned coefficients within the equivalence matrix. This matrix was thus continually improved based on the input of the previous run until coefficients were found that provided the desired distances in the weights assigned at each performance level. The final output from this procedure was the equivalence settings used for this analysis, which is presented in Table X. As shown on the LP formulation given, some of the variables in the model were assigned fractional coefficients. This was necessary in order to obtain a reasonable optimal solution. Several trial runs using strictly whole numbers failed to produce reasonable results, and after several trial runs, the model presented in Table XI was derived. Once established, these settings were used to fine-tune the equivalence matrix (Table IX). This matrix was, in turn, used to formulate an LP model which was run on the microcomputer version of LINDO [54]. The LP model input along with the output showing the different values at the different performance levels are presented in Table XI. The values from the LP solution were then used to score the performance of the test scores. After several tests, the chosen equivalence setting gave the most reasonable scoring of performances. Again for the purpose of parity in comparison between the alternatives, the maximum value attainable (X_{15}) was set at 5, as a constraint in the LP model, and every other variable was thus comparatively weighted.

TABLE IX

EQUIVALENCE MATRIX

X_{15}	=	X_{15}	X_{14}	X_{13}	X_{12}	X_{11}	X_{05}	X_{04}	X_{03}	X_{02}	X_{01}
16	=	15		4							
16	=	15					2				
16	=	14		4			2				
16	=	14			7	9					
16	=	13	4/3					4			7
16	=	12	4	4							
16	=	12	4/3				2		5	6	
16	=	11	4		7	9					
15	=	14		4							
15	=	13					2				7
15	=	12	4								
15	=	11	4/3		7			4		6	
15	=	10	4/3	8			2		5		
14	=	12				9	2				
14	=	11		4				4		6	
14	=	10	4						5		
14	=	9	4	4			2				
14	=	8		4	7	9	2	4	5		
14	=	7	4/3	4	7		2	4		6	7

Note: The numbers below each performance level (X1i, X0j) represents the combination of coefficients of the factors that would be required in order to equate them to the left-hand side (LHS) of the equation - the overall performance at the benchmark represented by the LHS.

The weights generated by the LP model presented in Table XI are summarized in Table XII.

TABLE X

EQUIVALENCE SETTINGS

$$X_{15} = X_{15}$$

$$4/3X_{14} = X_{15}$$

$$4X_{13} = X_{15}$$

$$7X_{12} = X_{15}$$

$$12X_{11} = X_{15}$$

$$2X_{05} = X_{15}$$

$$4X_{04} = X_{15}$$

$$6X_{02} = X_{15}$$

$$8X_{01} = X_{15}$$

Where:

X_{1i} = Expected outcome attained at level i

X_{0i} = Non-expected outcome attained at level i

TABLE XI

A LINEAR PROGRAMMING MODEL USED
TO GENERATE SCORING WEIGHTS

```
MAX      X15 + X14 + X13 + X12 + X11 + X05 + X04 + X03 + X02 + X01
SUBJECT TO
        2)   2 X15 - 1.333333 X14 - 7 X12 >=   0
        3) - X15 + 4 X13 <=   0
        4) - X15 + 2 X05 <=   0
        5) - 2 X15 + 4 X13 + 2 X05 <=   0
        6) - 2 X15 + 7 X12 + 9 X11 <=   0
        7) - 3 X15 + 1.333333 X14 + 4 X04 + 7 X01 <=   0
        8) - 4 X15 + 4 X14 + 4 X13 <=   0
        9) - 4 X15 + 1.333333 X14 + 2 X05 + 5 X03 + 6 X02 <=   0
       10) - 5 X15 + 4 X14 + 7 X12 + 9 X11 <=   0
       11) - X15 + 4 X13 <=   0
       12) - 2 X15 + 2 X05 + 7 X01 <=   0
       13) - 3 X15 + 4 X14 <=   0
       14) - 4 X15 + 1.333333 X14 + 7 X12 + 4 X04 + 6 X02 <=   0
       15) - 5 X15 + 1.333333 X14 + 8 X13 + 2 X05 + 5 X03 <=   0
       16) - 2 X15 + 9 X11 + 2 X05 <=   0
       17) - 3 X15 + 4 X13 + 4 X04 + 6 X02 <=   0
       18) - 4 X15 + 4 X14 + 5 X03 <=   0
       19) - 5 X15 + 4 X14 + 4 X13 + 2 X05 <=   0
       20) - 6 X15 + 4 X13 + 7 X12 + 9 X11 + 2 X05 + 4 X04 + 5 X03 <=   0
       21) - 7 X15 + 1.333333 X14 + 4 X13 + 7 X12 + 2 X05 + 4 X04 + 6 X02
      + 7 X01 <=   0
       22)    X15 - X14 >=   0
       23)    X14 - X13 >=   0
       24)    X13 - X12 >=   0
       25)    X12 - X11 >=   0
       26)    X05 - X04 >=   0
       27)    X04 - X03 >=   0
       28)    X03 - X02 >=   0
       29)    X02 - X01 >=   0
       30)    X15 =    5
END
```

TABLE XII

WEIGHTS GENERATED USING LP MODELING OF EQUIVALENCE

ISD Score	Weight (if Expected Outcome)	Weight (if not Expected Outcome)
1	0.416667	0.625000
2	0.714286	0.833333
3	1.250000	1.000000
4	3.750000	1.250000
5	5.000000	2.500000

Formulation for Using the Weights Established From the Preference Matrix and LP Formulation for Scoring Projects

The scores obtained using the weights from the last two alternative approaches incorporated two components of performance. The first component comprised the goal-driven attainment of the indicated performance level, and the second component handled the serendipitous attainment of the indicated performance level. The basic idea in both weighting techniques was to reward success and penalize failures. The rewards for goal-driven successes were set higher than that for serendipitous successes, and the penalties for failures in those factors that were objectives for the project were considerably higher. The objective of this weighting technique was to achieve dominance of the final score by the ratings from those factors that were expected outcomes of the project, while also adequately accounting for those other factors that would tend to contribute to successful AMT implementation efforts. The weighting concept used is rooted in the fundamental theorem of utility, which has to do with preferences, and is tailored to guarantee the ability to assign a score to each project evaluated so that, for any two alternate projects, one is preferred to the other if and only if the score of the first is greater than the score of the second (Fishburn, 1970).

In both the cases the preference matrix and the LP model anyone using them has the freedom of selecting their preference levels, and in both cases, either the matrix or the LP model can be easily updated to accommodate those changes, and new weights derived.

The formula that was used to obtain the score of each project's performance for both methodologies is as follows:

$$\text{Score} = \left[100 * [(1/17 \sum_{e=1}^{17} W_e] \right] , \text{ if } N = 17$$

$$= \left[(95/N) \sum_{e \in N} W_e + (5/M) \sum_{x \in M} W_x \right] , \text{ if } N < 17$$

Where:

W_e = Weights assigned to factors that were expected outcomes for the project at the different levels of goal attainment

W_x = Weights assigned to factors that were not expected outcomes for the project at the different levels of goal attainment

N = Total number of factors indicated and rated by respondents as expected outcomes for the project (1 - 17)

M = Total number of factors rated by respondents that were not expected outcomes of the project (0 - 16)

N + M = 17

The weights of 95 and 5 assigned to the normalized components of the score representing the factors that were expected outcomes, and those that were not respectively, are assigned to preserve the order of scores, based predominantly on goal-driven attainment of different levels of successes in cases where N < 17. The assigned order preserving weights implied that 95% of the total score obtained was contributed by ratings of factors that were expected outcomes for the project, and 5% was contributed by ratings of factors that were not expected outcomes for the project. Prior to establishing the 95/5 weight combination that was finally used in scoring the test data, sensitivity tests were conducted using weight combinations of 80/20, 85/15, 90/10, 95/5 and 96/4. The weight combinations of 80/20, and 85/15 failed the ordering test using the test data with weights obtained from the preference matrix. Weight combinations of 90/10, 95/5, and 96/4 passed the ordering test using this scenario, and were thus candidates for acceptance. However, when using the weights generated from the LP formulation, only the weight combinations of 95/5 and 96/4 passed the ordering test. The weight combination of 90/10 was thus eliminated as a candidate for further consideration. In comparing the two surviving candidates, it was observed that the 95/5 weight combination gave a more reasonable ranking. It would therefore more accurately reflect the ranking of data from the questionnaire such that for any two given respondents, the one with the higher score will always be ranked higher than the second. This combination was thus used for obtaining the scores in the rest of the analysis. A cluster analysis was then run to group respondents into clusters using the scores obtained. This was accomplished using the SYSTAT statistical software [109]. Two and three clusters were obtained for the purpose of adequately separating the successful projects from the unsuccessful ones. The clusters of projects obtained from the analysis were subsequently designated by the author as successes or failures. These definitions were made, based on the mean scores obtained for each cluster. The cluster with the highest mean score was defined as the successful group of projects, and the cluster with the lowest mean score was defined as the unsuccessful group of projects. A listing showing the clusters of two and three groups, obtained for the test data using the weights obtained from the LP formulation is presented in Tables XIII and XIV respectively.

TABLE XIII

TWO CLUSTERS GENERATED FOR THE SAMPLE DATA

SUMMARY STATISTICS FOR 2 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
LPDATA	208337.916	1	70451.786	28	82.801	0.000

CLUSTER NUMBER: 1

CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
1	77.09	LPDATA	345.59	422.91	500.00	44.32
2	35.42					
3	26.67					
4	12.79					
5	23.75					
6	61.01					
11	47.91					
13	62.38					
14	3.80					
15	47.67					
16	11.15					
17	30.76					
18	4.50					
19	40.32					
20	33.21					
21	57.72					
22	74.17					
23	77.33					
24	18.26					
25	3.80					
26	52.09					
27	41.85					
28	11.96					
29	52.09					

CLUSTER NUMBER: 2

CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
7	83.74	LPDATA	125.00	214.58	298.32	62.34
8	50.90					
9	45.53					
10	42.31					
12	89.58					
30	42.78					

TABLE XIV

THREE CLUSTERS GENERATED FOR THE SAMPLE DATA

SUMMARY STATISTICS FOR 3 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
LPDATA	241162.054	2	37627.648	27	86.524	0.000

CLUSTER NUMBER: 1

CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
1	60.34	LPDATA	389.71	439.66	500.00	33.23
2	18.68					
3	9.92					
4	29.54					
5	40.50					
13	45.64					
14	20.54					
15	30.93					
16	27.89					
17	47.50					
18	21.24					
19	23.58					
20	49.95					
24	1.52					
25	20.54					
26	35.34					
27	25.10					
28	28.70					
29	35.34					

CLUSTER NUMBER: 2

CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
6	34.71	LPDATA	257.35	327.20	375.00	43.67
7	28.88					
8	61.72					
11	47.80					
21	38.00					
22	21.54					
23	18.39					
30	69.84					

CLUSTER NUMBER: 3

CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
9	13.61	LPDATA	125.00	155.44	172.27	21.56
10	16.83					
12	30.44					

Summary of Evaluation and Validation Procedures

In order to classify participating projects into groups as either successful or unsuccessful projects, for the purpose of performing the necessary tests for the hypotheses stated for the study, a scoring technique had to be developed. The scores obtained from this technique were then used in a cluster analysis to obtain the desired groups. Four (4) scoring methodologies were were developed for scoring the participants' performances, based on ISD data. An evaluation process for each of the techniques developed involved performing a primary ordering test of a portion of the test data, followed by secondary tests for consistency of scores between some hypothetical data points. Validity of a scoring technique was determined by its performance on both the primary test, as well as the secondary tests. The chosen tests were further refined using sensitivity tests prior to final acceptance for application in scoring the entire test data. The scores obtained by using the chosen methodology serves as input to a cluster analysis for desired grouping of projects. The clusters obtained from the analysis were then defined as either successes or failures depending on the mean scores obtained from each cluster. This definition of groups was done to obtained the grouping required in order to conduct the required tests for each of the hypotheses. A two-tailed t-test for independent groups, with a between-groups design was used, with a 95% confidence interval.

CHAPTER V

PRESENTATION AND ANALYSIS OF DATA

Introduction

The purpose of this study was to survey Advanced Manufacturing Technology (AMT) project implementations in U. S. companies, to obtain the necessary data to analyze the possible commonalities in success factors across several AMT implementations. This would take into account, the complex relationships that is required between strategy formulation and the core organizational systems, in order to attain their effects relative levels of successes in those projects. This was achieved by reaching a consensus among the participants on the relative importance of the factors addressed by each hypothesis, based on their AMT implementation experiences. This was accomplished through the use of mail questionnaires. This chapter is devoted to the presentation and analysis of the data, and relating it to the null hypotheses. Topics covered in this chapter includes: Questionnaire return rates, results of the data pertaining to each of the sections in the questionnaire, and the summary. Additional information obtained through the open-ended questions are presented in Appendix F.

Questionnaire Return Rates

The survey sample for this study consisted of a total of 97 knowledge workers that have been involved in the planning and/or implementation of their company's AMT projects. The initial mailing of the questionnaire was made on February 22, 1989, to an initial group of 80 respondents. Among this group were replications of at least two people from each project. In those cases where no more than one name could be obtained by the time for the initial mailing, the individuals contacted were asked to supply names of at least two more people who were involved in the planning and/or implementation of the project evaluated in the questionnaire. This was to enable contact with those people directly. At the time of the initial mailing of the instruments, three dates were designated as accounting and corresponding times. These were the times established for keeping records of the questionnaires returned, and sending letters of reminders or replacement questionnaires to non respondents as necessary.

As at the first designated accounting time, two week after the initial mailing, 12 questionnaires, representing 15 percent of the total mailed were returned. At this time the first reminder with a second mailing of the instrument was sent to those participants that had not replied at that time. Out of those that had responded, six additional names were provided. Questionnaires were mailed to those people, and the date recorded for possible follow-up mailings in line with the established time lines.

The second accounting and correspondence date was five weeks after the initial mailing, and three weeks after the first follow-up. At this time, an additional twenty-three questionnaires, representing 29 percent of the total mailed, and 34 percent of the non-respondents, as of the first accounting date, were received. At this time it was necessary to send a second reminder to the last remaining non-responding participants. Eleven additional names were supplied with these returns. The names that were sent in for the required replications of responses were handled on a similar time table as the initial mailings, starting from the day of receipt of the names and correct mailing addresses. Six questionnaires were returned that were not completed. A note that accompanied one of the incomplete questionnaires explained that all the projects at that division were "confidential projects" and hence they could not complete the questionnaire. Two other respondents indicated that their company does not want to participate in the study. One of the non completed returns indicated that they did not at that time have projects that the survey would apply. One more explanation for the non completed questionnaire was that the proposed respondent had moved from the location mailed to which the survey was mailed at an early stage in their project, and would not have enough information to complete the questionnaire. The total number of questionnaires finally sent out was 97. A total of 49 (50.52%) questionnaires were returned. The total number of subjects finally used (usable return rate) was 43 out of 97 (44.33%). Twenty-eight projects were represented in this sample.

Demographic Data

This presents the demographic data of the respondents who participated in this study. The data obtained from this section of the questionnaire was not intended to serve as a particular variable or set of variables in the analysis, but rather to provide a general background information on the respondents. This was only intended to give the researcher some idea about the validity of the information obtained. A summary of the demographic data of respondents is presented in Table XV.

The geographical distribution of the projects represented in the sample, by states, is presented in Table XVI.

The industries represented in this study fall into the general industrial classification of transportation equipment, electrical and electronics, and industrial metal working. These groups of industries were selected because the nature of the production processes make them the most likely users of AMT [58].

TABLE XV

RESPONDENTS DEMOGRAPHIC DATA

	Group I (Successes) Percentages (%)	Group II (Failures) Percentages (%)
Number of Years in current position		
Less than 1	6.67	00.00
1 to 3	36.67	50.00
4 to 7	40.00	25.00
8 to 12	0.00	25.00
12 to 16	6.67	0.00
Over 16	10.00	0.00
Level of Formal Education Completed		
High School	0.00	0.00
Some College	6.67	0.00
Bachelors Degree	50.00	62.50
Graduate Degree(s)	43.33	37.50
Total Number of Years of Experience in this Technology Area		
Less than Two	13.33	0.00
2 to 5	13.33	37.50
6 to 9	20.00	25.00
10 to 13	10.00	25.00
14 to 17	6.67	12.10
Over 17	43.33	0.00
Have you been Involved in Your AMT operation Lately?		
YES	70.00	37.50
NO	30.00	62.50

TABLE XVI

GEOGRAPHICAL DISTRIBUTION OF PROJECTS SURVEYED: BY STATES

Location of the Project (State)	Number of Projects From Each State
Arizona	2
California	3
Colorado	1
Florida	1
Georgia	1
Illinois	1
Indiana	1
Louisiana	1
Michigan	1
New Jersey	1
New York	3
Ohio	1
Oklahoma	1
Pennsylvania	3
Texas	4
Utah	1

Results of the Data Pertaining to Each of the Hypotheses

The analysis presented in this section was conducted to test for any possible general patterns that the factors tested in the null hypotheses would appear to influence the performances of groups of projects in the survey sample. t-Test was used to test each of the hypothesis with the significance level set at $p < .05$. The data results of the analyses are presented in summary tables. In each of the hypotheses tested, if the p value obtained in the analysis was greater than .05, the null hypotheses failed to be rejected. If the p value computed for the factor tested was less than .05, the null hypotheses was rejected. These, along with other pertinent statistics are summarized in the discussion of the results of the analysis for each hypotheses, presented in the next section.

Results of the Analyses

An analysis of each hypothesis test is presented in this section. In each analysis, the hypothesis is restated; the set of questions, from the questionnaire, that was used to obtain the information from respondents for testing the hypothesis is reproduced; the statistics is provided; and the implications of the results of the test is given.

In the the statistics presented for each hypothesis presented in this section, either a pooled or separate variance is specified. Separate variance statistics uses the separate variances within groups to compute its error, while the pooled variance statistics uses the pooled within-groups variance, as in the analysis of variance (ANOVA) [109].

In order to choose the right "t" formula, it is necessary to know the sample sizes, variances, and if the samples are related. In choosing the correct formula, it is fairly easy to determine if the sample sizes are equal. The numbers in each sample are either the same or they are not. However, to determine if the variances are homogeneous, Hartley's test for homogeneity of population variances [69, pp. 415-416] was used. The formula for Hartley's test is as follows:

$$F = S^2_{max} / S^2_{min}$$

Where: S^2_{max} and S^2_{min} are the largest and smallest variances of groups.

The calculated F value was compared to F table value at the 0.05 significance level with $N_1 - 1$ and $N_2 - 1$ degrees of freedom. If the calculated value was greater than or equal to the table value, then $S_1 \neq S_2$; if the calculated value was strictly less than the table value, then $S_1 = S_2$. This test was conducted for each of the hypothesis, and the results determined the set of statistics used for interpretation of the results. The statistics used are recorded for each analysis.

Hypothesis #1

The degree of effectiveness in aligning the core organizational systems with the corporate strategy will not be a significant factor in differentiating successful and unsuccessful organizations in their efforts to implement AMT.

Questions Used:

1. This organization had an overall corporate statement of objectives for its Advanced Manufacturing Technology (AMT) efforts, within which the plan for this particular AMT implementation was specified.

2. This organization adequately assessed the prevailing values and attitudes in the firm, in selecting its methodology for achieving the desired goals from this Advanced Manufacturing Technology (AMT).

3. This organization's scheme of events directed at achieving the desired outcomes of this Advanced Manufacturing Technology (AMT) fits the general technological patterns that I am familiar with.

4. In its plans for achieving the desired goals from this Advanced Manufacturing Technology (AMT), this organization adequately assessed its organizational structure, and made the adjustments required in order to reach those goals.

5. This organization made any organizational structure changes necessary for transition to the Advanced Manufacturing Technology (AMT) environment prior to implementation.

6. This organization had a strategic focus for its Advanced Manufacturing Technology (AMT) which increased cohesion within the AMT implementation organization.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 3.076$, $df = 26$, $p = 0.005$).

Successes: ($\bar{X} = 5.230$, $R = 6.333 - 3.500$, $S = 0.699$).

Failures: ($\bar{X} = 4.120$, $R = 4.833 - 2.000$, $S = 1.069$).

Result of the Hypothesis Test:

Rejected the null hypothesis

Implications:

The degree of alignment of the core organizational systems with the corporate strategy was statistically significant for differentiating between successful and unsuccessful AMT implementation efforts.

Hypothesis #2

The degree of effective alignment of employee attitudes with the corporate strategy will not be a significant factor in differentiating successful and unsuccessful AMT implementation efforts.

Questions Used:

7. The reward system in this organization recognized individual efforts to attain the desired goals from this Advanced Manufacturing Technology (AMT).

8. The reward system in this organization recognized group efforts to attain the desired goals from this Advanced Manufacturing Technology (AMT).

9. This organization's top management provided continual motivation, and rewarded compliance with the Advanced Manufacturing Technology (AMT) philosophy.

10. Top management's evaluation of middle management considered performances that reflect the positive effects of change resulting from the Advanced Manufacturing Technology (AMT) implementation.

11. This organization's top management provided adequate incentives for middle and operational management staff to support the Advanced Manufacturing Technology (AMT) program.

12. This organization's top management provided adequate incentives for labor groups to support our Advanced Manufacturing Technology (AMT) efforts.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 0.020$, $df = 26$, $p = 0.984$).

Successes: ($\bar{X}$ = 4.637, R = 6.000 - 2.833, S = 0.779).

Failures: ($\bar{X}$ = 4.630, R = 5.667 - 3.611, S = 0.859).

Result of the Hypothesis Test:

Failed to reject the null hypothesis

Implications:

The degree of alignment of employee attitudes with corporate objectives was not significantly different between successful and unsuccessful AMT implementation efforts.

Hypothesis #3

The strategy formulation process will not be significant in differentiating successful and unsuccessful AMT implementation efforts.

Questions Used:

13. This organization's strategy formulation process explicitly includes consideration of implementation issues such as required reorganizations, staffing changes, modifications to systems and policies.

14. The key middle managers in this organization usually have a chance to review and comment on proposed strategies before resources are allocated.

15. Strategic proposals are usually critically discussed and consensus reached prior to acceptance in this organization.

16. There is a corporate staff support group for strategy formulation within this organization.

17. This organization usually has a formal system for internally reviewing strategic proposals.

18. This organization's Advanced Manufacturing Technology (AMT) efforts were designed to support its strategic business objectives.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 2.742$, $df = 26$, $p = 0.011$).

Successes: ($\bar{X}$ = 5.013, R = 6.167 - 3.333, S = 0.757).

Failures: ($\bar{X}$ = 4.019, R = 5.167 - 3.167, S = 0.757).

Result of the Hypothesis Test:

Rejected the null hypothesis

Implications:

Successful projects did a better job of addressing implementation issues in their strategy formulation, and this was a significant factor for differentiating between successful and unsuccessful AMT implementation efforts.

Hypothesis #4

An organization's position along the organic - mechanistic dimension will not make a significant difference in the degree of success attained in their efforts to implement Advanced Manufacturing Technology (AMT).

Questions Used:

19. This organization has clear rules and regulations that everyone is expected to follow closely.

20. Policies in this organization are reviewed by the people they affect before being implemented.

21. Everyone in this organization knows who his/her immediate supervisor is. Reporting relationships are clearly defined.

22. Jobs in this organization are clearly defined; everyone knows exactly what is expected of him/her in any specific job position.

23. All decisions in this organization must be reviewed and approved by upper level management.

24. Standard activities in this organization are always covered by clearly outlined procedures that everyone is expected to follow.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 0.234$, $df = 26$, $p = 0.817$).

Successes: ($\bar{X} = 4.657$, $R = 5.833 - 2.667$, $S = 0.902$).

Failures: ($\bar{X} = 4.750$, $R = 5.833 - 3.833$, $S = 0.689$).

Result of the Hypothesis Test:

Failed to reject the null hypothesis

Implications:

An organization's position along the organic - mechanistic dimension was not statistically significant for differentiating between successful and unsuccessful AMT implementation efforts.

Hypothesis #5

The nature of the relationship between the technology supplier and the user firm will not be significant in differentiating successful and unsuccessful AMT implementation efforts.

Questions Used:

25. This organization formed an implementation team with the Advanced Manufacturing Technology (AMT) supplier at the project site during its AMT project implementation.

26. This organization established a long term, mutual commitment with the Advanced Manufacturing Technology (AMT) supplier to support the integration the new technology in our plant.

27. There were key people from the Advanced Manufacturing Technology (AMT) supplier firm who worked very closely with our project team in the efforts to implement the AMT in our plant.

Statistics: Two-tailed t-test for independent groups; separate variances. ($t = 0.294$, $df = 20.02$, $p = 0.772$).

Successes: ($\bar{X} = 4.765$, $R = 7.000 - 1.000$, $S = 1.526$).

Failures: ($\bar{X} = 4.889$, $R = 6.000 - 4.333$, $S = 1.655$).

Result of the Hypothesis Test:

Failed to reject the null hypothesis

Implications:

The nature of the relationship between the technology supplier and the user firm was not statistically significant for differentiating the more successful AMT implementations from the less successful ones.

Hypothesis #6

The existence of an AMT champion will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Questions Used:

28. This organization allowed people with ambition and desire (regardless of their rank in management) to lead in the implementation of this Advanced Manufacturing Technology (AMT) project.

29. There was a key person from this organization who worked extremely hard at building a team to integrate the Advanced Manufacturing Technology (AMT) in our plant.

30. There was a key person from the technology supplier firm who worked extremely hard at building a team to integrate the Advanced Manufacturing Technology (AMT) in our plant.

31. The project leader for the Advanced Manufacturing Technology (AMT) implementation had a deep commitment and desire to succeed in the AMT implementation.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 1.612$, $df = 26$, $p = 0.119$).

Successes: ($\bar{X} = 5.405$, $R = 6.750 - 4.000$, $S = 0.723$).

Failures: ($\bar{X} = 4.861$, $R = 6.000 - 3.750$, $S = 0.779$).

Result of the Hypothesis Test:

Failed to reject the null hypothesis

Implications:

The existence of an AMT champion was not statistically significant for distinguishing between successful and unsuccessful AMT projects.

Hypothesis #7

The position of the AMT champion in the organization will not make a significant difference between successful and unsuccessful AMT projects.

Questions Used:

32. The project manager was the key person who "championed" this organization's Advanced Manufacturing Technology (AMT) efforts.

33. The person who directed our AMT implementation efforts was in a key management position.

34. The person who directed our Advanced Manufacturing Technology (AMT) efforts, controlled the resources necessary for implementing the project.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 1.806$, $df = 26$, $p = 0.428$).

Successes: ($\bar{X} = 5.353$, $R = 7.000 - 3.000$, $S = 1.205$).

Failures: ($\bar{X} = 4.962$, $R = 6.000 - 3.889$, $S = 0.880$).

Result of the Hypothesis Test:

Failed to reject the null hypothesis

Implications:

The position of the AMT project in the organization was not statistically significant for distinguishing between successful and unsuccessful AMT projects.

Hypothesis #8

The existence of an employee educational program prior to AMT implementation will not be a significant factor in distinguishing between successful and unsuccessful AMT implementation efforts

Questions Used:

35. This organization had a comprehensive educational program to communicate to all employees, the reasons for necessary changes related to the Advanced Manufacturing Technology (AMT) prior to actual installation of the system.

36. This organization had an educational program for top-level managers, focusing on the Advanced Manufacturing Technology (AMT) to be implemented prior to the actual installation of the system.

37. This organization had an educational program for middle managers, focusing on the Advanced Manufacturing Technology (AMT) to be implemented prior to the actual installation of the system.

38. This organization had an educational program for operations personnel, focusing on the Advanced Manufacturing Technology (AMT) to be implemented prior to the actual installation of the system.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 2.371$, $df = 26$, $p = 0.025$).

Successes: ($\bar{X} = 4.530$, $R = 6.500 - 2.000$, $S = 1.251$).

Failures: ($\bar{X} = 3.250$, $R = 4.250 - 2.000$, $S = 1.358$).

Result of the Hypothesis Test:

Rejected the null hypothesis

Implications:

The existence of an employee educational program prior to AMT implementation was significant for distinguishing between successful and unsuccessful AMT implementation efforts.

Hypothesis #9

The degree of availability of hands-on training program for employees after the installation of the AMT system will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Question Used:

39. This organization had a comprehensive hands-on training program to introduce the Advanced Manufacturing Technology (AMT) to the employees after the actual installation of the system.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 0.772$, $df = 26$, $p = 0.447$).

Successes: ($\bar{X} = 5.492$, $R = 6.000 - 3.000$, $S = 1.117$).

Failures: ($\bar{X} = 5.111$, $R = 6.000 - 3.667$, $S = 0.861$).

Result of the Hypothesis Test:

Failed to reject the null hypothesis

Implications:

The degree of availability of hands-on training program for employees after the installation of the AMT system was not statistically significant for differentiating between successful and unsuccessful projects.

Hypothesis #10

The degree of top-down planning and bottom-up implementation in an organization will not be a significant factor for distinguishing between successful and unsuccessful AMT implementation efforts.

Questions Used:

40. This organization has a broad corporate plan for its Advanced Manufacturing Technology (AMT) scheme, which provides guidelines for individual projects.

41. The process for developing this organization's Advanced Manufacturing Technology (AMT) implementation plan incorporated employee participation to feed information from the shop floor back to upper management.

42. The overall plan for integrating this Advanced Manufacturing Technology (AMT) into the organization was carried out by upper level management, and the information was passed downward.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 3.905$, $df = 26$, $p = 0.000$).

Successes: ($\bar{X} = 4.609$, $R = 6.000 - 3.000$, $S = 0.726$).

Failures: ($\bar{X} = 3.222$, $R = 4.667 - 2.333$, $S = 0.935$).

Result of the Hypothesis Test:

Rejected the null hypothesis

Implications:

The degree of to which organizations had a corporate plan for the overall AMT implementation scheme, which provided guidelines for individual projects, with each project implementation being executed by individual project groups was significant in distinguishing between successful and unsuccessful AMT implementation efforts.

Hypothesis #11

The pace of implementation will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Questions Used:

43. This organization took a step-wise approach to adapt and implement the Advanced Manufacturing Technology (AMT) project incrementally in programmed phases.

44. This organization rushed the implementation of each phase of its Advanced Manufacturing Technology (AMT) program.

45. The pace at which our Advanced Manufacturing Technology (AMT) was implemented was so slow that the initial zeal that pushed the project along in its earlier stages was lost.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 2.441$, $df = 26$, $p = 0.022$).

Successes: ($\bar{X} = 4.971$, $R = 7.000 - 3.333$, $S = 0.881$).

Failures: ($\bar{X} = 3.926$, $R = 5.333 - 2.667$, $S = 1.110$).

Result of the Hypothesis Test:

Rejected the null hypothesis

Implications:

The degree to which organizations used a step-wise/phased approach to project implementation, without any of the phases being either too slow or rushed was statistically significant for differentiating between successful and unsuccessful AMT projects.

Hypothesis #12

The degree to which organizations obtained experience with a pilot project prior to implementing a full scale project will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Questions Used:

46. This organization started its implementation push with a pilot project that was easy and had high probability of success, and then followed it up with successively more complex ones.

47. This organization obtained experience with a manageably-sized (Pilot) project prior to a full scale implementation.

48. The pilot project used to obtain experience in this organization was of similar technology to the full scale Advanced Manufacturing Technology (AMT) project.

49. This organization hired individuals who were familiar with the type of Advanced Manufacturing Technology (AMT) to be implemented to aid in its implementation efforts.

Statistics: Two-tailed t-test for independent groups; separate variances. ($t = 0.533$, $df = 6.0$, $p = 0.613$).

Successes: ($\bar{X} = 4.441$, $R = 6.250 - 2.750$, $S = 1.109$).

Failures: ($\bar{X} = 4.056$, $R = 6.250 - 1.250$, $S = 1.694$).

Result of the Hypothesis Test:

Failed to reject the null hypothesis

Implications:

The difference in degree to which organizations obtained experience with a pilot project and followed it up with successively more complex ones in full scale implementation was not statistically significant for distinguishing between successful and unsuccessful AMT implementation efforts.

Hypothesis #13

The organization and composition of the AMT project team will not be a significant factor differentiating successful and unsuccessful AMT implementation efforts.

Questions Used:

50. All the key functional areas were represented in the project team(s) for this organization's Advanced Manufacturing Technology (AMT) implementation.

51. This organization assigned its most capable people to the project.

52. This organization had an in-house project leader, who coordinated the efforts for the Advanced Manufacturing Technology (AMT) implementation.

53. The individual team members of this organization's project team were dedicated to the Advanced Manufacturing Technology (AMT) project on a full-time basis for the entire duration of the project.

54. The staff that worked on this organization's Advanced Manufacturing Technology (AMT) project were involved with the project only on a part-time basis while still performing their regular duties.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 1.183$, $df = 26$, $p = 0.248$).

Successes: ($\bar{X} = 5.045$, $R = 7.000 - 3.500$, $S = 0.993$).

Failures: ($\bar{X} = 4.533$, $R = 5.600 - 3.600$, $S = 0.665$).

Result of the Hypothesis Test:

Failed to reject the null hypothesis

Implications:

The degree to which organizations had staff dedicated to the AMT project on a full time basis, assigned the most capable people in the organization to the project, and had adequate representation of the key functional areas in the project team was not statistically significant for differentiating successful AMT implementations from failures.

Hypothesis #14

The degree of management commitment and support of the AMT program in an organization will not be a significant factor differentiating successful and unsuccessful AMT implementation efforts.

Questions Used:

55. This organization's top management was directly involved in its Advanced Manufacturing Technology (AMT) planning.

56. Top management understood/supported the implementation effort, and committed adequate financial resources to the Advanced Manufacturing Technology (AMT) efforts.

57. This organization's top management actively supported our Advanced Manufacturing technology (AMT) efforts with adequate human resource commitments.

58. This organization's top management directed its strategic planning efforts towards the successful implementation of this Advanced Manufacturing Technology (AMT).

59. Top management in this organization clearly communicated the corporate strategic goals and objectives driving the AMT implementation to the implementation planners.

60. Corporate planners in this organization clearly communicated the corporate strategic goals and objectives driving the AMT implementation to the implementation planners.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 0.041$, $df = 26$, $p = 0.968$).

Successes: ($\bar{X} = 4.656$, R = 6.000 - 2.333, S = 0.874).

Failures: ($\bar{X} = 4.676$, R = 6.167 - 1.667, S = 1.614).

Result of the Hypothesis Test:

Failed to reject the null hypothesis

Implications:

The degree of management and support of the AMT program in an organization was not statistically significant for differentiating between successful and unsuccessful AMT implementation efforts.

Hypothesis #15

The magnitude of product redesign or simultaneously designing a new product in parallel with implementing a dedicated AMT will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Questions Used:

61. This organization redesigned existing products for dedicated production on the Advanced Manufacturing Technology (AMT) facility, after the system was implemented.

62. This organization simultaneously designed new products along with a dedicated Advanced Manufacturing Technology (AMT) facility.

63. Product redesign concurrent with system implementation contributed significantly to the attainment of the desired levels of performance from our AMT system.

Statistics: Two-tailed t-test for independent groups; separate variances. ($t = 0.259$, $df = 5.8$, $p = 0.806$).

Successes: ($\bar{X} = 3.532$, R = 6.000 - 1.667, S = 0.993).

Failures: ($\bar{X} = 3.741$, R = 5.667 - 1.000, S = 1.906).

Result of the Hypothesis Test:

Failed to reject the null hypothesis

Implications:

The degree to which organizations redesigned their existing product lines or simultaneously designed a new product for dedicated production on the AMT system was not statistically significant for distinguishing between successful and unsuccessful AMT implementation efforts.

Hypothesis #16

The degree of adequacy of the particular technology to an application in the organization will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Questions Used:

64. This organization attempted to apply some technologies that are not compatible with the rest of the Advanced Manufacturing Technology (AMT) in the overall technological scheme.

65. This organization purchased/installed some of the Advanced Manufacturing Technology systems without a clear understanding of what the technology could do, and how it would satisfy the needs that exist.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 2.628$, $df = 26$, $p = 0.014$).

Successes: ($\bar{X} = 4.458$, $R = 6.500 - 1.834$, $S = 1.195$).

Failures: ($\bar{X} = 2.972$, $R = 5.333 - 1.500$, $S = 1.356$).

Result of the Hypothesis Test:

Rejected the null hypothesis

Implications:

The adequacy of a particular technology implemented to an application, and its compatibility with existing technologies in the organization was a statistically significant factor for distinguishing between successful and unsuccessful AMT implementation efforts.

Hypothesis #17

The degree of information integrity in an organization prior to AMT implementation will not be a significant factor in differentiating between successful and unsuccessful AMT implementation efforts.

Questions Used:

66. The existing database configuration in our organization was too awkward for compatibility with the Advanced Manufacturing Technology (AMT).

67. This organization had a standard data communication system for adequate exchange of product description data, prior to attempting to implement the Advanced Manufacturing Technology (AMT).

68. This organization had adequate interfacing of information between the necessary functional departments, prior to attempting to implement the Advanced Manufacturing Technology (AMT) project.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 0.448$, $df = 26$, $p = 0.629$).

Successes: ($\bar{X} = 4.260$, $R = 6.333 - 2.333$, $S = 1.130$).

Failures: ($\bar{X} = 4.000$, $R = 5.333 - 2.000$, $S = 1.265$).

Result of the Hypothesis Test:

Failed to reject the null hypothesis

Implications:

The degree of information integrity within an organization prior to *AMT implementation* was *not* statistically significant for differentiating between successful and unsuccessful AMT implementation efforts.

Hypothesis #18

The degree of availability of qualified systems integrators in an organization will not make a significant difference between successful and unsuccessful AMT implementation efforts.

Question Used:

69. This organization had enough people possessing the technical competency required to integrate the Advanced Manufacturing Technology in our plant.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 0.711$, $df = 26$, $p = 0.484$).

Successes: ($\bar{X} = 5.049$, $R = 7.000 - 2.000$, $S = 1.310$).

Failures: ($\bar{X} = 4.611$, $R = 6.000 - 2.667$, $S = 1.452$).

Result of the Hypothesis Test:

Failed to reject the null hypothesis

Implications:

The degree to which organizations had qualified systems integrators during the AMT project planning and implementation process was not statistically significant for differentiating between successful and unsuccessful AMT implementation efforts.

Hypothesis #19

The degree of alignment of an organization's AMT strategy to its culture will not be a significant factor in differentiating between successful and unsuccessful AMT implementation efforts.

Questions Used:

70. In this organization, conflicts and differences in values, beliefs, and norms about coordinative activities, primary goals, and approaches to change are quickly dealt with and effectively solved.

71. When changes are necessary, everyone in this organization has a clear idea of what sort of changes are and are not acceptable.

72. In this organization, people do the best they can; there is little pressure to strive for specific goals.

73. People in this organization are very successful in dealing with and resolving ambiguity, and can effectively coordinate the actions of individuals and units.

74. This organization has a long history of maintaining stable patterns of shared values, beliefs, and behavioral norms.

75. In this organization, the pressure to maintain the status quo is so great that if a major change were required for the organization to survive, it might not.

76. There is little consensus in this organization with regard to goals, practices, or needed changes.

77. This organization handles problems of adapting to change with a high degree of effectiveness.

78. Most people in this organization have their own goals that may or may not be compatible with one another.

79. People in this organization have clear concepts of their own roles and how they relate to the roles of others.

80. This organization has shown that it is able to set and reach important goals.

Statistics: Two-tailed t-test for independent groups; pooled variances. ($t = 2.229$, $df = 26$, $p = 0.035$).

Successes: $(\bar{X} = 4.607, R = 7.000 - 3.545, S = 0.907)$.

Failures: $(\bar{X} = 3.939, R = 4.727 - 3.182, S = 0.720)$.

Result of the Hypothesis Test:

Rejected the null hypothesis

Implications:

The degree of alignment of an organization's AMT strategy with its culture was a statistically significant differentiating factor between successful and unsuccessful AMT implementation efforts.

Results of the Responses to the Open-Ended Question Dealing With the Expected Outcomes of AMT

A section of the questionnaire designed and used for the study asked open-ended questions to give the respondents the opportunity to express their views on some of the aspects of AMT implementation. Question # 4 asked the respondents to state the top three specific benefits of AMT project implementation to their firms. The responses obtained, presented in its entirety in Appendix F showed that all the factors listed as a set in the ISD section of the questionnaire were represented. This was a confirmation of the fact that the factors included in the set, and used for scoring project implementation performance was a reasonable set of factors for that purpose.

Summary of the Analysis of Data

The purpose of this study was to assess the success factors behind different organizations' efforts to implement Advanced Manufacturing Technologies (AMTs). It is anticipated that assessing and documenting these factors will provide valuable information to various functions in the organization planning implementation strategies for the future. A detailed discussion and summary of the interpretation of the data analysis presented in this chapter is presented in Chapter VI.

This project is expected to shed some light on the reasons why some AMT implementations succeeded and why others failed. It should also give some indication as to what factors are more critical to successful system implementation. This information is expected to be useful to the following functions within an organization: 1. The CEO - It would serve a valuable role in strategic planning, by providing information that would be helpful for matching the strategic objectives with the thrust areas identified as driving forces by a consensus of experts. 2. The Resource Allocator - The outcome of this research project will aid the resource allocator in determining the priorities on the set of activities that needs to be undertaken in order to accomplish the company's business objectives. 3. Implementation Specialists, Project Managers/Groups - The ratings will provide some information on the factors that are considered critical for successful implementation, as well as pointing out what the possible pitfalls to be avoided are.

Generally, these different functions will be served by providing guidelines on the factors that a consensus of experts have determined the levels of criticality for AMT implementation. The approach to achieving these goals have already been outlined.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to survey knowledge workers (people that were involved at some time in the planning and/or implementation of their companies' AMT) in companies that have implemented Advanced Manufacturing Technologies (AMTs) in the United States, in order to analyze the combination of factors within an organization that in general, contributed to implementation success achievement levels attained by typical groups of successful projects. In order to get this accomplished, a thorough review of related literature was conducted in order to ascertain factors that have been identified in a majority of the projects described in literature as contributors to the various levels of success in the individual projects. From the information obtained from literature, nineteen factors were selected due to their predominance as individual projects success factors. These factors thus formed the basis for the nineteen null hypotheses that were stated for this study. Information obtained from the literature search was also used to develop a questionnaire which was used to conduct the survey. The questionnaire was designed to enable collection of quantifiable data from survey participants to test each of the hypotheses. A section of the questionnaire, the implementation success diagnoses (ISD) was designed to obtain information to enable the researcher to distinguish the more successful projects from the less successful ones. In order to make this distinction, scoring techniques were developed, one of which was chosen for use in scoring the projects represented in the sample based on their performance relative to goals set for the project. The scores obtained for each project were, in turn, used to perform a cluster analysis which separated the projects into clusters designated as either successes or failures for the purpose of the analysis. The nineteen null hypotheses stated for this study were tested, and the typical combination of factors for success in AMT implementation as indicated by the successful group efforts were delineated.

The respondents to this study consisted of 97 knowledge workers sampled across the United States. The questionnaire used for this study was developed by the researcher. It consisted of five sections which, when responded to, provided answers pertaining to the nineteen null hypotheses stated for the study. There were 49 returned questionnaires, of which six were unusable, yielding 43 usable returns or 44.3 percent. A total of twenty-eight projects were represented in the study. For each project represented, effort was made to obtain replications of at least two respondents for the analysis. The analysis was based on clusters of projects as either successful or unsuccessful projects. The clusters were obtained using weighted scores of project performance obtained for each project evaluated as a basis. These clusters were then used as the groupings for testing the individual hypotheses for significant differences between the groups. Clusters of two and three groups were tested in the effort to obtain the best grouping of projects. Both clustering techniques produced similar results when used to test the hypotheses. The 2-cluster grouping was used for the analysis in this study. A summary of all the hypotheses tested, along with the test results are presented in Table XVII.

TABLE XVII

SUMMARY OF THE NULL HYPOTHESES WITH TEST RESULTS

Hypothesis #	Factor Addressed	Status of Test
1	Alignment of the core organizational system with the corporate strategy	Rejected the null hypothesis
2	Alignment of employee attitudes with the corporate objectives	Failed to reject the null hypothesis
3	Strategy formulation process	Rejected the null hypothesis
4	Position along the organic - mechanistic dimension	Failed to reject the null hypothesis
5	Relationship between the technology supplier and the user firm	Failed to reject the null hypothesis
6	Existence of an AMT champion	Failed to reject the null hypothesis
7	Position of the AMT champion	Failed to reject the null hypothesis
8	Existence of an educational program	Rejected the null hypothesis
9	Availability of hands-on training program	Failed to reject the null hypothesis
10	Top-down planning and bottom-up implementation	Rejected the null hypothesis

TABLE XVII (Continued)

Hypothesis #	Factor Addressed	Status of Test
11	Pace of implementation	Rejected the null hypothesis
12	Obtaining experience with a pilot project	Failed to reject the null hypothesis
13	Organization and composition of the project team	Failed to reject the null hypothesis
14	Management commitment and support	Failed to reject the null hypothesis
15	Existing Product redesign or new product design	Failed to reject the null hypothesis
16	Adequacy of the particular technology to an application	Rejected the null hypothesis
17	Information integrity	Failed to reject the null hypothesis
18	Availability of qualified systems integrators	Failed to reject the null hypothesis
19	Alignment of strategy with the organizational culture	Rejected the null hypothesis

Conclusions

The objective of this study was to investigate AMT implementation efforts across a group of projects to determine any possible commonality of factors accountable for AMT implementation successes across that variety of AMT projects. The finding would then indicate if there is any discernible pattern of success factors across the whole spectrum. Any such pattern would thus provide a general set of factors which influence success or failure of AMT implementation transferable from one project to the next.

The conclusions reported in this chapter were based upon the population studied, and should be applied with caution in any attempts to generalize to other populations.

Based on the data analyzed for the respective null hypotheses tested, the following conclusions were reached:

* Overall, although all of the factors addressed in the nineteen null hypotheses were success factors in individual projects reported in literature, they were not all significant across a spectrum of Advanced Manufacturing Technology (AMT) projects.
* Seven out of the nineteen factors that were investigated in the hypotheses stated for this study were significant in differentiating between successful and unsuccessful AMT implementation. They thus formed the generalized pattern of commonality that was sought across projects, producing a consensus-based set of success factors for implementing advanced manufacturing technologies, or factors that would lead to failures in AMT implementation efforts if not adequately addressed.
* The first null hypothesis addressing the alignment of the core organization system was rejected, indicating that the core organization systems illustrated in Figure 1 - strategy formulation, cultural/political system, organizational structure,

technical system, and organizational management processes - as much as possible, need to be made to work in unison in order to implement AMT strategy successfully.

* The factors addressed in the other hypotheses that were rejected, indicate the areas of emphasis to deal with in order to get the AMT mission accomplished.

The seven factors which were significant in distinguishing successes from failures were: An organization's:-

1. Ability to effectively align the core organizational systems with the corporate strategy.

2. Strategy formulation process.

3. Educational program for employees prior to AMT implementation.

4. Top-down planning and bottom-up implementation.

5. Pace of implementation.

6. Adequacy of a particular technology to an application in the organization.

7. Degree of alignment of AMT strategy with organizational culture.

A summary of the null hypotheses that were rejected, signifying their statistical significance as differentiating factors between successful and unsuccessful AMT implementation efforts is presented in Table XVIII. A summary of the null hypotheses that failed to be rejected is presented in Table XIX.

TABLE XVIII

SUMMARY OF THE NULL HYPOTHESES REJECTED IN THE STUDY

Hypothesis #	Factor Addressed	Status of Test
1	Alignment of the core organizational system with the corporate strategy	Rejected the null hypothesis
3	Strategy formulation process	Rejected the null hypothesis
8	Existence of an educational program	Rejected the null hypothesis
10	Top-down planning and bottom-up implementation	Rejected the null hypothesis
11	Pace of implementation	Rejected the null hypothesis
16	Adequacy of the particular technology to an application	Rejected the null hypothesis
19	Alignment of strategy with the organizational culture	Rejected the null hypothesis

TABLE XIX

SUMMARY OF THE NULL HYPOTHESES THAT FAILED TO BE REJECTED IN THE STUDY

Hypothesis #	Factor Addressed	Status of Test
2	Alignment of employee attitudes with the corporate objectives	Failed to reject the null hypothesis
4	Position along the organic - mechanistic dimension	Failed to reject the null hypothesis
5	Relationship between the technology supplier and the user firm	Failed to reject the null hypothesis
6	Existence of an AMT champion	Failed to reject the null hypothesis
7	Position of the AMT champion	Failed to reject the null hypothesis
9	Availability of hands-on training program	Failed to reject the null hypothesis
12	Obtaining experience with a pilot project	Failed to reject the null hypothesis
13	Organization and composition of the project team	Failed to reject the null hypothesis
14	Management commitment and support	Failed to reject the null hypothesis
15	Existing Product redesign or new product design	Failed to reject the null hypothesis
17	Information integrity	Failed to reject the null hypothesis
18	Availability of qualified systems integrators	Failed to reject the null hypothesis

One hypothesis measured the placement of organizations along the organic/mechanistic continuum. For this factor a higher score showed that the organization was tending toward the highly mechanistic and bureaucratic type of setting, while a lower score showed the tendency towards an organic and adaptive organization. The results from this test showed that the more successful organizations leaned more toward the organic side than the less successful ones. Successful implementations would thus tend to be associated with an organic and adaptive organization.

Recommendations for AMT Implementation Practices

The recommendations proposed are based on the findings and conclusions of this study. It is recommended that companies planning to implement new AMT systems adequately incorporate the factors listed above as those distinguishing the more successful projects from the less successful ones. The author does not suggest that the importance of the other factors investigated be discounted, but merely recommends, based on the findings of this study, that attention be given to factors that were identified as being critical to successful implementation across several projects than others. It is expected that these findings will serve as input to advanced manufacturing technology strategy implementation process, as well as pointing out some direction in terms of AMT resource allocation. It should also provide project managers and implementation specialists with at least a starting point for implementation planning, as well as contribute to the general theory of AMT implementation.

The set of expected outcomes used in the study was a good set since they were all addressed by the respondents to the survey on the open-ended questions presented in Appendix F.

Recommendations for Further Research

There is immense opportunity for further expansion of this research. The following is a set of recommendations that would further expand the knowledge in the area of AMT implementation. The recommendations proposed are based on the findings and conclusions of this study.

It is recommended that a comparative study be conducted between different industries to determine if there are significant differences between industries. Once that is accomplished, an international scope can be embraced based on the experience obtained, with a comparative study of implementation practices between industrialized nations, notably between the United States and Japan.

It is further recommended that a similar research be conducted using a wider scope of companies and more industry representations to determine if there are differences in the combination of factors leading to successful project implementations in each industry. This would further strengthen the claim on the generalized set of success factors.

It is also recommended that a similar study be conducted with an extension as a longitudinal study to compare the changes in study information with a passage of time, as people change their group membership and the projects change focus/emphasis over time.

It is recommended that with appropriate funding, a similar study be designed to incorporate on-site interviews as a back-up for more robust data collection procedure for analysis. This would give the researcher an opportunity to get some reactions from diverse groups of people who might impact implementation success.

A similar study should be conducted to explore more details on the level interaction required of each specific factor identified as a success factor, to determine possibilities for enhancements in each factor.

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APPENDIXES

APPENDIX A

QUESTIONNAIRE PRE-TEST FORM

INSTRUCTIONS TO CRITIQUING THE QUESTIONNAIRE

The critiquing of this questionnaire is divided into three parts. The first part deals with the individual questions/statements, the second part deals with the overall questionnaire, and the third part asks for some specific opinions, ideas, and suggestions from each participant.

PART I. please read each question/statement in the attached questionnaire, then answer the critiquing questions below. If the answer to critiquing question is yes, do nothing. If the answer is no, write the section number and question number (for example II,3 : for section II, question number 3) in the space to the right of the critiquing question.

CRITIQUING QUESTIONS

1. Is it clear? ------------------
2. Is it complete? ------------------
3. Does it deal with a single idea? ------------------
4. Is it brief? ------------------
5. Do you understand precisely what the question statement is soliciting? ------------------
6. Is it objective, without suggesting a response? ------------------
7. Is it courteous, without adverse connotations? ------------------

Any other comments? Please include the section and question number to which they pertain.

PART II. Please review the overall questionnaire and answer the questions below. Circle only one response to each question.

1. The design of the overall questionnaire is logically arranged? (yes) (no)
2. Directions for completing the questionnaire are clear and complete? (yes) (no)
3. The overall length of the questionnaire is ... ?
   (Too long) (Okay) (Too short)

4. Questions are presented in good psychological order, proceeding from general to specific responses?
   (yes) (no)

5. Any additional comments and suggestions?

PART III. Please answer the following questions briefly, in your own words.

1. What is the length of time it would take to complete the questionnaire if you were not evaluating each question?

2. Which areas could be regarded as being overly sensitive?

3. Which questions or areas were confusing?

4. Any additional comments or suggestions?

APPENDIX B

QUESTIONNAIRE

REQUIREMENTS FOR SUCCESSFUL IMPLEMENTATION OF ADVANCED MANUFACTURING TECHNOLOGY (AMT).

The following questions are designed to identify the relative contributions of various factors to successful implementation of Advanced Manufacturing Technology (AMT) projects.

It is anticipated that some of these factors may be more important in your company's Advanced Manufacturing Technology (AMT) implementation efforts than in other companies. Please indicate your perception of the effect of each of the factors covered in this instrument on your Advanced Manufacturing Technology (AMT) implementation. **Your response to all items** will assist in the development of a set of requirements for successful **AMT** implementation. This will enable managers who are designing implementation strategies for the future to follow some logical sequence, based on the results of the survey, for successful system implementation.

PLEASE ANSWER ALL THE QUESTIONS IN THE FOLLOWING SECTIONS

THIS QUESTIONNAIRE REQUIRES APPROXIMATELY 20 MINUTES TO COMPLETE

IN APPRECIATION OF YOUR TIME IN COMPLETING THIS QUESTIONNAIRE, A SUMMARY OF THIS STUDY WILL BE MADE AVAILABLE TO YOU WHEN THE STUDY IS COMPLETED. IF YOU DESIRE TO RECEIVE THE SUMMARY, PLEASE CHECK THE SPACE PROVIDED AT THE END OF THE INSTRUMENT

NOTE: YOUR RESPONSES TO THE ENTIRE INSTRUMENT WILL BE KEPT STRICTLY CONFIDENTIAL, AND WILL NOT BE LINKED TO YOU OR YOUR COMPANY WHEN THE DATA IS ANALYZED

I. SPECIFIC AMT PROJECT TO BE EVALUATED

<u>INSTRUCTIONS</u>: Your company may have implemented several Advanced Manufacturing Technology (**AMT**) projects to date. In the spaces provided below, **please fill in the information on one specific project in your company, and answer the following questions related to the project.** Your responses to all the questions in this instrument should be based on this project.

SPECIFIC AMT PROJECT: ______________________________

DIVISION/DEPARTMENT: ______________________________

TITLE OF PROJECT LEADER? ______________________________

HOME DEPARTMENT OF PROJECT LEADER? ______________________________

WHAT IS YOUR OFFICIAL JOB TITLE? ______________________________

1. How are (were) you involved (if at all) in the AMT implementation process? (e.g. If you are (were) a project manager, describe the duties performed in that capacity).

2. Please characterize the relative size of the project (e.g. machine cell, ... , entire plant, square footage involved, amount ($) spent on project, etc).

3. Please characterize the relative scope of the project, in terms of functions covered during the various implementation phases: (check all that apply).

_____a. Marketing and Sales

_____b. Engineering Design

_____c. Process Planning

_____d. Fabrication

_____e. Assembly

_____f. Materials

_____g. Purchasing

_____h. Quality Assurance

_____i. Shipping and Receiving

_____j. Other(s) (Please Specify) ______________________________

____

____

____

4. Please give a brief description of the project in terms of what the goals were, and how you went about achieving them.

II. IMPLEMENTATION SUCCESS DIAGNOSIS (ISD)

INSTRUCTIONS: Your company had some specific expected outcomes for this project. For each of the items listed below, please indicate the response that best fits the current status of your firm's Advanced Manufacturing Technology (AMT) implementation results for this project as follows:

1. In the space provided before each of the items listed, please indicate [Yes/No] if the factor was an expected outcome of your AMT system, and hence used to justify the system's implementation.

2. For every factor listed below, please rate by checking [✔] the appropriate box to the right, as it was affected by your Advanced Manufacturing Technology (AMT) project implementation.

RATING

- Level Declined After AMT Implementation
- No Changes In level After AMT Implementation
- Some Improvement Realized
- Substantial Improvement Realized But Target Levels Not Met
- Expected Levels Achieved/Exceeded

EXPECTED OUTCOME? [Yes/No]		FACTOR	Expected Levels Achieved/Exceeded	Substantial Improvement Realized But Target Levels Not Met	Some Improvement Realized	No Changes In level After AMT Implementation	Level Declined After AMT Implementation
Y	0.	Product Quality	☐	☐	☑	☐	☐
____	1.	Product Quality	☐	☐	☐	☐	☐
____	2.	Flexibility to accommodate dynamic product mix changes	☐	☐	☐	☐	☐
____	3.	Productivity	☐	☐	☐	☐	☐
____	4.	On-time delivery	☐	☐	☐	☐	☐
____	5.	Information flow	☐	☐	☐	☐	☐
____	6.	Manufacturing cost	☐	☐	☐	☐	☐

RATING

- Level Declined After AMT Implementation
- No Changes In Level After AMT Implementation
- Some Improvement Realized
- Substantial Improvement Realized But Target Levels Not Met
- Expected Levels Achieved/Exceeded

EXPECTED OUTCOME? [YES/NO]	FACTOR	Expected Levels Achieved/Exceeded	Substantial Improvement Realized But Target Levels Not Met	Some Improvement Realized	No Changes In Level After AMT Implementation	Level Declined After AMT Implementation
____7.	Inventory turnover	☐	☐	☐	☐	☐
____8.	Work-in-process	☐	☐	☐	☐	☐
____9.	Material cost	☐	☐	☐	☐	☐
____10.	Lead times	☐	☐	☐	☐	☐
____11.	Floor space requirements	☐	☐	☐	☐	☐
____12.	Direct labor cost	☐	☐	☐	☐	☐
____13.	Indirect labor cost	☐	☐	☐	☐	☐
____14.	Responsiveness to shifting customer expectations	☐	☐	☐	☐	☐
____15.	Long-term profitability	☐	☐	☐	☐	☐
____16.	Stockholder benefits	☐	☐	☐	☐	☐
____17.	Overall system performance relative to system objectives	☐	☐	☐	☐	☐
____18.	Other(s) (Please List)	☐	☐	☐	☐	☐
____18a.	____________________	☐	☐	☐	☐	☐
____19.	____________________	☐	☐	☐	☐	☐
____20.	____________________	☐	☐	☐	☐	☐

III. AMT IMPLEMENTATION SURVEY

INSTRUCTIONS: THIS PART OF THE QUESTIONNAIRE IS CONCERNED WITH YOUR FIRM'S ADVANCED MANUFACTURING TECHNOLOGY (AMT) IMPLEMENTATION PROCESS. PLEASE CAREFULLY READ EACH STATEMENT BELOW, THEN CHECK [✓] ONE BOX TO THE RIGHT THAT MOST ACCURATELY REPRESENTS YOUR FIRM'S SITUATION AS IT RELATES TO THIS PARTICULAR PROJECT.

	AGREE STRONGLY	AGREE	AGREE SLIGHTLY	NEUTRAL	DISAGREE SLIGHTLY	DISAGREE	DISAGREE STRONGLY
1. THIS ORGANIZATION HAD AN OVERALL CORPORATE STATEMENT OF OBJECTIVES FOR ITS ADVANCED MANUFACTURING TECHNOLOGY (AMT) EFFORTS, WITHIN WHICH THE PLAN FOR THIS PARTICULAR AMT IMPLEMENTATION WAS SPECIFIED.	☐	☐	☐	☐	☐	☐	☐
2. THIS ORGANIZATION ADEQUATELY ASSESSED THE PREVAILING VALUES AND ATTITUDES IN THE FIRM, IN SELECTING ITS METHODOLOGY FOR ACHIEVING THE DESIRED GOALS FROM THIS ADVANCED MANUFACTURING TECHNOLOGY (AMT).	☐	☐	☐	☐	☐	☐	☐
3. THIS ORGANIZATION'S SCHEME OF EVENTS DIRECTED AT ACHIEVING THE DESIRED OUTCOMES OF THIS ADVANCED MANUFACTURING TECHNOLOGY (AMT) FITS THE GENERAL TECHNOLOGICAL PATTERNS THAT I AM FAMILIAR WITH.	☐	☐	☐	☐	☐	☐	☐
4. IN ITS PLANS FOR ACHIEVING THE DESIRED GOALS FROM THIS ADVANCED MANUFACTURING TECHNOLOGY (AMT), THIS ORGANIZATION ADEQUATELY ASSESSED ITS ORGANIZATIONAL STRUCTURE, AND MADE THE ADJUSTMENTS REQUIRED IN ORDER TO REACH THOSE GOALS.	☐	☐	☐	☐	☐	☐	☐
5. THIS ORGANIZATION MADE ANY ORGANIZATIONAL STRUCTURE CHANGES NECESSARY FOR TRANSITION TO THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) ENVIRONMENT PRIOR TO IMPLEMENTATION.	☐	☐	☐	☐	☐	☐	☐
6. THIS ORGANIZATION HAD A STRATEGIC FOCUS FOR ITS ADVANCED MANUFACTURING TECHNOLOGY (AMT) WHICH INCREASED COHESION WITHIN THE AMT IMPLEMENTATION ORGANIZATION.	☐	☐	☐	☐	☐	☐	☐
7. THE REWARD SYSTEM IN THIS ORGANIZATION RECOGNIZED INDIVIDUAL EFFORTS TO ATTAIN THE DESIRED GOALS FROM THIS ADVANCED MANUFACTURING TECHNOLOGY (AMT).	☐	☐	☐	☐	☐	☐	☐
8. THE REWARD SYSTEM IN THIS ORGANIZATION RECOGNIZED GROUP EFFORTS TO ATTAIN THE DESIRED GOALS FROM THIS ADVANCED MANUFACTURING TECHNOLOGY (AMT).	☐	☐	☐	☐	☐	☐	☐
9. THIS ORGANIZATION'S TOP MANAGEMENT PROVIDED CONTINUAL MOTIVATION, AND REWARDED COMPLIANCE WITH THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) PHILOSOPHY.	☐	☐	☐	☐	☐	☐	☐

	AGREE STRONGLY	AGREE	AGREE SLIGHTLY	NEUTRAL	DISAGREE SLIGHTLY	DISAGREE	DISAGREE STRONGLY
10. TOP MANAGEMENT'S EVALUATION OF MIDDLE MANAGEMENT CONSIDERED PERFORMANCES THAT REFLECT THE POSITIVE EFFECTS OF CHANGE RESULTING FROM THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) IMPLEMENTATION.	☐	☐	☐	☐	☐	☐	☐
11. THIS ORGANIZATION'S TOP MANAGEMENT PROVIDED ADEQUATE INCENTIVES FOR MIDDLE AND OPERATIONAL MANAGEMENT STAFF TO SUPPORT THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) PROGRAM.	☐	☐	☐	☐	☐	☐	☐
12. THIS ORGANIZATION'S TOP MANAGEMENT PROVIDED ADEQUATE INCENTIVES FOR LABOR GROUPS TO SUPPORT OUR ADVANCED MANUFACTURING TECHNOLOGY (AMT) EFFORTS.	☐	☐	☐	☐	☐	☐	☐
13. THIS ORGANIZATION'S STRATEGY FORMULATION PROCESS EXPLICITLY INCLUDES CONSIDERATION OF IMPLEMENTATION ISSUES SUCH AS REQUIRED REORGANIZATIONS, STAFFING CHANGES, MODIFICATIONS TO SYSTEMS AND POLICIES.	☐	☐	☐	☐	☐	☐	☐
14. THE KEY MIDDLE MANAGERS IN THIS ORGANIZATION USUALLY HAVE A CHANCE TO REVIEW AND COMMENT ON PROPOSED STRATEGIES BEFORE RESOURCES ARE ALLOCATED.	☐	☐	☐	☐	☐	☐	☐
15. STRATEGIC PROPOSALS ARE USUALLY CRITICALLY DISCUSSED AND CONSENSUS REACHED PRIOR TO ACCEPTANCE IN THIS ORGANIZATION.	☐	☐	☐	☐	☐	☐	☐
16. THERE IS A CORPORATE STAFF SUPPORT GROUP FOR STRATEGY FORMULATION WITHIN THIS ORGANIZATION.	☐	☐	☐	☐	☐	☐	☐
17. THIS ORGANIZATION USUALLY HAS A FORMAL SYSTEM FOR INTERNALLY REVIEWING STRATEGIC PROPOSALS.	☐	☐	☐	☐	☐	☐	☐
18. THIS ORGANIZATION'S ADVANCED MANUFACTURING TECHNOLOGY (AMT) EFFORTS WERE DESIGNED TO SUPPORT ITS STRATEGIC BUSINESS OBJECTIVES.	☐	☐	☐	☐	☐	☐	☐
19. THIS ORGANIZATION HAS CLEAR RULES AND REGULATIONS THAT EVERYONE IS EXPECTED TO FOLLOW CLOSELY.	☐	☐	☐	☐	☐	☐	☐
20. POLICIES IN THIS ORGANIZATION ARE REVIEWED BY THE PEOPLE THEY AFFECT BEFORE BEING IMPLEMENTED.	☐	☐	☐	☐	☐	☐	☐
21. EVERYONE IN THIS ORGANIZATION KNOWS WHO HIS/HER IMMEDIATE SUPERVISOR IS. REPORTING RELATIONSHIPS ARE CLEARLY DEFINED.	☐	☐	☐	☐	☐	☐	☐
22. JOBS IN THIS ORGANIZATION ARE CLEARLY DEFINED; EVERYONE KNOWS EXACTLY WHAT IS EXPECTED OF HIM/HER IN ANY SPECIFIC JOB POSITION.	☐	☐	☐	☐	☐	☐	☐

	AGREE STRONGLY	AGREE	AGREE SLIGHTLY	NEUTRAL	DISAGREE SLIGHTLY	DISAGREE	DISAGREE STRONGLY
23. ALL DECISIONS IN THIS ORGANIZATION MUST BE REVIEWED AND APPROVED BY UPPER LEVEL MANAGEMENT.	☐	☐	☐	☐	☐	☐	☐
24. STANDARD ACTIVITIES IN THIS ORGANIZATION ARE ALWAYS COVERED BY CLEARLY OUTLINED PROCEDURES THAT EVERYONE IS EXPECTED TO FOLLOW.	☐	☐	☐	☐	☐	☐	☐
25. THIS ORGANIZATION FORMED AN IMPLEMENTATION TEAM WITH THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) SUPPLIER AT THE PROJECT SITE DURING ITS AMT PROJECT IMPLEMENTATION.	☐	☐	☐	☐	☐	☐	☐
26. THIS ORGANIZATION ESTABLISHED A LONG TERM, MUTUAL COMMITMENT WITH THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) SUPPLIER TO SUPPORT THE INTEGRATION THE NEW TECHNOLOGY IN OUR PLANT.	☐	☐	☐	☐	☐	☐	☐
27. THERE WERE KEY PEOPLE FROM THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) SUPPLIER FIRM WHO WORKED VERY CLOSELY WITH OUR PROJECT TEAM IN THE EFFORTS TO IMPLEMENT THE AMT IN OUR PLANT.	☐	☐	☐	☐	☐	☐	☐
28. THIS ORGANIZATION ALLOWED PEOPLE WITH AMBITION AND DESIRE (REGARDLESS OF THEIR RANK IN MANAGEMENT) TO LEAD IN THE IMPLEMENTATION OF THIS ADVANCED MANUFACTURING TECHNOLOGY (AMT) PROJECT.	☐	☐	☐	☐	☐	☐	☐
29. THERE WAS A KEY PERSON FROM THIS ORGANIZATION WHO WORKED EXTREMELY HARD AT BUILDING A TEAM TO INTEGRATE THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) IN OUR PLANT.	☐	☐	☐	☐	☐	☐	☐
30. THERE WAS A KEY PERSON FROM THE TECHNOLOGY SUPPLIER FIRM WHO WORKED EXTREMELY HARD AT BUILDING A TEAM TO INTEGRATE THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) IN OUR PLANT.	☐	☐	☐	☐	☐	☐	☐
31. THE PROJECT LEADER FOR THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) IMPLEMENTATION HAD A DEEP COMMITMENT AND DESIRE TO SUCCEED IN THE AMT IMPLEMENTATION.	☐	☐	☐	☐	☐	☐	☐
32. THE PROJECT MANAGER WAS THE KEY PERSON WHO "CHAMPIONED" THIS ORGANIZATION'S ADVANCED MANUFACTURING TECHNOLOGY (AMT) EFFORTS.	☐	☐	☐	☐	☐	☐	☐
33. THE PERSON WHO DIRECTED OUR AMT IMPLEMENTATION EFFORTS WAS IN A KEY MANAGEMENT POSITION.	☐	☐	☐	☐	☐	☐	☐
34. THE PERSON WHO DIRECTED OUR ADVANCED MANUFACTURING TECHNOLOGY (AMT) EFFORTS, CONTROLLED THE RESOURCES NECESSARY FOR IMPLEMENTING THE PROJECT.	☐	☐	☐	☐	☐	☐	☐

	AGREE STRONGLY	AGREE	AGREE SLIGHTLY	NEUTRAL	DISAGREE SLIGHTLY	DISAGREE	DISAGREE STRONGLY
35. THIS ORGANIZATION HAD A COMPREHENSIVE EDUCATIONAL PROGRAM TO COMMUNICATE TO ALL EMPLOYEES, THE REASONS FOR NECESSARY CHANGES RELATED TO THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) PRIOR TO ACTUAL INSTALLATION OF THE SYSTEM.	☐	☐	☐	☐	☐	☐	☐
36. THIS ORGANIZATION HAD AN EDUCATIONAL PROGRAM FOR TOP-LEVEL MANAGERS, FOCUSING ON THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) TO BE IMPLEMENTED PRIOR TO THE ACTUAL INSTALLATION OF THE SYSTEM.	☐	☐	☐	☐	☐	☐	☐
37. THIS ORGANIZATION HAD AN EDUCATIONAL PROGRAM FOR MIDDLE MANAGERS, FOCUSING ON THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) TO BE IMPLEMENTED PRIOR TO THE ACTUAL INSTALLATION OF THE SYSTEM.	☐	☐	☐	☐	☐	☐	☐
38. THIS ORGANIZATION HAD AN EDUCATIONAL PROGRAM FOR OPERATIONS PERSONNEL, FOCUSING ON THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) TO BE IMPLEMENTED PRIOR TO THE ACTUAL INSTALLATION OF THE SYSTEM.	☐	☐	☐	☐	☐	☐	☐
39. THIS ORGANIZATION HAD A COMPREHENSIVE HANDS-ON TRAINING PROGRAM TO INTRODUCE THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) TO THE EMPLOYEES AFTER THE ACTUAL INSTALLATION OF THE SYSTEM.	☐	☐	☐	☐	☐	☐	☐
40. THIS ORGANIZATION HAS A BROAD CORPORATE PLAN FOR ITS ADVANCED MANUFACTURING TECHNOLOGY (AMT) SCHEME, WHICH PROVIDES GUIDELINES FOR INDIVIDUAL PROJECTS.	☐	☐	☐	☐	☐	☐	☐
41. THE PROCESS FOR DEVELOPING THIS ORGANIZATION'S ADVANCED MANUFACTURING TECHNOLOGY (AMT) IMPLEMENTATION PLAN INCORPORATED EMPLOYEE PARTICIPATION TO FEED INFORMATION FROM THE SHOP FLOOR BACK TO UPPER MANAGEMENT.	☐	☐	☐	☐	☐	☐	☐
42. THE OVERALL PLAN FOR INTEGRATING THIS ADVANCED MANUFACTURING TECHNOLOGY (AMT) INTO THE ORGANIZATION WAS CARRIED OUT BY UPPER LEVEL MANAGEMENT, AND THE INFORMATION WAS PASSED DOWNWARD.	☐	☐	☐	☐	☐	☐	☐
43. THIS ORGANIZATION TOOK A STEP-WISE APPROACH TO ADAPT AND IMPLEMENT THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) PROJECT INCREMENTALLY IN PROGRAMMED PHASES.	☐	☐	☐	☐	☐	☐	☐
44. THIS ORGANIZATION RUSHED THE IMPLEMENTATION OF EACH PHASE OF ITS ADVANCED MANUFACTURING TECHNOLOGY (AMT) PROGRAM.	☐	☐	☐	☐	☐	☐	☐
45. THE PACE AT WHICH OUR ADVANCED MANUFACTURING TECHNOLOGY (AMT) WAS IMPLEMENTED WAS SO SLOW THAT THE INITIAL ZEAL THAT PUSHED THE PROJECT ALONG IN ITS EARLIER STAGES WAS LOST.	☐	☐	☐	☐	☐	☐	☐

	AGREE STRONGLY	AGREE	AGREE SLIGHTLY	NEUTRAL	DISAGREE SLIGHTLY	DISAGREE	DISAGREE STRONGLY
46. THIS ORGANIZATION STARTED ITS IMPLEMENTATION PUSH WITH A PILOT PROJECT THAT WAS EASY AND HAD HIGH PROBABILITY OF SUCCESS, AND THEN FOLLOWED IT UP WITH SUCCESSIVELY MORE COMPLEX ONES.	☐	☐	☐	☐	☐	☐	☐
47. THIS ORGANIZATION OBTAINED EXPERIENCE WITH A MANAGEABLY-SIZED (PILOT) PROJECT PRIOR TO A FULL SCALE IMPLEMENTATION.	☐	☐	☐	☐	☐	☐	☐
48. THE PILOT PROJECT USED TO OBTAIN EXPERIENCE IN THIS ORGANIZATION WAS OF SIMILAR TECHNOLOGY TO THE FULL SCALE ADVANCED MANUFACTURING TECHNOLOGY (AMT) PROJECT.	☐	☐	☐	☐	☐	☐	☐
49. THIS ORGANIZATION HIRED INDIVIDUALS WHO WERE FAMILIAR WITH THE TYPE OF ADVANCED MANUFACTURING TECHNOLOGY (AMT) TO BE IMPLEMENTED TO AID IN ITS IMPLEMENTATION EFFORTS.	☐	☐	☐	☐	☐	☐	☐
50. ALL THE KEY FUNCTIONAL AREAS WERE REPRESENTED IN THE PROJECT TEAM(S) FOR THIS ORGANIZATION'S ADVANCED MANUFACTURING TECHNOLOGY (AMT) IMPLEMENTATION.	☐	☐	☐	☐	☐	☐	☐
51. THIS ORGANIZATION ASSIGNED ITS MOST CAPABLE PEOPLE TO THE PROJECT.	☐	☐	☐	☐	☐	☐	☐
52. THIS ORGANIZATION HAD AN IN-HOUSE PROJECT LEADER, WHO COORDINATED THE EFFORTS FOR THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) IMPLEMENTATION.	☐	☐	☐	☐	☐	☐	☐
53. THE INDIVIDUAL TEAM MEMBERS OF THIS ORGANIZATION'S PROJECT TEAM WERE DEDICATED TO THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) PROJECT ON A FULL-TIME BASIS FOR THE ENTIRE DURATION OF THE PROJECT.	☐	☐	☐	☐	☐	☐	☐
54. THE STAFF THAT WORKED ON THIS ORGANIZATION'S ADVANCED MANUFACTURING TECHNOLOGY (AMT) PROJECT WERE INVOLVED WITH THE PROJECT ONLY ON A PART-TIME BASIS WHILE STILL PERFORMING THEIR REGULAR DUTIES.	☐	☐	☐	☐	☐	☐	☐
55. THIS ORGANIZATION'S TOP MANAGEMENT WAS DIRECTLY INVOLVED IN ITS ADVANCED MANUFACTURING TECHNOLOGY (AMT) PLANNING.	☐	☐	☐	☐	☐	☐	☐
56. TOP MANAGEMENT UNDERSTOOD/SUPPORTED THE IMPLEMENTATION EFFORT, AND COMMITTED ADEQUATE FINANCIAL RESOURCES TO THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) EFFORTS.	☐	☐	☐	☐	☐	☐	☐

	AGREE STRONGLY	AGREE	AGREE SLIGHTLY	NEUTRAL	DISAGREE SLIGHTLY	DISAGREE	DISAGREE STRONGLY
57. THIS ORGANIZATION'S TOP MANAGEMENT ACTIVELY SUPPORTED OUR ADVANCED MANUFACTURING TECHNOLOGY (AMT) EFFORTS WITH ADEQUATE HUMAN RESOURCE COMMITMENTS.	☐	☐	☐	☐	☐	☐	☐
58. THIS ORGANIZATION'S TOP MANAGEMENT DIRECTED ITS STRATEGIC PLANNING EFFORTS TOWARDS THE SUCCESSFUL IMPLEMENTATION OF THIS ADVANCED MANUFACTURING TECHNOLOGY (AMT).	☐	☐	☐	☐	☐	☐	☐
59. TOP MANAGEMENT IN THIS ORGANIZATION CLEARLY COMMUNICATED THE CORPORATE STRATEGIC GOALS AND OBJECTIVES DRIVING THE AMT IMPLEMENTATION TO THE IMPLEMENTATION PLANNERS.	☐	☐	☐	☐	☐	☐	☐
60. CORPORATE PLANNERS IN THIS ORGANIZATION CLEARLY COMMUNICATED THE CORPORATE STRATEGIC GOALS AND OBJECTIVES DRIVING THE AMT IMPLEMENTATION TO THE IMPLEMENTATION PLANNERS.	☐	☐	☐	☐	☐	☐	☐
61. THIS ORGANIZATION REDESIGNED EXISTING PRODUCTS FOR DEDICATED PRODUCTION ON THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) FACILITY, AFTER THE SYSTEM WAS IMPLEMENTED.	☐	☐	☐	☐	☐	☐	☐
62. THIS ORGANIZATION SIMULTANEOUSLY DESIGNED NEW PRODUCTS ALONG WITH A DEDICATED ADVANCED MANUFACTURING TECHNOLOGY (AMT) FACILITY.	☐	☐	☐	☐	☐	☐	☐
63. PRODUCT REDESIGN CONCURRENT WITH SYSTEM IMPLEMENTATION CONTRIBUTED SIGNIFICANTLY TO THE ATTAINMENT OF THE DESIRED LEVELS OF *PERFORMANCE FROM OUR* AMT SYSTEM.	☐	☐	☐	☐	☐	☐	☐
64. THIS ORGANIZATION ATTEMPTED TO APPLY SOME TECHNOLOGIES THAT ARE NOT COMPATIBLE WITH THE REST OF THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) IN THE OVERALL TECHNOLOGICAL SCHEME.	☐	☐	☐	☐	☐	☐	☐
65. THIS ORGANIZATION PURCHASED/INSTALLED SOME OF THE ADVANCED MANUFACTURING TECHNOLOGY SYSTEMS WITHOUT A CLEAR UNDERSTANDING OF WHAT THE TECHNOLOGY COULD DO, AND HOW IT WOULD SATISFY THE NEEDS THAT EXIST.	☐	☐	☐	☐	☐	☐	☐
66. THE EXISTING DATABASE CONFIGURATION IN OUR ORGANIZATION WAS TOO AWKWARD FOR COMPATIBILITY WITH THE ADVANCED MANUFACTURING TECHNOLOGY (AMT).	☐	☐	☐	☐	☐	☐	☐
67. THIS ORGANIZATION HAD A STANDARD DATA COMMUNICATION SYSTEM FOR ADEQUATE EXCHANGE OF PRODUCT DESCRIPTION DATA, PRIOR TO ATTEMPTING TO IMPLEMENT THE ADVANCED MANUFACTURING TECHNOLOGY (AMT).	☐	☐	☐	☐	☐	☐	☐

	AGREE STRONGLY	AGREE	AGREE SLIGHTLY	NEUTRAL	DISAGREE SLIGHTLY	DISAGREE	DISAGREE STRONGLY
68. THIS ORGANIZATION HAD ADEQUATE INTERFACING OF INFORMATION BETWEEN THE NECESSARY FUNCTIONAL DEPARTMENTS, PRIOR TO ATTEMPTING TO IMPLEMENT THE ADVANCED MANUFACTURING TECHNOLOGY (AMT) PROJECT.	☐	☐	☐	☐	☐	☐	☐
69. THIS ORGANIZATION HAD ENOUGH PEOPLE POSSESSING THE TECHNICAL COMPETENCY REQUIRED TO INTEGRATE THE ADVANCED MANUFACTURING TECHNOLOGY IN OUR PLANT.	☐	☐	☐	☐	☐	☐	☐
70. IN THIS ORGANIZATION, CONFLICTS AND DIFFERENCES IN VALUES, BELIEFS, AND NORMS ABOUT COORDINATIVE ACTIVITIES, PRIMARY GOALS, AND APPROACHES TO CHANGE ARE QUICKLY DEALT WITH AND EFFECTIVELY SOLVED.	☐	☐	☐	☐	☐	☐	☐
71. WHEN CHANGES ARE NECESSARY, EVERYONE IN THIS ORGANIZATION HAS A CLEAR IDEA OF WHAT SORT OF CHANGES ARE AND ARE NOT ACCEPTABLE.	☐	☐	☐	☐	☐	☐	☐
72. IN THIS ORGANIZATION, PEOPLE DO THE BEST THEY CAN; THERE IS LITTLE PRESSURE TO STRIVE FOR SPECIFIC GOALS.	☐	☐	☐	☐	☐	☐	☐
73. PEOPLE IN THIS ORGANIZATION ARE VERY SUCCESSFUL IN DEALING WITH AND RESOLVING AMBIGUITY, AND CAN EFFECTIVELY COORDINATE THE ACTIONS OF INDIVIDUALS AND UNITS.	☐	☐	☐	☐	☐	☐	☐
74. THIS ORGANIZATION HAS A LONG HISTORY OF MAINTAINING STABLE PATTERNS OF SHARED VALUES, BELIEFS, AND BEHAVIORAL NORMS.	☐	☐	☐	☐	☐	☐	☐
75. IN THIS ORGANIZATION, THE PRESSURE TO MAINTAIN THE STATUS QUO IS SO GREAT THAT IF A MAJOR CHANGE WERE REQUIRED FOR THE ORGANIZATION TO SURVIVE, IT MIGHT NOT.	☐	☐	☐	☐	☐	☐	☐
76. THERE IS LITTLE CONSENSUS IN THIS ORGANIZATION WITH REGARD TO GOALS, PRACTICES, OR NEEDED CHANGES.	☐	☐	☐	☐	☐	☐	☐
77. THIS ORGANIZATION HANDLES PROBLEMS OF ADAPTING TO CHANGE WITH A HIGH DEGREE OF EFFECTIVENESS.	☐	☐	☐	☐	☐	☐	☐
78. MOST PEOPLE IN THIS ORGANIZATION HAVE THEIR OWN GOALS THAT MAY OR MAY NOT BE COMPATIBLE WITH ONE ANOTHER.	☐	☐	☐	☐	☐	☐	☐
79. PEOPLE IN THIS ORGANIZATION HAVE CLEAR CONCEPTS OF THEIR OWN ROLES AND HOW THEY RELATE TO THE ROLES OF OTHERS.	☐	☐	☐	☐	☐	☐	☐
80. THIS ORGANIZATION HAS SHOWN THAT IT IS ABLE TO SET AND REACH IMPORTANT GOALS.	☐	☐	☐	☐	☐	☐	☐

IV. OVERALL OPINIONS

INSTRUCTIONS: This part of the questionnaire is designed to obtain your opinions of the factors that you consider essential to the Advanced Manufacturing Technology (AMT) implementation process in order to realize the system's full potential. Please answer all the questions in your own words as completely as possible.

1. If you had to implement your AMT system all over again, what would you do differently?

2. In your opinion, what are the top three factors inhibiting a more rapid implementation of this AMT project in your firm?

1.

2.

3.

3. In your opinion, what are the top three factors that contributed to the successful implementation of this AMT project in your firm?

1.

2.

3.

4. In your opinion what are the top three specific benefits of this AMT project implementation to your firm?

1.

2.

3.

5. Which department(s) were represented in your project team for the AMT implementation? (Please list department and number of people represented from each department.)

DEPARTMENT	# OF PEOPLE REPRESENTED

V. DEMOGRAPHICS

INSTRUCTIONS: This part of the questionnaire is concerned with information about the individual respondent's background that will help to place proper perspective on the study. Simply omit any question you do not wish to answer in this section.

1. Please indicate the time you have spent in your present position (√).

_____a. Less than 1 year

_____b. 1 to 3 years

_____c. 4 to 7 years

_____d. 8 to 12 years

_____e. 12 to 16 years

_____f. Over 16 years

2. Please check the level of formal education you have completed (√).

_____a. High School

_____b. Some College

_____c. Bachelors Degree

_____d. Graduate Degree(s)

3. Please indicate your total number of years of experience in this technology area (√).

_____a. Less than 2 years

_____b. 2 to 5 years

_____c. 6 to 9 years

_____d. 10 to 13 years

_____e. 14 to 17 years

_____f. Over 17 years

4. Have you been involved in your **AMT** system operation recently?

______a. Yes ______b. No

5. If your response to #4 above is Yes, What are (were) your duties with the **AMT** system operation?

6. Please list the top three activities related to your AMT system that you spend most of your time performing : From 1 = (most of your time spent) to 3 = (third most of your time spent).

1.

2.

3.

THANK YOU FOR YOUR TIME AND EFFORT. YOUR RESPONSES WILL BE HELD IN STRICTEST CONFIDENCE.

☐ **Check here if you wish to receive a summary of this survey**

APPENDIX C

INITIAL CORRESPONDENCE

OSU

Oklahoma State University

INDUSTRIAL ENGINEERING AND MANAGEMENT

STILLWATER, OKLAHOMA 74078-0540
ENGINEERING NORTH, ROOM 322
(405) 744-6055
FAX: (405) 744-7673

January 19, 1989

REQUIREMENTS FOR SUCCESSFUL IMPLEMENTATION OF ADVANCED MANUFACTURING TECHNOLOGY

Dear

We are conducting a doctoral level research to study "The Requirements for Successful Implementation of Advanced Manufacturing Technology (AMT)", in the United States. This study is being conducted by the school of Industrial Engineering and Management at Oklahoma State University, and your project(s) has been chosen to be included in the sample for this study. Your name was supplied to us by who worked with you during the project.

She indicated that you are extremely knowledgeable about the project that was implemented at your company, and that you would be able/willing to complete the attached survey for us. Your experiences would be very valuable to us in our efforts to complete this research and since we are making this request of only a small select group, your individual reply is most important to make our information useful and reliable in guiding future implementation efforts.

The attached questionnaire should take about twenty (20) to twenty-five (25) minutes of your time to complete. Please answer all the questions in the questionnaire completely. If at all possible, please return the completed instrument to reach us within the next week.

When the instrument is completed, please fold it lengthwise so that the return address is visible, and staple it closed, and drop it in the mail. Return postage is provided for your convenience.

We want to assure you that your responses to the entire instrument will be kept strictly confidential, and will not be linked to you or your company when the data is analyzed. You will notice a number on your questionnaire. This number will only be used for our internal control and verification purposes. At no time will questionnaires be identified by name.

Page 2

As a token of our appreciation for your time and effort, a packet of Superior Brand Pekoe tea bag is included. We thought you might enjoy a nice cup of tea while completing the questionnaire. A summary of this study will also be made available to you whe n the study is completed. If you would like to receive the summary, please check the box provided at the end of the instrument, and one will be mailed to you.

If you have any questions about this survey, please call us at (405) 744 - 6055.

Sincerely,

John W. Nazemetz, Ph.D.
Research Director

Silvanus J. Udoka
Principal Investigator

APPENDIX D

FIRST FOLLOW-UP LETTER

OSU

Oklahoma State University

INDUSTRIAL ENGINEERING AND MANAGEMENT

STILLWATER, OKLAHOMA 74078-0540
ENGINEERING NORTH, ROOM 322
(405) 744-6055

February 10, 1989

Dear

About two weeks ago, a questionnaire seeking your opinions on the Requirements for Successful Implementation of Advanced Manufacturing Technology (AMT) was mailed to you. You were selected as a part of the survey sample, due to your extensive knowledge in the implementation process of some projects in your company.

If you have already completed and returned the questionnaire to us, please accept our sincere thanks. If not, please do so today. Your response is very important to the successful completion of this study.

If, by some chance you did not receive the questionnaire, or it got misplaced, a replacement is enclosed, and return postage is provided. As a token of our appreciation for your time and effort in completing the questionnaire, a pack of Flavored Lipton Caffeine Free Tea is included. We thought you might enjoy a cup of tea this time around, just in case you prefer caffeine-free tea to regular caffeine tea which was the token enclosed in our first mailing.

Your cooperation is greatly appreciated.

Sincerely,

John W. Nazemetz

John W. Nazemetz, Ph.D.
Research Director

Silvanus J. Udoka
Principal Investigator

APPENDIX E

SECOND FOLLOW-UP LETTER

OSU

Oklahoma State University

INDUSTRIAL ENGINEERING AND MANAGEMENT

STILLWATER, OKLAHOMA 74078-0540
ENGINEERING NORTH, ROOM 322
(405) 744-6055
FAX: (405) 744-7673

February 17, 1989

REQUIREMENTS FOR SUCCESSFUL IMPLEMENTATION OF ADVANCED MANUFACTURING TECHNOLOGY

Dear

About three weeks ago, a questionnaire seeking your opinions on the Requirements for Successful Implementation of Advanced Manufacturing Technology (AMT) was mailed to you. You were selected to be included in the survey sample due to your extensive knowle dge in the the process of implementing some projects in your company. We would therefore greatly appreciate it if you would take some time to complete and return the questionnaire to us today. Your response is very important to the successful completion o f this study. If, however, you have already completed and returned the questionnaire to us, please accept our sincere thanks.

If by some chance you did not receive the questionnaire, or it got misplaced, a replacement copy is enclosed, and return postage is provided for your convenience. When the instrument is completed, please fold it lengthwise so that the return address is v isible, and staple it closed, and drop it in the mail.

As a token of our appreciation of your time and effort in completing the questionnaire, a one-cup pack of Flavored Lipton Caffeine-Free Tea-Bag is included. We thought you might enjoy a cup of tea while completing the questionnaire. You will notice that w e included a caffeine-free tea this time around, just in case you prefer caffeine-free tea to the regular tea-bag which was the token enclosed in our first mailing.

If you have any questions about this survey, please call us at (405) 744 - 6055.

Sincerely,

John W. Nazemetz
John W. Nazemetz, Ph.D.
Research Director

Silvanus Udoka
Silvanus J. Udoka
Principal Investigator

CENTENNIAL
1890 • 1990

Celebrating the Past . . . Preparing for the Future

APPENDIX F

DATA FROM OPEN-ENDED QUESTIONS

RESPONSES TO THE OPEN ENDED QUESTIONS

Open-ended questions were included in the survey questionnaire to give the respondents an opportunity to express their views on AMT implementation issues beyond the set of items provided in the closed-ended questions. The questions asked were expected to to provide some support, and to further strengthen the responses to closed-ended items. The responses to open-ended questions are presented below, grouped by individual questions. The responses as presented here were quoted as close as possible to the form presented by the respondents, with the only changes occurring in statements that had information that would reveal the identity of the respondents or their firms. The reader will notice repetitions of some items in the responses. these were left in the sets to indicate the frequency of occurrence of each item under each question posed.

QUESTION #1:

If you had to implement your AMT system all over again, what would you do differently?

The responses as given by the respondents for this question, are listed below:

1. Start the software development off with a more clearly defined set of requirements.
2. Involve more personnel from the affected departments in the planning stages.
3. Locate designers and developers together sooner.
4. Obtain agreement from all departments represented in the AMT team that technical direction as well as budget and schedule control is provided by AMT program office and not line organizational departments.
5. Combine "visual-aids" project with the "actual" project to insure timely implementation.
6. Develop a more thorough requirements definition prior to starting computer software design.
7. Provide a break between operations to simplify the line design, as opposed to one complex line.
8. Plant staff came on board over 12 months. after plant design was set. Should be part of planning. Average age of staff, excluding plant manager, was 29. No one had a good knowledge of managing processor much experience managing people.
9. Better up-front planning about the plant operating organization and what's ahead.
10. More specific simulation concerning the flexibility of the manufacturing process.
11. Insist that more technical competence and experience be involved.

12. Concentrate all efforts to evolve human systems towards the proper development of the technical systems.
13. Insist upon appropriate start-up staffing to deal with the myriad of problems at that time.
14. Set higher standards for completeness and accuracy of specifications and documentation.
15. Use more commercial software instead of "homegrown" variety.
16. Use distributed computers and UNIX, instead of IBM mainframe.
17. We developed this system with this particular project in mind. I would like to have included other plant locations in this project and developed it on a corporate wide basis. We were the plant in our firm to develop this type of system. If it was on the corporate level, we would have been able to realize a greater benefit for the company.
18. Secure participation and support of middle management.
19. Push for more rapid implementation.
20. Involve shop earlier; too much engineering.
21. Better definition of project management to factory management.
22. Obtain unquestioned support and commitment of resources (proper personnel, commitment of all affected organizations) by top management.
23. Be more intentional in providing training and application of "management of change" principles.

24. Work more closely with user's in the beginning.
25. Would draw from the middle managers and hourly employees. More of their ideas and attempts to obtain greater buy-in to the concept.
26. Detailed analysis of possible threats to plants execution.
27. Set-up small prototype implementation.
28. Better education of support groups.
29. Since we are implementing in phases we are able to adjust to the variances encountered. However, I would train the implementation Team more extensively prior to starting and establish realistic goals to scheduling.
30. Define and develop a more through AS-IS/TO-BE scenario with the defined cost and saving estimates.
31. Obtaining higher management input and support and additional resources.
32. Try to secure enough funding for the AMT implementation process. Insufficient funding is a major constraint to a successful AMT program.
33. Select more flexible, smaller, lower cost equipment.
34. Ensure involvement at all levels.
35. Prepare manufacturing through quality improvements prior to implementation.
36. Full time project team.
37. Commitment from upper and middle management via pay incentives.

38. Take a better look a the information flow existing and desired after implementation.

39. Provide education to management early and a more detailed training later.

40. Take a longer range look at downstream data requirements in such areas as technical publications, shop floor data access, etc.

41. More cell team leader training.

42. Would change some machine tools and control hardware.

43. Try to make it more user-friendly.

44. Spend more time educating people as to the process and focus more participation by the people in-house.

45. The in-house participants need to take complete ownership of the problem and the solution.

46. The system went in on time and met all of the signed-off users requirements and system functional specs. The only thing I would change has to deal with corporate culture and the way in which its various departments interact with the corporation and each other.

47. Have more face to face meetings with vendors on interfacing of equipment.

48. Spend more time "selling" the system.

49. Ascertain more definitive customer requirements and forecast of need.

50. Charter the user organization with authority and responsibility for entire project. Top management should communicate that charter through all organizations, to minimize "turf wars" and duplication of effort.

QUESTION #2:

In your opinion, what are the top three factors inhibiting a more rapid implementation of this AMT project in your firm?

The list of the top three factors as presented by respondents for this question, are as follows:

1. Lack of user acceptance.
2. Inadequate functional design (revisions required).
3. Priority conflict with ongoing production demand.
4. Changing requirements.
5. Non-standard hardware.
6. Lengthy software development.
7. Machine vendor missed delivery dates.
8 Agreement to control hardware for production implementation.
9. Aggressive support of all departments involved in the project implementation.
10. Line design was too complex.
11. Plant staff did not "Buy In" to the project teams design.
12. Simulation not detailed enough - did not examine the complexity in the inspection/packaging process.
13. Late designation of key staff.
14. No one had real in depth experience with processors.

15. Lead engineer on site was of "old school" "I know how to do it".
16. Too much new technology being tackled at one time.
17. Inadequate engineering support for designed systems.
18. Inadequate staff support for start-up circumstances.
19. Need to continue manufacturing during cutover to new system.
20. Too few software developers.
21. Users' resistance to change.
22. Employees who are against change.
23. "Old Timers" who do not trust automation and computers.
24. Employees, especially middle management, who were too busy to learn about the system.
25. Lack of active support of middle management.
26. Some key managers who declined to participate.
27. Inadequate push from the top.
28. Lack of commitment.
29. Poor choice of personnel resources.
30. Lack of adequate funds.
31. Government procurement process.
32. Tradition (we have not done it that way).
33. Communication up and down between management.
34. Vast size of plant.
35. Age of plant.
36. Organizational boundaries.
37. Lack of support and acceptance by mid managers and hourly employees.

38. Lack of in-house ability to develop new business systems required for CIM system. We have 100 programmers working on this issue but this will be the primary factor inhibiting more rapid implementation.
39. Adjusting to change.
40. Lack of training.
41. Scheduling - not to inhibit production requirements.
42. Space requirements.
43. Lack of top management awareness/support.
44. Middle management turf battles/inertia.
45. Huge size of organization (45,000 people).
46. Savings justification.
47. Development/implementation functions better defined.
48. Better researched cost impacts external to the actual project.
49. Customer acceptance.
50. Project approval.
51. Priority.
52. Budget constraints.
53. Long-term orientation of the AMT process.
54. Management in-fighting.
55. Poor process control and product quality.
56. Poor education of employees (all levels) (traditional education, not project specific).
57. Poor product design.
58. Culture change.
59. Commitment.

60. Resources.

61. No disposition toward long term suppliers in this technology area.

62. Each factory is it's own profit center, hence they have the ability to make their own choices of systems and level of integration.

63. Education/training.

64. Leadership.

65. Reward system.

66. Leadership training.

67. Team member training.

68. Identifying location of cell teams in the manufacturing flow.

69. Copying the concept many plants lack the qualified personnel.

70. Level of staff and financial requirements.

71. Lack of direction from top management.

72. Staff in-fighting in terms of priorities.

73. No full-time employees on AMT projects.

74. Managements reluctance to spend the money.

75. Resistance to change.

76. Intangible cost and value of the study to develop an implementation plan.

77. The tendency to rely on the consultant team too much - and then not value the results they present.

78. Lack of corporate and facility buy-in and participation.

79. Poor communication and co-ordination within the various departments involved.
80. More participation by the "customers"... they often do not really know what they want, change direction frequently and cause schedule delays and cost build ups.
81. Interfacing with Government.
82. Interfacing with vendors.
83. Time required to justify the project.
84. Time required to build consensus.
85. Time required to resolve divisional differences.
86. Lack of top level strategic direction.
87. Lack of long term resource commitment.
88. Resistance to change.
89. Budget allocations (almost always short of operation needs).
90. Management in-fighting.
91. Long-range orientation of R&D and associated costs.
92. Customer requirements.
93. Geographical dispersion.
94. Lack of competent management.
95. Economic factors - program cancellations.
96. Lack of cooperation from product engineering in design modifications for robotic manufacturing.

QUESTION #3:

In your opinion, what are the top three factors that contributed to the successful implementation of this AMT project in your firm?

the list of the top three factors as presented by respondents for this question are listed below:

1. Building a project team and isolating them from political demands of home departments.
2. Top management interest, support, and commitment to successful implementation.
3. User participation in design.
4. Contractually imposed demonstration dates.
5. Good people assigned to the project.
6. Location of designers and developers together.
7. Middle management Support.
8. Pragmatic approach to implementation.
9. Decision to implement was strategic and not based on short term Return on Investment (ROI).
10. All disciplines were involved in the project.
11. Project management focus.
12. Technical support at start-up by people who know the process to be automated.
13. Top management support of doing things differently.
14. Adequate funding.

15. Top management agreement to "do it right" even if schedule slipped.
16. Project management and planning.
17. Selection of individuals on plant staff.
18. Top management support to correct system design errors.
19. Highly competent software developers.
20. Management support.
21. Starting the system up in a new plant.
22. Dedication of the team members.
23. This AMT project was implemented in a new plant - no old habits or retraining required.
24. Desire of team members to accept a challenge.
25. Support for concept from top of the plant (although it could have been more demanding).
26. Outstanding project leader.
27. Very successful introduction of MRP just proceeding JIT on shop floor.
28. Hard work by contractor and project team.
29. Management support/corporation.
30. Cross-functional team.
31. Good upfront planning.
32. New technology organization with creative/assertive leader.
33. Assignment of "can do" people to project.
34. Management commitment.
35. Customer support.
36. User buy-in.

37. Dollars available to support project.

38. Strong commitment on part of upper management.

39. Having time to implement system without being forced to address other issues immediately.

40. Championship was effective.

41. Simple beginning.

42. Advertise success/education.

43. Top management support.

44. The ability and desire to challenge.

45. Dedication of implementation Team.

46. Small core of dedicated enthusiastic people.

47. Consultant expertise.

48. Customer pressure on company.

49. Perseverance.

50. Strong coordination and affiliation.

51. Thorough planning.

52. Technical know how.

53. Customer support.

54. Available equipment.

55. Dedicated staff.

56. Market demand.

57. Competition.

58. Better understanding of management.

59. Good project team.

60. Multidisciplined implementation team.

61. A "local champion".

62. Good education/training.

63. Top management commitment.
64. Employee involvement.
65. Incentive system.
66. Total team effort.
67. Large volume production product.
68. People wanting to improve and be part of improvement.
69. Planning.
70. Teamwork.
71. Phased implementation.
72. Middle management's desire to see it happen.
73. The engineer's ability to figure out and make it happen.
74. Commitment and determination by a dedicated few.
75. Timeliness of the program relative to the upward or downside market conditions present.
76. Vision of where the company needs to be technically in the next 5 years.
77. Dedicated, knowledgeable, trained core team in a multi-disciplined environment.
78. Re-use of existing hardware and software "modules" from previous efforts.
79. Clear and concise requirements and specifications in line with user expectations.
80. Head of project team.
81. Team leaders.
82. Plant maintenance.
83. The understanding and longevity of middle managers.

84. The commitment of the design team.

85. The clear need for the system.

86. Strong problem manager (over both engineering and manufacturing.

87. Dedicated full time team.

88. Market demand and pressure.

89. Dedication and perseverance of project personnel.

90. Need to outwit competition.

91. Management.

92. Technical expertise.

93. Hard work.

94. Cooperation amongst cognizant organizations.

95. Good vendor/supplier support.

96. Clear understanding of specifications and requirements.

QUESTION #4:

In your opinion, what are the top three specific benefits of this AMT project implementation to your firm?

the list of the top three factors as presented by respondents for this question are provided below:

1. Flexibility to respond to changing production demand.
2. Visibility of tomorrow's requirements today.
3. Reduced work in process (WIP) inventories.
4. Reduced lead times.
5. Reduced scrap and rework.
6. Learn how to become partners.
7. Consolidated data base.
8. User education about factory of the future.
9. Competitive position for the future.
10. Reduced production cost.
11. Reduced inventories.
12. Capacity - meet sales forecast.
13. Flexibility - quick changeovers, small runs, better service.
14. Regional support of the business as opposed to having "all the eggs" in one basket with one plant.
15. Proved AMT can work.
16. Reduced management costs and tighter process control.
17. Reduced inventories.

18. New manufacturing facility in western half of country - customer service.
19. Provides second U.S. manufacturing site which could potentially be favorable during corporate negotiations
20. Manufacturing capacity.
21. Decreased lead-times.
22. Smaller inventories; work-in-process and raw material.
23. Lower costs through decreased labor requirements.
24. Improved customer service.
25. Improved quality.
26. Less labor required to perform tasks.
27. Greatly shortened manufacturing interval - greater flexibility.
28. Potential for lower cost.
29. Sparked improvements in other parts of this facility and in other facilities.
30. More efficient process planning.
31. More efficient design process.
32. Reduction in process planning time.
33. Routing standardization.
34. Tooling standardization.
35. Exposure as a company with innovative manufacturing technology.
36. Set the tone for follow-on projects to modernize.
37. Future survival.
38. Financial.
39. Communications.

40. Reduced cost.
41. Better turnaround time for production.
42. Reduced inventory or parts in process.
43. Productivity improvements.
44. Inventory savings.
45. Plant form for integration.
46. Improved quality.
47. Improved productivity.
48. Reduction of cost.
49. Will reduce costs.
50. Manufacturing will be more flexible.
51. Quality improvement.
52. Costs savings.
53. Quality.
54. Cost savings.
55. Reduces span time.
56. Introduction of new technology.
57. Streamlining of the production process.
58. Cost reduction.
59. Product quality improvement.
60. Learned not to do it again.
61. Learned where to focus attention.
62. Single plan used by all organizations.
63. Reduced inventory and WIP cost.
64. Proactive instead of reactive management.
65. Reduced product cost.
66. Improved product quality.

67. Reduced product change/introduction times.
68. Customer satisfaction.
69. Company reputation.
70. Reduce the overall product costs.
71. Cost reduction.
72. WIP reduction.
73. Cycle time reduction.
74. Quality improvement.
75. Lead time reduction.
76. Cost savings.
77. Reduce paperwork.
78. Increased production.
79. Easier access to information.
80. It forced us to examine and question the way we do things.
81. Spin off projects that come from the study time. We were not aware needed doing.
82. Visible "success story" to prove that our methods, tools and people can provide higher quality systems at lower overall cost.
83. Increased user acceptance and understanding which leads to better process capabilities.
84. Provided a test bed or platform for higher level integration activities.
85. Quality product.
86. Worker safety improvements.
87. Productivity improvements.

88. Accuracy of information.

89. Timeliness of information.

90. Manufacturing performance.

91. Enhanced competitive position on this product line.

92. Will serve as pilot for other plant application.

93. Cost reduction.

94. Quality improvement.

95. Streamlining of production process.

96. Knowledge.

97. Experience.

98. Potential future improvements.

99. Increased flexibility in implementing design changes.

100. Reduced tooling costs.

101. Reduced schedule impact during design changes.

VITA

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Candidate for the Degree of

Doctor of Philosophy

Thesis: AN INVESTIGATION INTO THE REQUIREMENTS FOR SUCCESSFUL IMPLEMENTATION OF ADVANCED MANUFACTURING TECHNOLOGY (AMT)

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