

INTERN EXPERIENCE AT  
TECH TRAN CORPORATION  
NAPERVILLE, ILLINOIS

AN INTERNSHIP REPORT

by

Joseph Alan Morgan

Submitted to the College of Engineering  
of Texas A&M University  
in partial fulfillment of the requirement for the degree  
of

DOCTOR OF ENGINEERING

JULY 1982

Major Subject: Industrial Engineering

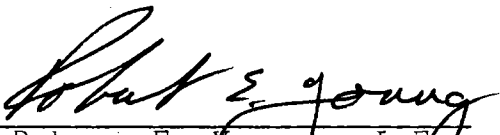
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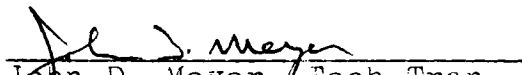
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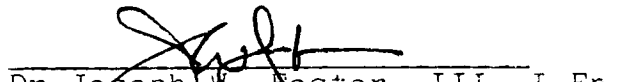
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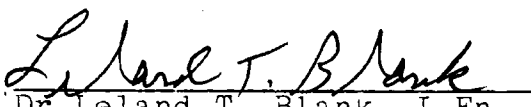
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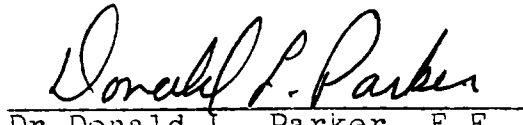
  
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July 1982

## ABSTRACT

Intern Experience at Tech Tran Corporation  
Naperville, Illinois. (July 1982)

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Chairman of Advisory Committee: Dr Robert E. Young

This report presents a survey of the author's internship experience with Tech Tran Corporation during the period September 1, 1981 through May 1, 1982. The eight month internship was spent as an associate engineer and associate editor assigned to the engineering branch. The intent of this report is to demonstrate that this experience fulfills the requirements of the Doctor of Engineering internship.

The author's internship activities are presented to document the achievement of three major objectives: orientation to professional engineering consulting; development of management and interpersonal skills; and recognizable contributions to the internship firm. These objectives were attained through trips to various organizations, meetings, and conferences involved in manufacturing technology, assignments as an engineering consultant representing Tech Tran, and work performed on three major Tech Tran contracts.

The result of this internship experience was an appreciation for both the technical and non-technical aspects of operating an engineering consulting firm. The conclusion of the report is that the objectives were realized, and the internship requirements for the degree of Doctor of Engineering were satisfied.

## ACKNOWLEDGEMENTS

There are many people without whom this internship experience would not have been possible and are thus deserving of my sincere appreciation and gratitude. I would first like to thank all the wonderful people at Tech Tran for their guidance, encouragement, and friendship. I am particularly indebted to Mr Ron Sanderson for his wit and wisdom and to Ms Claudia Kulak for her untiring assistance. I am especially indebted to Mr John Meyer, my internship supervisor. Mr Meyer's patience, openness, and support were the key to the success of the internship.

I am certainly grateful to Dr Robert E. Young, my committee chairman during both my master's and doctor's degree programs, for his advice, direction, and understanding. I would also like to thank the other members of my committee for their support of my graduate studies.

Most importantly, I would like to thank my wife, Donna, and my children, Alan and Kathi, for the many sacrifices they have so willingly endured so that I might pursue my graduate degrees. Without them, it would all be for naught. Thank you family.

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## FINAL SET OF OBJECTIVES

DOCTOR OF ENGINEERING INTERNSHIP OF JOSEPH A. MORGAN

TECH TRAN CORPORATION, NAPERVILLE, ILLINOIS

SEPTEMBER, 1981 - MAY, 1982

### OBJECTIVE I - ORIENTATION

Become familiar with the overall organization of Tech Tran Corporation. Observe the interaction between consultants and clients. Understand how the various functions of the firm are utilized to produce results. Place special emphasis on those areas with ongoing activities in my field of expertise so as to expand my education and broaden my knowledge.

### OBJECTIVE II - DEVELOPMENT

Take every opportunity to develop technical, managerial and interpersonal skills.

a. Improve technical expertise by continued research in state-of-the-art manufacturing processes and application of my engineering skills.

b. Study and practice the managerial techniques used by Tech Tran. Participate in discussions involving philosophy of management and client relationship.

c. Improve oral communication techniques by making presentations at proposal, in-process review, or other types of contractual meetings.

d. Organize and conduct effective business meetings involving consultants and clients in order to accomplish specific goals.

e. Develop capability to compose effective memorandum, letters, proposals, reports, and other types of written communications.

### OBJECTIVE III - CONTRIBUTION

Make an identifiable contribution to Tech Tran Corporation by planning and execution of assignments relating to:

a. Development of an effective and comprehensive technical program management philosophy for the US Army Research and Development Command's Manufacturing Methods and Technology Program.

b. Engineering management level summaries of current innovative technologies in the area of automated electronic manufacturing for publication in Manufacturing Technology Horizons.

c. Justification of current projects and development of future project goals and priorities for the US Army Missile Command's Manufacturing Methods and Technology Program.

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## INTRODUCTION

The Doctor of Engineering program offers a viable alternative to the student who desires a non-research oriented course of study beyond the Master degree level. The primary purpose of the Doctor of Engineering degree is to prepare individuals to assume leadership positions as professional engineering managers. To function effectively in this role, the student must be well versed in his chosen technical discipline and have a broad knowledge of such non-technical fields as business administration, finance, and management. The Doctor of Engineering degree combines advanced academic studies with an extensive internship program.

The internship program provides the practical learning experience required for these positions of increased authority and responsibility. During the internship, the intern is able to function in a non-academic environment and is able to apply his knowledge to the solution of real-world problems in the field of technical management. Under the tutelage of an internship supervisor, the intern performs in a work environment designed to prepare him for an upper management position at the successful conclusion of his program.

This report describes the author's Doctor of Engineering internship with Tech Tran Corporation in Naperville, Illinois. The internship began September 1, 1981 and continued through May 1, 1982.

Mr John D. Meyer, President of Tech Tran Corporation, assumed the responsibilities of internship supervisor. The intern was assigned administratively to the Engineering Branch (see Fig. 1), but project assignment and functional control was exercised primarily by Mr Meyer.

While at Tech Tran, the intern was involved in numerous projects and activities. Three factors were normally considered in making these project assignments: 1) the intern's background and interests, 2) the internship objectives and requirements, and 3) the specific Tech Tran projects which were on-going during the internship time period. Job assignments were not limited to technical or engineering projects. Through the efforts of the internship supervisor, exposure was gained in areas such as development of managerial philosophy and policy, and identification and evaluation of new manufacturing processes. Figure 2 shows the approximate percentage of the total internship period spent performing each of the diversified activities which comprised the total internship experience.

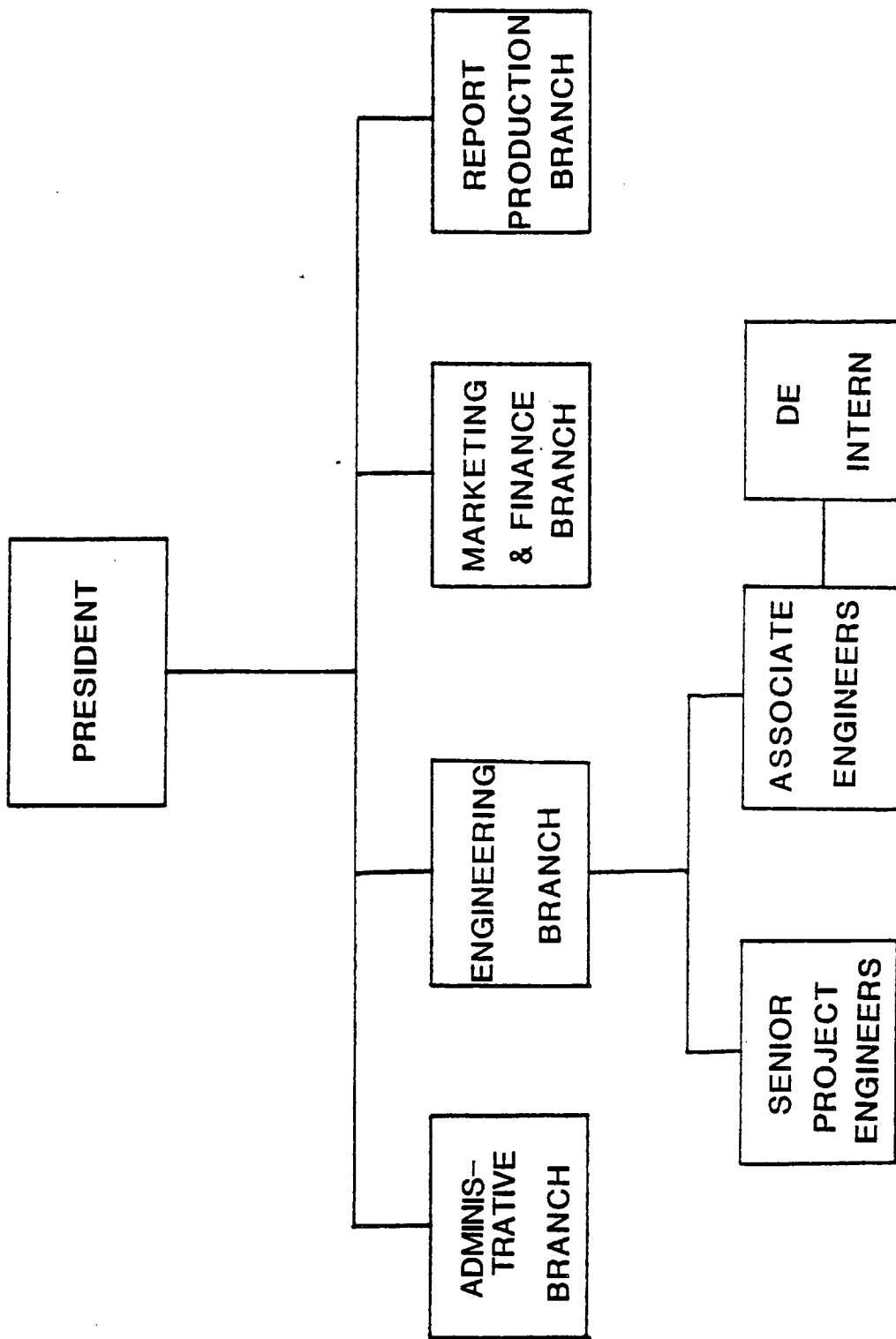


FIGURE 1. TECH TRAN CORPORATION ORGANIZATIONAL CHART.

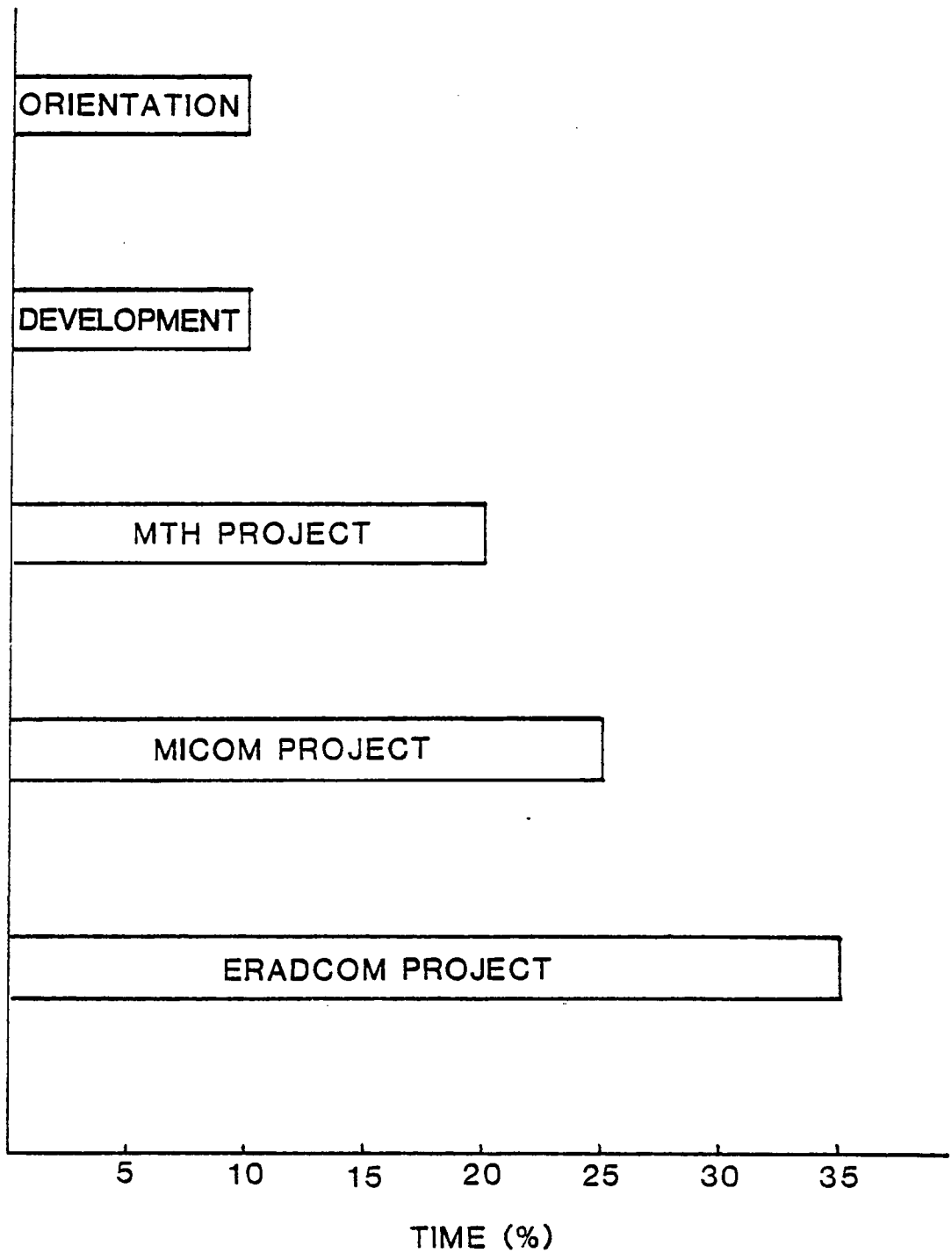


FIGURE 2. INTERNSHIP ACTIVITIES TIME ALLOCATION CHART.

The primary goal of the intern's doctorate program is to become an effective and capable technical program manager in the area of automated manufacturing. The secondary goal is to obtain educational and practical experience necessary to progress to the executive level within a large corporation or to start a private business. The internship at Tech Tran Corporation has greatly contributed to realizing these goals.

Upon completion of the doctorate program, it is highly probable that this intern will be assigned as an Air Force technical program manager. As such, a significant portion of this assignment will involve interaction with private industry. Obtaining the perspective of an professional consultant working on government contracts at Tech Tran significantly increased the effectiveness this intern will have in monitoring future Air Force programs.

Because Tech Tran is a relatively new consulting firm, the intern was able to observe, first-hand, the difficulties and obstacles, as well as the rewards and advantages, of beginning a new business. These experiences will prove highly beneficial should the intern have the opportunity to start his own business.

During the course of the eight month internship, the intern received assignments as an Associate Engineer, Tech Tran Corporation and as an Associate Editor,



Manufacturing Technology Horizons. As an Associate Engineer, the intern's duties and responsibilities were those of an engineering management consultant to Tech Tran's clients from both private industry and governmental agencies. Specifically, these duties included: attending numerous conferences, meetings, and government laboratory tours; research and data collection via data base and literature reviews; telephone and in-person interviews; analysis of technical, managerial and financial data; reduction of these data to implementation strategies in the form of procedures and guidelines; and documentation of efforts through presentations, technical summaries, and reports.

In addition to consulting services, Tech Tran Corporation publishes a bimonthly technology digest called Manufacturing Technology Horizons. Duties as an Associate Editor of the digest consisted of: surveying private industry and governmental research and development facilities for new or improved technologies; determining potential impact of candidate R&D projects on the manufacturing environment; and summarizing selected technical projects in managerial-level terms for publication.

As a result of working directly for the president and chief engineer of a newly incorporated firm, the intern has gained a greater appreciation for both the

technical and nontechnical aspects of starting and running a small business. This variety of experiences has provided a more enlightened view of this type of endeavor which could not otherwise have been achieved in such a short time frame.

The intent of this report is to demonstrate that the internship with Tech Tran Corporation satisfies the internship requirements of the Doctor of Engineering Program. This will be accomplished by showing that each of the objectives has been met.

Following the next section, which describes the internship company, the report is subdivided into four main sections. The first deals directly with the orientation and development objectives. The remaining three sections correspond to three major projects accomplished during the internship which satisfy the contribution objective.

## THE INTERNSHIP COMPANY

Formed in 1978, Tech Tran Corporation is an engineering consulting firm which provides specialized services and information products in the area of technology management. The company possesses significant expertise in long-range planning; research and development management; technology forecasting; and market research. Although Tech Tran conducts assignments in a wide variety of industries, the firm concentrates the majority of its resources in the area of new manufacturing processes and methods. Tech Tran's clients include industrial manufacturers, government agencies, engineering and consulting firms, and research institutes.

Tech Tran employs a group of approximately twenty staff members who are supplemented by over twenty additional part-time consultants. The consulting firm's headquarters are located in Naperville, Illinois, a suburb of Chicago. The company also has employees in the Washington D.C. area, Huntsville, Alabama, and Dayton, Ohio. Collectively, these individuals represent a unique resource in the field of technology transfer and assessment.

Since its formation, Tech Tran has evolved into a central focal point for information associated with

manufacturing on both a national and international level. The company has recently initiated several new ventures to expand its role in information transfer activities. These include publication of Manufacturing Technology Horizons, a bimonthly digest on new production technology. Other projects include the preparation of a series of technology assessments and forecasts in selected manufacturing technology areas such as robotics; lasers in metalworking; computer-aided process planning; and the development of several proprietary computerized data bases on manufacturing technology references, needs and development projects.

## ORIENTATION AND DEVELOPMENT

### Introduction

A major goal of the Doctor of Engineering internship program is to provide a nonacademic environment which affords the student an opportunity to participate in "real world" engineering management and to observe professional engineers and managers in action. To achieve this goal, two separate objectives were established for the internship.

- o Orientation. Become familiar with the overall organization and understand how the various functions of the firm are utilized to produce results.

- o Development. Take every opportunity to develop technical, managerial, and interpersonal skills.

The first objective permits the intern to become familiar with the overall organization of the internship company and to understand how the workings of the various functions of the firm are utilized to produce results. Because Tech Tran Corporation is a relatively small firm, orientation to the company itself required only a small fraction of the internship. This objective was, therefore, broadened to encompass orientation to the world of engineering management consulting.

The second objective provides the intern with a chance to develop his own technical and managerial skills. As this objective is difficult to achieve within the confines of academia, the Doctor of Engineering internship is particularly well suited for this purpose.

Satisfying these first two objectives was an on-going function that was accomplished throughout the entire internship. Although all internship activities played a role in achieving these objectives, there were particular functions which typified the manner in which these objectives were realized. Through a series of trips, visits, meetings and technical shows the intern experienced an in-depth indoctrination into the profession of engineering consulting and expanded his abilities as a technical manager. A representative sampling of these activities is presented in the following paragraphs. A discussion of the benefits obtained from this type of exposure is contained in the summary of this section.

A significant proportion of Tech Tran's assignments in the area of technology assessment is with governmental agencies. The agencies include both civilian and military organizations involved in manufacturing research and development. For a consultant to actively participate in such projects, he must have a working knowledge of these organizations, their internal structure, and current projects of interest.

In order to achieve a broad exposure to this environment, the intern supervisor arranged for the intern to make numerous visits to a wide range of government organizations. In most cases the intern was able to spend at least a full day at each location. Some of the more interesting and useful visits are described in the following paragraphs.

#### National Bureau of Standards

One of the first agencies visited by the intern was the National Bureau of Standards (NBS) located in the Maryland suburbs of Washington D.C. The point of contact for this visit was Mr Bradford M. Smith from the Manufacturing Systems Group. Highlights of the trip included a tour of the NBS facilities, attending a planning meeting for a technical report to be published by NBS, and discussions of projects of mutual interest to NBS and Tech Tran.

NBS is actively involved in robotics and automation technology. The Bureau is pursuing research related to interface standards, performance measures, and programming languages for systems and integrated computer-aided-manufacturing systems. As part of this research, NBS is developing and constructing a hierarchically controlled flexible manufacturing system. The major goal of this

project is to stimulate diffusion of advanced manufacturing concepts in both government and industry so that the economies of mass production can be brought to the small job shop. The primary purposes of the facility are 1) to be a showpiece of American technology, and 2) to support research and development by both NBS personnel and other manufacturing firms and research institutions involved in automated processes.

The tour focused on the automated facilities which were presently under construction. These included the computer-aided-design graphics installation and the machining workstations. Tech Tran's main interest is in machining workstations because of the potential for developing new manufacturing processes and methods. NBS has an impressive track record, and meeting and talking with the individuals assigned to these projects was invaluable to a consultant assigned to assess and evaluate future impacts of new technologies.

Because of the intern's background and interest in automated manufacturing, Mr Smith arranged for the intern to attend an afternoon meeting being held to review the status of a two volume technical report on the Bureau's automated manufacturing system. During a break in the meeting, the intern had the opportunity to meet and talk with the co-chairmen of the meeting, Dr James S. Albus, Head of the Industrial Systems Division, and Mr Robert



J. Hocken, Head of the Manufacturing Systems Group. Both of these gentlemen are respected authorities in the field of manufacturing and industrial automation technology.

Mr Smith also arranged several impromptu meetings with project leaders in the areas of microprocessor control and robotics. Of particular interest to the intern were the vision and proximity sensor systems being adapted to commercially available robots.

The intern was also briefed on the methodology NBS plans to use in implementing their hierarchical network of microprocessor-based controllers. NBS will not be using the more conventional event-driven interrupt control technique but rather a "billboard" approach which was developed at NBS. This approach is reported to be easier to implement and test. Exposure to this type of "first-hand" information is an excellent example of the beneficial aspects of the Doctor of Engineering internship program.

The intern and Mr Smith concluded the visit with a discussion of potential projects which might be undertaken by Tech Tran in support of the NBS automated facility. Two projects were identified as a result of these discussions. First, a need existed for a study to be prepared on the development and implementation of sensors into automated manufacturing processes. Secondly, a study was required to assess the state-of-the-art in

robot controllers. Both of these projects were subsequently initiated by Tech Tran through multi-client proposals. This intern provided some of the research and background investigation for the sensor project.

### Office of Technology Assessment

The Office of Technology Assessment (OTA) is a government agency which provides advice and guidance on technological subjects directly to Congress and numerous congressional subcommittees. As part of the Communication and Information Technology Program, OTA sponsored a robotics workshop at its Washington D.C. offices. The purpose of the workshop was to gather information on the status of robotics and their implication in the industrial community both in the U.S. and abroad.

Attendance at the meeting consisted of twenty-five invited guests who formed the nucleus of the workshop. The guests included congressional staff members, executives from robot manufacturing/user firms such as Unimation and General Electric, economists and investment analysts, and experts in foreign technology. Each of these guests was a respected authority in his field as it related to robotics. This intern was fortunate to be selected to represent Tech Tran Corporation at the workshop as a member of a small audience.

Four papers were presented during the morning sessions on several key areas of robotics. Dr James S. Albus of the National Bureau of Standards discussed the history of robot technology and presented a synopsis of significant research and a forecast of the future of robotics. The outspoken economist Dr Bela Gold presented his views on productivity and competitiveness in the robot age. A paper entitled "Robotics and Its Relationship to the Automated Factory" was presented by Mr Eli S. Lustgaren of Paine, Webber, Mitchell, Hutchins, Inc. The Japanese and Soviet efforts were assessed in a paper delivered by Mr Paul Aron of Diawa Securities America, Inc.

After the presentations the chairman conducted a roundtable discussion which focused on technology questions dealing with definitions, state-of-the-art, boundaries, and horizons. Other issues such as the economic, social, and political aspects of robotics were also addressed. After these discussions, the workshop participants fielded questions and comments from the audience.

This one-day meeting exposed the intern to more technical and non-technical information than could be collected in several months of library research. The intern was not only privileged to a variety of facts, figures, concepts, and opinions concerning robotics and

automation, but was also enlightened as to the lack of a consensus of opinion on what is needed and who should have responsibility in several critical areas of robot research and development, implementation, and utilization. The intern was also surprised at the misconceptions and lack of information which existed at this level.

The intern was impressed with the manner in which the chairman controlled the workshop. His ability to stimulate discussion yet avoid or quiet irrelevant conversation was very impressive. The opportunity to observe this type of managerial qualities in action was equally as important as the technological information which was gathered.

#### Pentagon

While in the Washington D.C. area, a meeting was arranged between the intern and Brigadier General Connelley, Chief of Air Force Plans for Contracting and Manufacturing, at his Pentagon office. General Connelley had recently returned from a visit to Japan where he toured several automated manufacturing facilities.

Discussions with General Connelley focused on his views of the Japanese utilization of robotics. The General also shared his ideas on how robotics could best

be used in the military environment. This meeting permitted the intern to gather more information on industrial automation and to better understand where this type of technology will be employed by the Defense Department.

### Air Force Manufacturing Technology Division

The Air Force Manufacturing Technology Division of the Materials Laboratory is part of the Air Force Wright Aeronautical Laboratories at Wright-Patterson Air Force Base in Dayton, Ohio. All program funding and management of projects dealing with new or improved manufacturing technology is handled by this division. The four major branches of this division are Metals, Non-metals, Electronics, and the newest, Computer Integrated Manufacturing. In fact the Air Force program office for its Integrated Computer-Aided Manufacturing (ICAM) Project is located in this latter branch.

During the internship, the intern made a one-day visit to the Manufacturing Technology Division. The Assistant Division Chief, Dr Vince J. Russo was the point of contact, and he provided an orientation briefing and a tour of the division.

Although the intern was introduced to the head of each of the four program offices, the highlight of the

visit was a meeting with Dr Norman M. Tallman, Chief Scientist of the Materials Laboratory. The meeting was extremely useful in understanding the need and scope of a new program the Air Force is initiating in the manufacturing technology research and development area.

As many of Tech Tran's assignments are linked to the DOD Manufacturing Technology Program, this visit was very useful. It permitted the intern to meet the engineers and managers responsible for Air Force Manufacturing Technology projects, to more fully understand the organizational structure and management philosophy of the Air Force program, and to collect information on upcoming Air Force projects.

#### ERADCOM Laboratories

Unlike the Air Force concept of centralized program management of its Manufacturing Technology program, the Army has decentralized this responsibility to each of its major commands. One of the major projects that the intern was involved in while at Tech Tran was with the Manufacturing Technology program of the Electronic Research and Development Command (ERADCOM). As part of this project, the intern visited three of ERADCOM's R&D laboratories. These were: 1) Harry Diamond Laboratories in Adelphi, Maryland; 2) Night Vision and Electro-Optics

Laboratory at Fort Belvoir, Virginia; and 3) Electronic Technology and Devices Laboratory at Fort Monmouth, New Jersey.

At each facility, the intern met with the Manufacturing Methods and Technology coordinator and received a tour of the laboratory. As at the Air Force laboratories these visits enabled the intern to meet the Army personnel from various technical and support areas who are involved in the Army's Manufacturing Technology program and discuss on-going and future projects of interest to Tech Tran.

#### Robot VI Conference

In addition to governmental agencies, the intern was able to attend several technical conferences. The most impressive of these was Robot VI. The sixth annual robot conference and exposition sponsored by SME was held at Cobo Hall in Detroit, Michigan in March, 1982. Due to its close proximity to the internship company, most of the Tech Tran technical staff attended the exposition.

In this intern's opinion, the SME show is one of the best technical displays available to industrial engineers and should be considered a must for anyone interested in automated manufacturing. A large portion of the leading and new-entry robot manufacturers such

as IBM and Westinghouse introduced new robots or complete product lines of robots. In addition, several presentations were made of recent research and development activities.

Robot VI permitted the intern to compare and contrast a wide variety of different robots doing various manufacturing tasks. Tasks ranged from product assembly and part manipulation to machining, welding, painting and test and inspection.

The intern also took advantage of this opportunity to meet and talk with executives, managers, and engineers of several companies involved in robotics. One such individual was Dr Dan L. Shunk, Director of Integrated Manufacturing Systems for the GCA Corporation's Industrial Systems Group. GCA is in the process of constructing a robot assembly facility in the Chicago area for a complete line of heavy, medium, and light load robots. His views on the future of robotic technology were both enlightening and informative.

### Meetings

Business meetings are recognized as the cornerstone of management consulting. The ability to conduct an effective business meeting is a fundamental skill that every aspiring technical manager must learn. Developing



these skills can be accomplished by both participating in and observing those who are well versed and highly skilled in conducting business meetings.

The intern supervisor has an extensive background in organizing and conducting effective meetings. Mr Meyer's capabilities stem from in-depth planning and preparation. The opportunity to observe and assist the intern supervisor prepare and conduct numerous business meetings has provided valuable insights into this facet of technical management. Because the intern traveled with Mr Meyer on several occasions he was able to observe him not only at intraoffice meetings but with clients and potential clients. Because of this exposure, the intern's ability to conduct effective meetings has been significantly improved.

### Summary

This section has documented representative internship activities which have provided the intern with an orientation to the field of engineering consulting. It has also provided documentation of activities which have resulted in the growth and development of the author's technical, management, and interpersonal skills.

Together with numerous other projects carried out during the internship, these activities constituted a

unique opportunity for the intern which would be difficult to duplicate. Being able to meet and converse with such a wide range of experts in the field of automated manufacturing, to be exposed to many new technologies and processes, and to have been involved in management-level decision making were uncomparable experiences. It is felt that few, if any, conventional positions could have offered such a stimulating program in such a short period of time.

In the following sections, the major internship projects which resulted in significant contributions to the internship firm are presented. The intent of these sections is to document that the third internship objective was satisfactorily accomplished.

## ERADCOM PROJECT

### Introduction

The extent to which an intern is able to make an identifiable contribution in an area of practical concern to the internship organization is the true measure of his experience. In satisfying this objective, the intern participated in three major projects while at Tech Tran Corporation. The three projects ran concurrently throughout much of the internship and were part of the various other activities described in the previous section.

This section focuses on one of the intern's major contributions to the Tech Tran Corporation. This was the development of a detailed technical management philosophy in the area of manufacturing technology. The client for this project was the US Army's Electronic Research and Development Command (ERADCOM), and the assignment centered around the management of Manufacturing Methods and Technology (MMT) projects by engineers within the ERADCOM organization.

The assignment encompassed approximately thirty-five percent of the intern's time and was highly beneficial to the intern's professional development in two ways. First, the intern was able to utilize his educational

background in such areas as electronics, management, finance, legal, and economics. Secondly, the intern prospered by the experience through his exposure to an entirely new area of manufacturing engineering and management.

The assignment forced the intern to very rapidly assimilate a myriad of information, facts, policies, directives, etc. in order to properly understand the tasks and objectives of the project. This situation is not uncommon in the engineering consulting profession, and the environment proved to be an excellent learning experience which will not soon be forgotten.

The purpose of this section is to describe the activities which were accomplished in the successful completion of the ERADCOM project. Sufficient background information on the ERADCOM organization and the Manufacturing Technology (also referred to as Man-Tech) program is provided in order that the reader more fully understand the work accomplished during the project. Following the background information, the problem which existed and the scope of the contract for Tech Tran's services is discussed. Next, the approach and accomplishments of the project are presented followed by a summary of the benefits which were achieved.

## Background

ERADCOM is the principle electronic research, development and acquisition center for the US Army. Headquartered in Adelphi, Maryland, the organization undertakes projects in such diverse areas as electronics signal intelligence, atmospheric sciences, target acquisition and combat surveillance, electronic fuzing, night vision, radar frequency and optical devices, instrumentation and simulation, and fluidics.

Program management of these diversified technical projects is vested in seven research and development laboratories within the ERADCOM organization. Each of the laboratories assumes a particular area of ERADCOM's overall mission responsibility and is somewhat autonomous in the management of their projects.

The responsibility for undertaking a viable Manufacturing Methods and Technology program is also part of ERADCOM's mission. The Army's MMT program is part of the DOD level Manufacturing Technology Program. The primary objectives of the tri-service (Air Force, Army, and Navy) program are to reduce acquisition costs and to improve materiel\* performance through the establishment

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\* Materiel denotes weapons and equipment of armed forces.

and implementation of new or improved manufacturing processes, techniques and equipment. The program attempts to bridge the gap between the R&D environment and the shop floor. Specifically, the goal of the program is to support scale-up to full production capability of technologies shown to be feasible in the laboratory.

As important as what the program is, is what the program is not. The scope of the Man-Tech Program does not encompass the research and development phase, nor does it provide for the actual implementation and use of the technology.

Although a tri-service program, each of the services has established their own management and funding structures consistent with DOD policies and criteria. The Army has chosen to decentralize their MMT Program so that each major command is responsible for funding and managing their own projects.

Within ERADCOM, the MMT Program has grown significantly in recent years to a level in excess of ten million dollars annually, and additional future growth is anticipated. Harry Diamond Laboratories, Night Vision and Electro-Optics Laboratory, and Electronic Technology and Devices Laboratory are the three ERADCOM laboratories that manage the major portion of ERADCOM's MMT effort. ERADCOM's program currently consists of individual projects in the area of detectors, displays, integrated electronics,

lasers, optics, materials/processes, and discrete solid-state devices. The majority of these projects are accomplished under contract to private industry with the contracts monitored by technical staff within the laboratories.

The technical staff member, or project engineer, is responsible for translating DOD and Army policy and directives into tasks and statements-of-work which meet the goals and objectives of the MMT Program. In so doing the engineer develops the initial project documentation and justification, prepares the procurement data package for contract solicitation and award, manages the contractor's technical efforts, and provides for follow-on activities to facilitate implementation and utilization of the project's results.

#### Problem and Scope of Project

One of the salient features of the Army's decentralization of responsibility for their MMT program is the ability to identify major thrust areas. Because each of ERADCOM's laboratories are product related, they can target significant problems where MMT projects will realize maximum benefits and utilization.

The disadvantage of this type of structure is the lack of involvement and appreciation by the project

engineers of the overall MMT Program goals.

Decentralization distributes the projects in such a manner that project engineers are normally involved in only one or two projects per year. The remainder of their time is focused on management of other R&D projects. In general, management considerations for R&D projects and MMT projects are quite dissimilar. Therefore, a lack of involvement and emphasis in MMT project management results in a lessening of the engineer's expertise as to the goals, objectives, and unique constraints of the MMT Program. Without a thorough knowledge of these factors, less than optimum effectiveness can be achieved.

The decentralized structure is also disadvantageous to ERADCOM due to its multiple laboratories. That is, each of the three laboratories participating in the MMT Program have in the past individually interpreted the program's policies and guidelines in establishing their own management practices.

Dissatisfied with the variation and inconsistencies among the three laboratories, ERADCOM contracted Tech Tran Corporation to provide engineering management consulting services to improve the overall capabilities of their program. The scope of this project was to develop a comprehensive approach to MMT project management. Specifically, Tech Tran was tasked to reduce current DOD and Army policies pertaining to the Man-Tech Program to



a practical and workable technical management philosophy and associated guidelines. Major factors considered in this development were funding strategies, project phasing, scheduling of deliverables, documentation of results, and transfer of the technology through implementation and utilization. Tech Tran was further tasked to document its findings and recommendations in a report which would become an ERADCOM handbook for project engineers to use in managing their MMT projects.

In addition to presenting a comprehensive technical management philosophy, the handbook would be used to prepare procurement data packages which would meet the special requirements and constraints of the MMT program. The preparation of a procurement package is a key activity in the solicitation, contracting, and management of MMT projects. Such a handbook would not only improve the productivity of the technical manager, but would also serve as a means of standardizing documentation and insuring that the package reflects those attributes required for successful project execution and implementation.

The contract was to be completed in a six month time frame. This length of time permitted Tech Tran to assemble the greatest amount of information possible for the handbook which could then be reproduced and distributed for use in the 1982 procurement cycle. Satisfying these obligations in the allotted time required a systematic

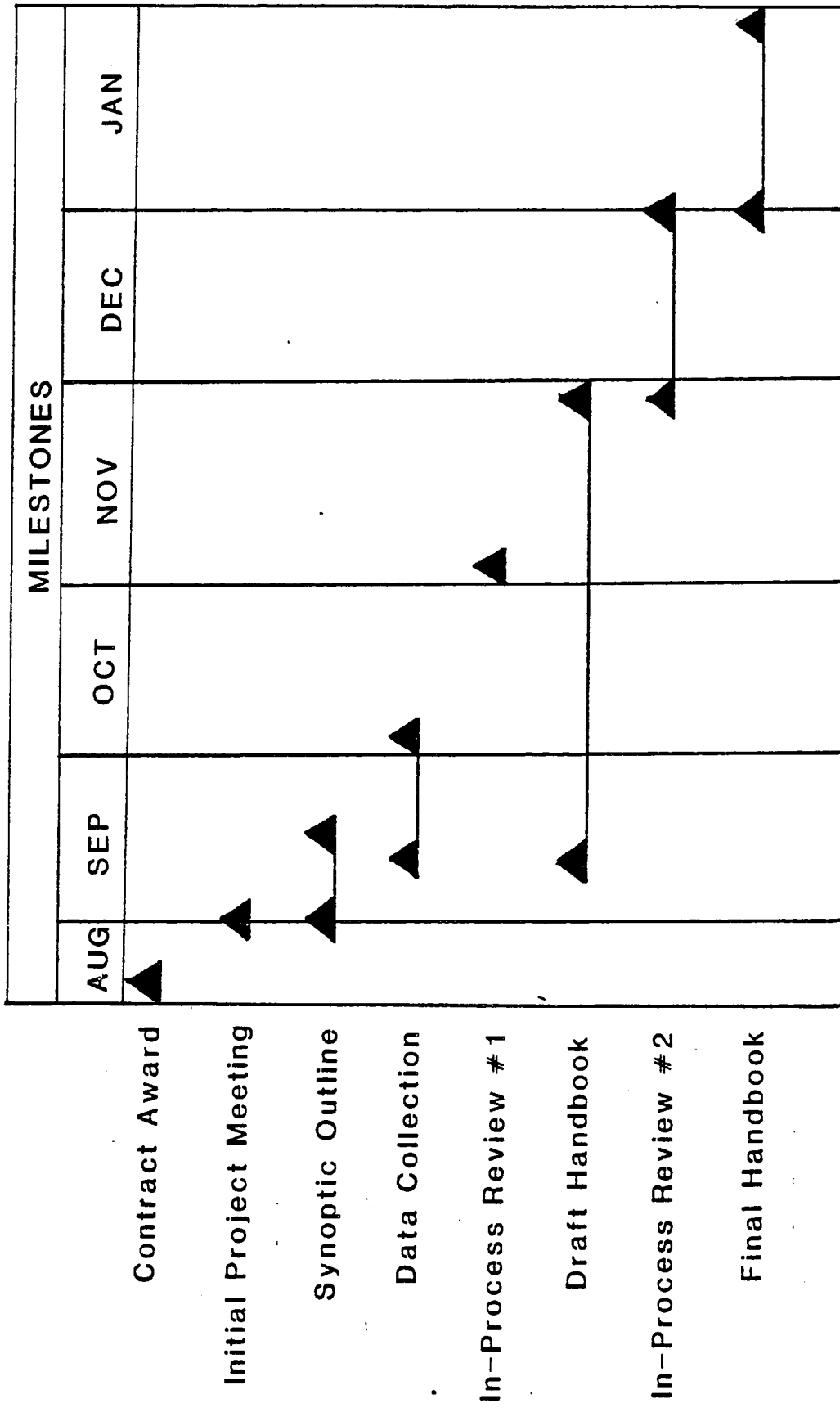


FIGURE 3. MILESTONE SCHEDULE FOR ERADCOM PROJECT.

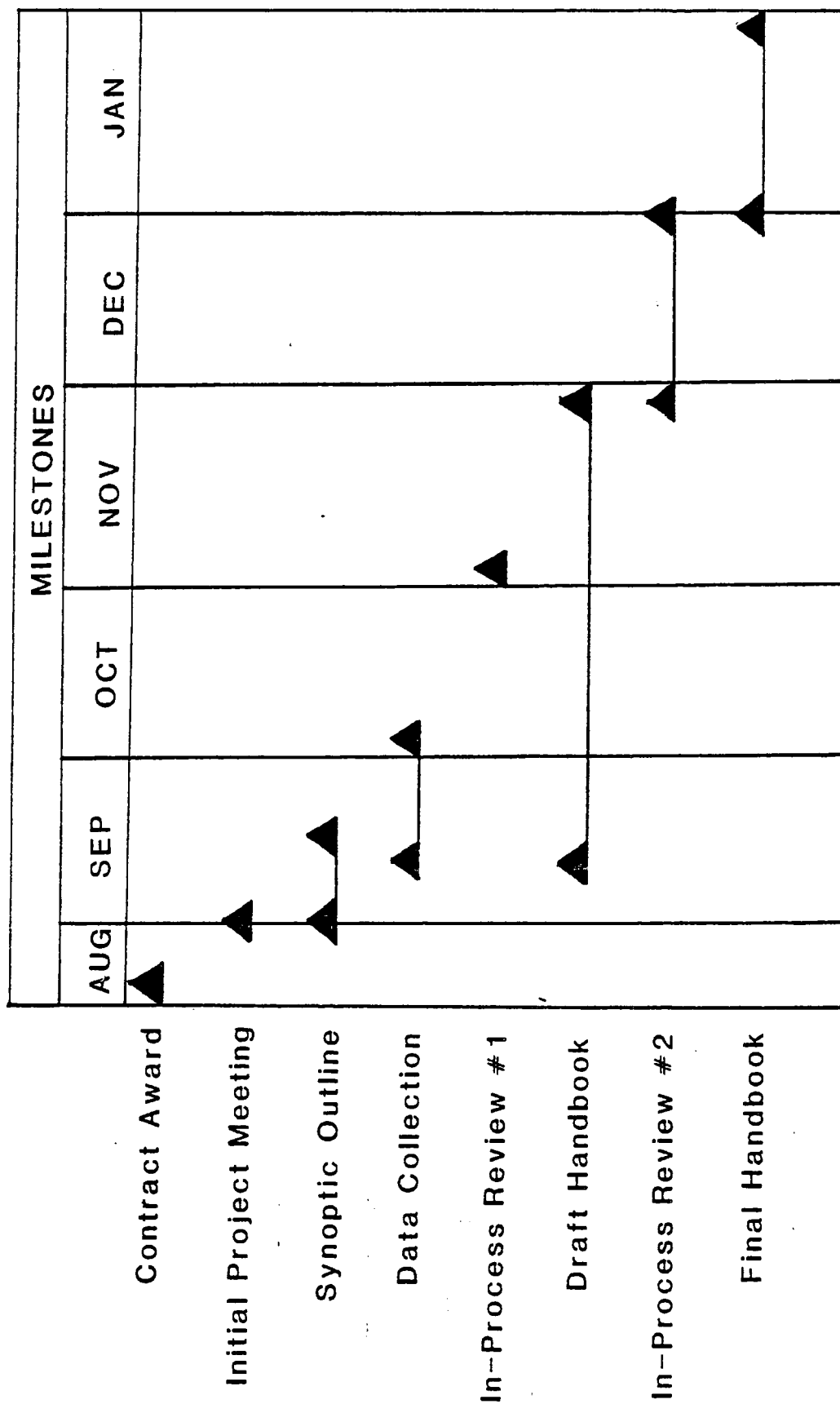


FIGURE 3. MILESTONE SCHEDULE FOR ERADCOM PROJECT.

approach. This approach together with the major accomplishments of the project are presented in the next section.

### Approach and Accomplishments

Tech Tran's approach to this assignment consisted of seven major project tasks. The milestone chart depicting the tasks is shown in Figure 3, and a brief description of each task is contained in the following paragraphs.

- o Initial Project Meeting - This meeting, held at ERADCOM during the first week of the project, was to review the objectives, approach, and schedule with the ERADCOM technical manager.

- o Preparation of Synoptic Outline - Tech Tran prepared a synoptic outline which described the organization and content of the final project documentation (See Appendix A).

- o Data Collection - An extensive data collection phase was completed in which personnel from all areas of ERADCOM's MMT program were contacted. In addition to the personal interviews, data collection also included review of numerous directives, regulations, and policy statements issued by various DOD, Army and ERADCOM offices.

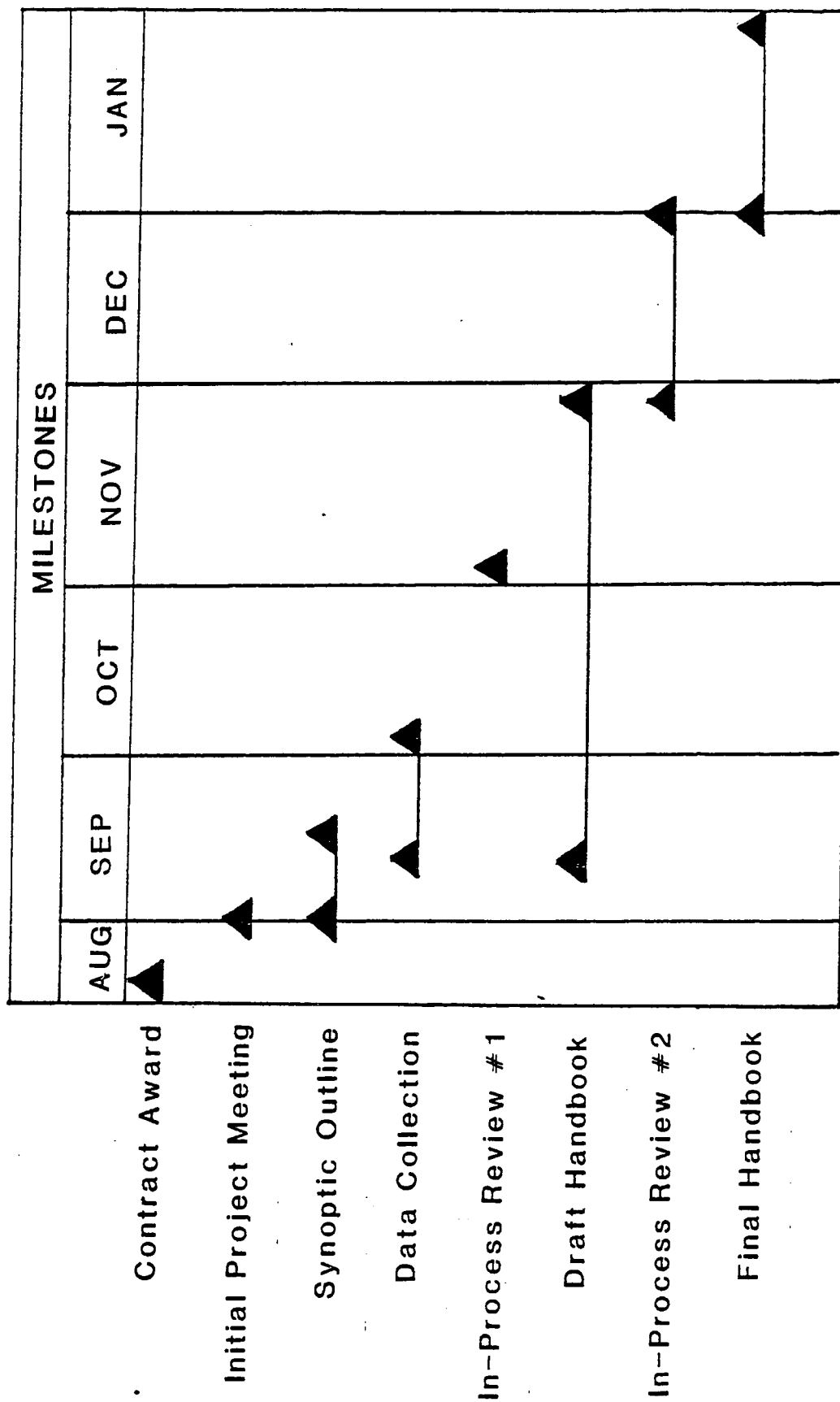


FIGURE 3. MILESTONE SCHEDULE FOR ERADCOM PROJECT.

- o In-Process Review #1 - An in-process review meeting was held to discuss Tech Tran's findings to date. A major goal of this meeting was to reach an agreement as to the technical management philosophy which would be adopted by ERADCOM for their MMT program.

- o Preparation of Draft Handbook - An initial draft of the handbook was prepared by Tech Tran and submitted to ERADCOM for review and approval.

- o In-Process Review #2 - ERADCOM reviewed the draft handbook and prepared a point-by-point list of changes, modifications, and additions to be made.

- o Preparation of Camera-Ready Handbook - Following receipt of ERADCOM's modifications, Tech Tran prepared a camera-ready copy of the handbook to be reproduced and distributed by ERADCOM (See Appendix B).

The intern first became associated with this project when his flight plans which were to take him from College Station to Chicago to begin his internship were changed at the last minute. Instead of going to Chicago, Tech Tran directed the intern to the Washington DC area. Here, the intern met the intern supervisor and a senior project engineer just prior to attending the initial project meeting. Although the intern was first assigned to assist the senior engineer, assignment and personnel changes resulted in the intern assuming full responsibility of project within the Tech Tran organization.

Being placed in the precarious position of "expert" in an area that one has little previous knowledge was rather startling, but one the intern found not unusual in the consulting business. Thanks to the patient guidance and assistance of the intern supervisor, this intern was able to complete the assignment and provide ERADCOM with a product that satisfied their needs (See Appendix B). The major accomplishments detailed in the remainder of this section provided the intern with an abundance of learning experiences and educational opportunities.

One of the first lessons learned during this project was that few things are as simple or as straightforward as they might appear. From reading the Request for Formal Proposal (RFP) issued by ERADCOM and the formal proposal submitted by Tech Tran, it appeared that this assignment would be exactly that - simple and straightforward. However, not too far into the initial project meeting, it became obvious that this would not be the case.

In addition to the ERADCOM headquarters technical monitor, each of the three laboratories involved in the MMT program made a presentation at the meeting. Although Tech Tran's approach was heartily approved, there was little else on which agreement could be reached. The main conclusion was that each of the laboratories did indeed manage their MMT projects differently and there was a definite need for more uniformity and standardization.

Another factor which surfaced as a result of the discussions was that the laboratories did not utilize the same contracting and legal offices to process their MMT projects. This resulted in still other differences in the manner in which projects were managed.

While Mr Meyer attempted to reach a consensus of opinion on some of the major issues, the intern used the time to become acquainted with the personnel involved in the program and to understand their ideas of how and why the program could be more effectively managed.

A significant lesson learned during the meeting and others of a similar nature was that of identifying the person who is really in charge. According to the contract agreement, the technical manager was the approving authority for all work completed under the contract. Although it would be his signature which certified task completion, it was not the technical manager who would actually make the decisions. Knowing this type of information in advance or obtaining it early in a project can mean the difference between success and failure. These types of lessons were learned through lengthy discussions with the intern supervisor. His frankness and objectivity in this rather nebulous area of technical management provided the intern with a much higher regard for the capabilities of a professional consultant.



Immediately following the project meeting the process of generating a synoptic outline was begun. This type of outline is a management tool utilized by Tech Tran to effectively communicate the contents of a proposed document to the client. The two part outline prepared for the ERADCOM project is contained in Appendix A. The first part contains the proposed table of contents, and the second part summarizes the contents of each section and identifies what will and will not be in the final document.

An iterative process of discussion, research, and preparation was used to generate the outline. Through discussions and meetings with the intern supervisor, areas requiring additional research and data collection were identified. From the information collected, the intern prepared a new and more detailed outline which was again reviewed by the supervisor.

This iterative process had numerous advantages. The intern's knowledge level and understanding of the Army's program and project objectives was rapidly increased. Potential problem areas were uncovered and resolved; graphic requirements were identified and initiated; and a preliminary balance between major topics was achieved.

The synoptic outline was well received by ERADCOM and helped decrease or eliminate several ambiguities which existed within the laboratories and between ERADCOM and Tech Tran personnel. The ability to prepare a satisfactory

final product within the time constraints was realized in a large degree by the effort which was expended in generating the synoptic outline. The intern has since come to regard this management tool as an essential part of the report preparation process.

After the outline was reviewed and approved, the major data collection phase was initiated. The purpose of this phase was to obtain pertinent facts and information to be used in developing a comprehensive philosophy for managing MMT projects which would be acceptable to all ERADCOM laboratories.

Personal interviews were utilized as the main source of information. The intern supervisor and the intern conducted in-person interviews of program directorate level personnel at ERADCOM headquarters. These interviews included both the technical areas as well as other areas such as contracting, procurement, and legal. At the conclusion of each interview, the intern prepared an interview report which summarized the major points. After observing and participating in the interviews held at ERADCOM and with MMT coordinators, lab chiefs, and project engineers at two of the laboratories, the intern conducted the interviews at the third laboratory on his own.

Observing and conducting the personal interviews was a learning experience. Being able to put the interviewee at ease and direct the course of the discussion is indeed

an art form. The interviewer must be well prepared, with a thorough knowledge of what information he wants to obtain. He must also be able to ask questions which are clear and concise and be able to accurately discern fact from opinion. Another characteristic that a good interviewer must develop is the ability to end an interview when no further information is available.

In all, approximately forty in-person and telephone interviews were made with personnel in ERADCOM, in other Army commands, and with Man-Tech personnel in the Air Force and Navy. As an integral part of the interview process, pertinent documentation was also identified and collected. This included relevant policy statements, procedures, regulations, directives, and currently completed and on-going MMT project proposals and contracts. This information was used as the basis for assessing how current projects were being managed, where deficiencies existed, and what improvements were needed.

To no one's surprise, Tech Tran did indeed document numerous areas of inconsistencies in project management practices between laboratories and marked differences in management concepts on the part of technical and contractual personnel. The type of project undertaken, the type of contract utilized, funding strategies, and implementation emphasis were a few of the major areas which Tech Tran identified as requiring specific changes in

current management policy. Tech Tran presented a list of their findings and recommendations at the first in-process review meeting.

At the top of the list, Tech Tran urged ERADCOM to more fully comply with updated Army regulations by adopting a program which was more generic technology and process oriented than end-item oriented. Tech Tran recommended that end-item production be limited to demonstrating the effectiveness of the new or improved process developed as part of the project.

Tech Tran strongly recommended that multi-year funding strategies be instituted for Man-Tech projects. ERADCOM's past procedure had been to allocate the total funds required for a project in the first year under one all-inclusive contract. Tech Tran, however, favored subdividing projects into a basic contract with an option which could be exercised at the convenience of the government. This policy normally provides more effective control on the part of the project engineer, more responsiveness by the the contractor, and permits more projects to be funded in a given year. In addition, significant cost savings can be realized by terminating unsuccessful projects at the conclusion of the basic contract.

In conjunction with new funding strategies, Tech Tran recommended that ERADCOM explore other types of contractual

agreements. A large number of past projects had been fixed price contracts. Although this type of contract is appropriate for some MMT projects, Tech Tran suggested that cost plus and incentive type contracts be utilized for projects with inherently high technical risk.

Together with the new funding and contracting strategies, Tech Tran also recommended that ERADCOM subdivide future projects into functional phases. Up to as many as five major phases were suggested depending on the magnitude of the project. The phasing concept provides for increased standardization and more effective project management. Tech Tran further suggested each key phase be subdivided into distinct tasks to improve productivity and uniformity and establish minimum project requirements.

Another area where Tech Tran recommended policy changes was in contract deliverables. The type, amount, and scheduling of deliverables can result in increased project cost or less than optimum project effectiveness. By requesting too many or irrelevant items to be delivered as part of the contract, the project engineer can unnecessarily increase the total cost or duration of the project. Under Tech Tran's recommendation the deliverables would be linked to the completion of each of the key phases. In so doing the information content and value to other government projects can be significantly improved.

Finally, to enhance the subsequent utilization of

the new manufacturing processes and procedures, Tech Tran highly recommended that the deliverables specified in ERADCOM contracts be more implementation oriented.

Specifically, Tech Tran suggested that deliverables such as process design specifications, equipment drawings, implementation plans, etc. become an integral part of the satisfactory completion of every MMT project. To further support implementation, Tech Tran recommended that future ERADCOM RFPs include appropriate clauses which require potential contractors to identify all claims to proprietary data rights. Limiting such claims can significantly improve the likelihood of full-scale implementation.

All of these recommendations, together with other procedural and operational changes were reviewed and approved by ERADCOM. A draft handbook which incorporated Tech Tran's findings into a comprehensive management guide was then prepared by Tech Tran. The handbook, a portion of which is contained in Appendix B, is divided into three parts. Part I, Overview and Philosophy, presents the background information on ERADCOM's MMT Program and provides the project engineer with understanding of his management objectives, duties, and responsibilities. The important factors, unique constraints, and potential problem areas involved in managing an MMT project are also discussed in Part I. Part II, Preparation Guidelines, contains the detailed information and examples needed by

the project engineer in order to prepare a procurement data package which is consistent with the management philosophy and guidelines developed during this project. The appendices contained in the third part of the handbook provide the project engineer with additional examples and reference material. For the sake of brevity, Appendix B contains only Part I and the first chapter of Part II. In all, the handbook was some 180 pages in length.

The changes and modifications in content and format requested by ERADCOM as a result of the second in-process review session were incorporated into the final document. The camera-ready copy was forwarded to ERADCOM in early February, 1982 for reproduction and distribution.

### Benefits

The benefits derived from the ERADCOM project can be grouped into three categories. First, there were those benefits realized by the client. Next, there were recognizable benefits to the internship company, and finally the intern received significant benefits from his involvement in the project.

ERADCOM will begin to realize a return on its investment during the 1982 procurement cycle and in future MMT projects. One of the primary functions of the handbook is to provide an effective communication link between upper

level policy makers and the project engineers assigned the technical management responsibilities for ERADCOM's MMT program. During the 1982 and 1983 cycles, the "first generation" document prepared by Tech Tran will be field tested. Because it is in a pamphlet form, ERADCOM will be able to update, refine, and expand its contents in a timely manner. Due to the multiple users, the handbook was developed so as not to preclude the use of additional guidelines or directives peculiar to a particular laboratory. The flexibility and scope of this management tool has caused considerable interest by other Army organizations involved in the Man-Tech Program.

Tech Tran's primary benefit has been in follow-on assignments which were stimulated by the ERADCOM project. The Army's Missile Command (MICOM) has tasked the consulting firm to expand the scope of the ERADCOM handbook. Whereas the ERADCOM project focused primarily on the activities involved in preparing a procurement data package, the MICOM project will address management of the entire program cycle. The management guidelines to be developed for MICOM will encompass the planning, execution, and implementation phases. The non-technical aspects such as the higher level decision making process will be stressed. Other possible benefits which Tech Tran may receive are a contract to provide a training seminar to ERADCOM project engineers and another contract to provide



periodic updates to the original handbook.

From the intern's perspective, it is hard to imagine a project which could have been more beneficial or well suited to the Doctor of Engineering internship program. The intern's role in this project could be described as project manager. As the intern's understanding of the Man-Tech Program increased during the project, the intern became the focal point among the firm's associate engineers for matters concerning the Army's MMT program. This project enabled the intern to apply his knowledge and training to the solution of a practical problem and it exposed the intern to an overall view of a major federal program in manufacturing technology. Most importantly, it enabled the intern to participate in converting policy statements into clear management practices. It is this type of experience that a Doctor of Engineering graduate must have to be an effective engineering manager, yet cannot obtain in a classroom environment.

The project required the use of the intern's background in electrical engineering and automated manufacturing processes. As all ERADCOM laboratories are involved in manufacturing processes of electronics and electronic devices, this background was extremely valuable. It not only permitted the intern to intelligently converse with project engineers on specific projects and problem areas, it was essential in developing

the hypothetical project which was used as an example throughout the handbook.

The project also permitted the intern to receive a broad exposure to a major DOD program in manufacturing technology. The perspective included an introduction to various types of federal appropriations and an appreciation of the contracting principles and acquisition regulations used by the federal government. The opportunity to study the overall operation of this program provided increased insights into the factors that govern the management of such a program.

The final benefit of the project was, in all probability, the most important. The formulation process utilized in developing ERADCOM's technical management plan is generic in nature. The same procedures and considerations used in molding the ERADCOM program could be transferred to many manufacturing related environments. The professional engineering activities which comprised this project are truly indicative of positions of responsibility and authority. The activities incorporated a diversified spectrum of interactions and communications with personnel in both technical and non-technical fields. In all, the intern found this assignment to be a challenging, enlightening, and rewarding experience.

## MANUFACTURING TECHNOLOGY

### HORIZONS PROJECT

#### Introduction

An engineering manager involved in automated manufacturing, as in any other technical discipline, must stay abreast of the latest developments which affect his environment. Most professionals utilize technical journals and publications to keep current on these types of activities. These periodicals help the technical manager maintain a state-of-the-art awareness of significant research projects and new products or processes in his field. One method that an engineer can use to maximize the benefits he receives is to review a wide cross section of such literature. Another method is to actually be involved in the process of identifying, researching, and reporting on the developments as they take place. It is this latter method that formed the basis of the intern's second major project. Specifically, the intern was assigned as an associate editor of Manufacturing Technology Horizons (MTH).

In the following paragraphs, the MTH publication, its goals, and its intended audience are discussed. The intern's duties and responsibilities as they related to

the digest are also presented, followed by the benefits derived from the assignment. Although it is not considered the most significant project in which the intern was involved, it was, however, the most interesting.

### The Digest

One of Tech Tran's major enterprises is the publication of Manufacturing Technology Horizons. MTH is a bi-monthly digest written for manufacturing and engineering managers and executives. Its primary objective is to report on current developments in manufacturing techniques and productivity. MTH strives to communicate the essence of a new development in a brief, concise, and unbiased manner. The emphasis of each article is on the technical impact rather than its marketability.

Although developments from any area of manufacturing may be considered for inclusion in MTH, the digest concentrates on those areas of wide utilization or interest. MTH normally features such areas as Metalworking, Test and Inspection, Non-metals Processing, Computer-aided Manufacturing, Production Planning and Control, and Electronics Production in each issue. In addition to the technical summaries, MTH contains two in-depth articles; Special Focus and Leaders in Development. Special Focus is a regular feature covering

major developments in a selected technology area such as robotics or injection molding. Leaders in Development focuses on major developers of manufacturing from around the world such as Battelle Laboratories. The digest is international in scope and includes recent developments taking place in government laboratories, research institutes, equipment manufacturers, trade and professional organizations, and universities. A copy of the March/April 1982 issue of MTH is contained in Appendix C.

In each MTH article, Tech Tran addresses several important factors. First, the key technical features of the new development are summarized. These features include information as to why the process, technique, or equipment is unique or innovative; and what has brought about its development. Next, the status of the development is reported. This provides answers to questions such as when will it be available for commercial use and what will be the investment required for implementation or integration. The potential benefits to the user are also included as is an assessment of the barriers which impede the utilization of the new technology. The final factor which is a part of all MTH articles is a point of contact. Tech Tran provides the name, address, and when possible, the telephone number of the person or persons who are best qualified to provide additional information on the new development. In many cases this is a high level executive

within the organization doing the research work.

MTH subscribers include many of the Fortune 500 companies in the US. Abroad, MTH has subscribers in Canada, Mexico, and in most of the western European countries. The digest has received excellent reviews from numerous engineering managers and several of the MTH articles have been reprinted in other technical publications.

### Duties and Responsibilities

Just prior to the start of the internship, Tech Tran formally announced its intent to publish MTH and was in the final stages of the conceptual phase when the intern joined the firm. These facts are significant in that the situation permitted the intern to not only make a contribution to the technical content of the digest, but to observe and be involved in the promotion, marketing and sales activities. These non-technical activities have influenced the remainder of the intern's academic course work.

As an associate editor, the intern's primary duties and responsibilities were to generate the managerial-level summaries of new developments in manufacturing technology. This task was generally accomplished through a systematic approach of identification, research, preparation, and

selection and editing.

In the first step, a new process or technique must be identified. One method used in the identification process is to perform a literature search of technical reports and journals, conference proceedings, trade publications, and news releases. An alternative method, and the more interesting of the two, is through direct contact with researchers in the manufacturing industry. Because of Tech Tran's diverse assignments in technology data collection, it is not uncommon to be in contact with such individuals as the director of R&D or the manufacturing manager of a large corporation. During these conversations it is possible to learn of recent projects in which the company is involved. No matter which method is used, once a potential development is identified, the research phase begins.

The research phase is utilized to collect the information necessary to prepare a candidate article. This phase of the process is generally the most involved and time consuming and may best be illustrated by an example.

The identification phase has indicated that a large corporation has recently integrated a new manufacturing technique into its automated production process. The technique is capable of being utilized in wide range of manufacturing processes, therefore, the research phase

is initiated. First the associate engineer must locate which of the corporation's manufacturing facilities is responsible for the new development. After this is completed, the difficult part begins. In most cases, the fact that the plant has just developed a new automated process is widely known. What is not clear is who should field questions concerning the new process or equipment. During the course of collecting the information, the associate editor may speak to marketing, advertising, sales, customer service, or a wide range of other departments. After each of these departments understands the intent of Tech Tran's inquiries, the associate editor is generally put in touch with an engineer who can answer his questions.

It was during this phase that the intern was able to improve his verbal communication skills. The intern discovered that the questions which were asked and the manner in which they were asked could significantly impact the outcome of an investigation. In some instances the intern was able to circumvent the intermediaries and get right to the person in charge of the development. In those cases where it was necessary to touch base with every department, the intern found that these departments did possess useful information as to pricing, availability, patents, etc. Asking the right questions to the right person expedited the data collection phase tremendously.



Once sufficient information and background material are collected, the next step is to generate an MTH candidate. This is a draft of the article to which all interview reports and supporting documentation is attached. The candidates are then reviewed by the publisher of MTH. If a candidate is selected, it begins the editing phase of the process.

In addition to the normal grammatical, format, and wording changes, the editing phase is used to expand and refine the information contained in the article. In many cases, follow-on or parallel activities by other organizations are uncovered through additional interviews or data collection. Other independent assessments of the development are also obtained during this phase.

The intern generated approximately twenty articles which were published in the first three issues of MTH. One of these appeared as the lead article in the premiere issue. Although project assignments were generally in the electronics area, the intern generated articles on a diversified range of developments. Some of the more interesting projects were in machining, test and inspection, process control, sensors, fiber optics, X-ray devices, and printed circuit board manufacturing processes. To a large degree the new developments included some form of automation.

In addition to the technical contributions made to

MTH, the associate editors were also involved in other facets of the publication. The technical staff promoted the importance and timeliness of the digest through written communications with information sources, during telephone interviews, and at meetings and technical conferences. During the final editing of the premiere edition, the intern was called upon to operate the word processing equipment which had recently been installed. This experience has firmly convinced this intern that every engineer and manager should have a thorough working knowledge of this type of equipment. Finally, the intern had the satisfaction of assisting in the cutting and pasting activities and in seeing the first issue go to the printers. However, this satisfaction was not the only benefit the intern derived from the project. In the next section, the beneficial aspects of the MTH project are explored.

### Benefits

The position of associate editor was a highly rewarding experience and extremely beneficial to the intern's professional development. This project encompassed most of the attributes expected in an internship assignment. It enabled the intern to exercise and build on his educational background. It dramatically

increased his awareness of current and planned R&D efforts in manufacturing technology. It extended the intern's communication skills, and it provided residual benefits by offering the intern an opportunity to observe the publishing process first hand. The associate editor position required the intern to research and assemble information from several different sources, make qualitative judgements as to the value and suitability of new developments, and then to succinctly summarize the pertinent facts for publication.

The intern's background in electronics and experience with automated control processes, microprocessors, and computers was put to good use during these projects. This was especially true in discussions with representatives from R&D organizations such as NBS, Hughes Aircraft, Westinghouse, and General Electric. Being able to understand the technical aspects of a new development and asking intelligent questions greatly improved the interaction between the interviewer and the engineer. As this interaction was more fully achieved, more information, thus a better article, was obtained.

In doing research for candidate articles, one factor continually surprised the intern. This was the inaccuracies which were present in some technical publications. During follow-up research on other periodical's articles, the intern found on several

occasions that the information was incorrect or did not emphasize the important aspects of the new development. This factor caused the intern to verify his articles with his information source.

A mandatory capability of tomorrow's industrial manager will be the ability to convey sophisticated technical developments to corporate executives. Tech Tran's demand to produce clear, concise, and unbiased summaries was instrumental in improving the intern's written communication skills. Through the editing process, the intern learned to express technical developments in a "bottom line" style that could be understood by non-technical readers. As this capability can only be obtained and refined through practical application, the intern has benefitted significantly from this experience.

Finally, the intern was exposed to an enormous amount of technical information and was able to talk with numerous researchers and engineers in a variety of manufacturing fields. The professional interactions with this caliber of individual was very motivating. In most cases, these people were open and willing to share their views and opinions. Because these thoughts were normally rooted in ten to thirty years of shop-floor experience, the intern was able to broaden his perspective of recent developments in the manufacturing environment and the future of this area of engineering.

## MICOM PROJECT

### Introduction

Tech Tran takes its name from TECHnology TRANSfer.

As the name implies, technology transfer is the movement of technology across organizational boundaries. The intent of technology transfer is to propagate the utilization of a process or methodology from one environment to another. This movement or propagation is one of the major goals of the DOD's Manufacturing Technology Program. Once a new process is established as part of a Man-Tech project, the program seeks to obtain wide dissemination and utilization of the technology in order to improve the military industrial base and decrease acquisition leadtimes and costs. However, there are significant problems involved in transferring federally sponsored manufacturing developments. Until recently technology transfer has been viewed as an academic exercise or it has been non-manufacturing related. Because of the impact that utilization of advanced technologies can have on future productivity, many organizations involved in the DOD program are placing increasing emphasis on this subject.

Tech Tran possesses significant expertise in technology transfer activities. Mr Meyer, the President

of the corporation, is well recognized as a leader in this field, and several of the technical staff have extensive backgrounds in this area. It is due to this level of expertise that Tech Tran has numerous contracts relating to the Man-Tech Program.

In addition to the ERADCOM project which was discussed earlier, Tech Tran's consulting services had also been retained by the US Army Missile Command (MICOM). The intern was able to make a recognizable contribution in this the third internship project.

The documentation of the intern's efforts as they relate to the MICOM assignment is similar to the previous projects. First, background information pertaining to the MICOM organization, its MMT program, and the major points of the contract are presented. The intern's duties and accomplishments are then discussed, followed by a summary of the benefits the intern realized through his participation in the project.

### Background

The US Army Missile Command is tasked with the primary responsibility of managing the Army's total missile and rocket program. MICOM's major responsibilities include research, development, procurement, and continued support of these weapon systems. The command, which is

headquartered at Redstone Arsenal, Alabama, is also engaged in laser research and is responsible for development of laser weaponry and laser designators used to guide missiles to their target.

To accomplish its mission, MICOM has actively participated in the Army's Manufacturing Methods and Technology Program. MICOM's current annual funding exceeds ten million dollars, and future growth is expected. Production support of MICOM's weapon systems requires a broad range of manufacturing technologies including metals, non-metals, electronics, computer-aided manufacturing, test and inspection, and optics. Of these, electronics had traditionally received the major attention, but future expansion of the CAM technology is anticipated.

Because of the diversity of MICOM's program, its recent growth, and MICOM's limited manning, outside engineering assistance was needed in the area of program planning and implementation of technology results from recent MMT projects. MICOM, therefore, contracted Tech Tran to provide technical and managerial support for their MMT program. One of the major objectives of this contract was to ultimately provide MICOM with a comprehensive plan for future work in this area. The development will take into consideration past project implementation results, priorities of present and future requirements, and an assessment of the inherent risks and attributes associated

with potential projects. The contributions the intern was able to make to the contractual effort are presented in the following section.

### Accomplishments

The MICOM contract was composed of five major tasks which called for:

1. Identification and analysis of technology transfer mechanisms.
2. Statistical analysis of diffusion and implementation of project results.
3. Investigation of the benefits derived from application of MMT-developed technology.
4. Manufacturing technology forecasting.
5. Development of systematic approach for selecting and prioritizing potential MMT projects.

The intern was not involved in all five phases of the contract due to its duration and timing. That is, work had already begun on the contract prior to the beginning of the internship and, because of its length, was still in progress at the termination of the internship. The intern's primary involvement, which accounted for approximately twenty-five percent of the internship activities, was focused on tasks three and five. Specifically, the work included the investigation



and evaluation of completed, on-going, and planned MMT projects. The completed and on-going projects were surveyed to determine the accomplishments, benefits, and degree of implementation achieved. The planned projects were evaluated in order to assess their applicability, merits, and priority for future MICOM funding. The details of the work performed under these two major tasks are presented in the following paragraphs.

Figure 4 contains a representative sample of the MICOM projects which the intern evaluated. The list includes the MICOM identification number, the project title, and the prime contractor. The list is presented to indicate the diversity of projects and manufacturing firms which were loosely grouped into the intern's assigned area of electronics. Funding for some of these projects exceeded one million dollars, and the duration of the projects ranged from between one and three years. Completion dates were from late 1981 back to the early 1970s.

Basically a seven step approach was utilized to evaluate the MICOM projects. These were:

- o Review project data,
- o Identify interview candidates,
- o Develop interview guide,
- o Conduct interviews,
- o Prepare interview reports,
- o Prepare project summaries, and

Figure 4. Sample of MICOM Projects

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Project	Name	Contractor
=====		
2972	The Application of Infrared Soldering to the Production of Electronic Modules	Advanced Kinetics
3133	Production of Lithium Ferrite Phase Shifter for Phased Array Radars	Raytheon
3134	Manufacturing Methods for Production of Field Effect Electron Emitters	Georgia Tech
3146	Fine Line Hybrid Substrates	MEC
3168	Production of Circuit Card Heat Pipes	Martin Marietta
3171	Automatic Monitoring and Control for Wave Soldering Machine	Westinghouse
3183	Improved Manufacturing Processes for Inertial Grade Quartz Flexure Accelerometer	Sundstrand
3217	Automated Production Methods for Traveling Wave Tubes	Litton
3227	Automatic Handling of Hybrid Chips Via Tape Carrier Lead Frame	Honeywell
3254	Low Cost Semi-Flexible Thin Film Semiconductor	MEC
3372	Development and Evaluation of Manufacturing Methods for Magnetic Components	Hughes Aircraft
3410	Production Methods for Heat Pipes for Hybrid/LSI	Hughes Aircraft
3438	Delidding Parallel Seam Sealed Hybrid Microelectronic Packages	Westinghouse

- o Complete Implementation Survey Form.

At the start of the contract, Tech Tran initiated a project folder for each of the approximately 250 individual MICOM MMT projects. During the first step of the investigation, the intern reviewed the P-16 funding document (a document which is used to obtain funding for governmental projects), numerous interim and final reports, and other documentation contained in the Tech Tran files.

The review step provided the intern with background information necessary to generate a list of interview candidates and to identify specific issues to be addressed in the interview. The interview list normally included the MICOM MMT coordinator, the MICOM and contractor project engineers, weapon system program managers, and other knowledgeable individuals.

Telephone interviews were normally used to collect information in the fourth step of the process. The goal of this phase was to answer several key questions. First, what was the need or problem that motivated the project? How was the project executed, what did it accomplish, and was it successful? What were the benefits achieved from the project, and to what level had the results been implemented? Finally, what actions were required to promote further utilization of this technology? In addition to this information the interview phase identified reasons for lack of wide spread implementation of the new

or improved technology which was established by the project.

At the conclusion of each interview, an interview report was generated. The purpose of this report was to summarize the salient points of the discussion. The interview report was for in-house use only and normally included a personal assessment of the facts and key issues.

After all the interviews were completed, the project was summarized in two different formats. The standard format described the history of the project, its objective and accomplishments, and the overall benefits. These summaries were written in layman's terms and were suitable for reading by individuals without technical backgrounds or a detailed understanding of the MMT program. The primary purpose of this first format was to provide the MMT coordinator with a dossier of managerial-level summaries which he could use to document past accomplishments of the program and justify future MMT projects. Two examples of the summaries prepared using the standard format are contained in Appendix D.

The second format was utilized to facilitate entry of data into MICOM's in-house management information system. Tech Tran provided three inputs to the data base system; a problem statement, a solution statement, and a project summary. Each of these inputs was constrained as to its length by the file structure of the data base

management system. Two representative examples of the data base summaries are contained in Appendix E.

By regulation, the implementation effectiveness of each MMT project must be evaluated every year for five years following the termination or completion of the project. To achieve this goal, the Army's Industrial Base Engineering Activity had developed an implementation survey which all Army commands involved in the MMT program utilized. In addition to technical information, the form also addresses economic and contractual factors. The final phase of the Tech Tran approach was to generate or update this survey form. Appendix F contains two examples of completed effectiveness reports.

Generally each package required from two to four man-days to complete. The completed investigation and evaluation packages were used internally as input to the other contract tasks and were also sent to MICOM for use by MMT personnel.

Just prior to the termination of the internship, the intern generated a memorandum to the intern supervisor concerning his work on the MICOM projects. The memorandum provided a qualitative ranking and support information for the projects which had been evaluated.

In addition to the routine survey work described above, MICOM would, from time to time, task Tech Tran to provide specialized project support on a short-term basis.

The intern was involved in one of these assignments.

In January, 1982, the Manufacturing Technology Advisor Group (the governing body of the DOD Man-Tech Program) held a series of Subcommittee Hearings on Microelectronics in New Orleans. The hearings were attended by approximately 150 people from industry and government tasked to review and evaluate DOD projects in this area. Each of the Tri-Service organizations working in microelectronics made presentations of recently completed and on-going projects. Tech Tran provided the project summaries for the MICOM presentation.

Approximately twenty MMT projects were summarized as part of this task. The intern evaluated six projects in the area of hybrid microelectronics. The projects ranged from new manufacturing technologies and materials to new cooling methodologies and test and inspection processes. An example of one of the evaluations is contained in Appendix G.

The fifth major contract task concentrated on the selection and prioritization of potential MMT projects. One of the assignments under this task was a review of candidate projects which MICOM was considering for future funding. In all the intern evaluated six such projects.

Based on information collected via research and telephone interviews, the candidates were evaluated on the basis of eight categories. First, the need of the

project was investigated to determine if a real problem was being addressed. Next, the suitability of the approach was assessed (i.e., was the proposed solution the best way to solve the problem).

The third and fourth categories assessed the project risk. Technical risk was considered low if the proposed project was likely to provide a technically acceptable solution to the problem. If the project was technically acceptable, the likelihood of utilization was evaluated in the assessment of the project's implementation risk.

As stated in a previous section, candidate MMT projects must meet stringent criteria before they can be funded under this program. One of the major factors is whether or not the project is intended to advance the present state of the art in manufacturing technology. Projects which are merely product design efforts or adaptations of already existing technologies do not meet these established criteria. Therefore, the suitability as an MMT project was the fifth evaluation category.

Pertinent information concerning related efforts by other government or industrial groups was the sixth category. Here, past, present, and planned projects were considered. The fact that another organization had been or was currently involved in a particular area of manufacturing technology could have significant bearing on MICOM funding.

As in any project being considered for funding, an assessment of the return on investment must be furnished. For these projects a benefit to cost analysis was performed as the seventh evaluation category.

The final category was used to provide a qualitative assessment of the overall priority of the candidate project. The assessment was made on the previous seven categories which were evaluated from MICOM's standpoint. An example of one of the candidate project evaluations performed by the intern is contained in Appendix H.

### Benefits

Providing quality services and demonstrating the ability to respond to peak workload periods are two characteristics that a small business must demonstrate through performance. The work accomplished as part of the MICOM contract supported Tech Tran's claims to these attributes. The intern was able to contribute to this effort.

Two of the assignments in which the intern was involved received considerable praise from MICOM's technical contract monitor. MICOM utilized the summaries generated by Tech Tran, verbatim, in its presentations at the Man Tech subcommittee hearings in New Orleans. It was reported that significant industrial interest was



generated by the results of some of these projects. Tech Tran's evaluations of potential projects had also played a key role in MICOM's selection and funding considerations for future MMT projects. Because of this type of performance, MICOM and Tech Tran were negotiating a continuation of these technical services at the end of the internship.

The intern found the projects which required immediate attention and rapid response very challenging. Making management decisions on technical projects is normally done with less than sufficient information. Developing the ability to clearly identify program goals and objectives and then making intelligent decisions based on these factors comes with experience. The assignments in the MICOM project contributed significantly to the intern's ability to function in this capacity.

As with all three major projects, this project enabled the intern to broaden his background of knowledge in electronics and automated manufacturing processes. It also required a knowledge of engineering economics, finance, and data and word processing.

## SUMMARY

The eight month internship with Tech Tran Corporation, which is documented herein, satisfies the internship requirements for the degree of Doctor of Engineering. The internship supervisor's final letter report to the chairman of the intern's advisory committee which is contained in Appendix I confirms that the internship objectives have been realized.

An excellent decision was made in selecting Tech Tran as the company in which to serve the internship. The consulting firm provided the proper forum required to achieve the intern's primary and secondary goals of his doctorate program. The intern was able to study and observe practically every aspect of the corporation. The positive, candid relationship with the intern supervisor, Mr Meyer, helped to make the internship both productive in a professional sense and enjoyable from a personal aspect.

## APPENDICES

## APPENDIX

## A

## ERADCOM SYNOPTIC OUTLINE

SYNOPTIC OUTLINE

"PREPARATION OF PROCUREMENT DATA  
PACKAGES FOR MANUFACTURING METHODS  
AND TECHNOLOGY (MM&T) PROJECTS"

Contract DAAK21-81-C-0096

16 September 1981

### FOREWORD

This synoptic outline is intended to provide the Army Electronics Research and Development Command (ERADCOM) with a detailed summary of the proposed contents of the pamphlet on "Preparation of Procurement Data Packages for Manufacturing Methods and Technology Projects." The outline has been prepared so that all interested parties will have a better understanding of the pamphlet's currently envisioned contents and focus.

The primary readers of this pamphlet are expected to be project engineers within ERADCOM laboratories. In preparing the synoptic outline it was assumed that these individuals had at least an introductory-level understanding of a procurement data package for such a project. Thus the pamphlet concentrates on those unique or difficult aspects of MM&T procurement as opposed to being a tutorial on contract law and procurement procedures.

This document is divided into two sections. Section I contains the table of contents, or general outline for the pamphlet. An estimate of the number of pages is included for each major topic. Section II contains the detailed synoptic outline which provides a description of each topic listed in the table of contents.

It should be noted that the pamphlet itself will be divided into three parts. Part I, Overview and Philosophy, will provide the reader with an introduction to the MM&T Program's goals and constraints, the contents of a procurement data package, an understanding of the project engineer's responsibilities, and key issues affecting the success of an MM&T project procurement. Part II, Preparation Guidelines, will contain the detailed information and examples needed by the project engineer to prepare an MM&T procurement data package. Part III, Appendices, will provide the reader with a variety of reference material including sample statements of work, Contract Data Requirements Lists, Data Item Descriptions and a bibliography.

Reviewers of this document are encouraged to recommend changes or additions that will result in improvement of the pamphlet's content and structure.

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S E C T I O N   I I

SYNOPTIC OUTLINE

## SYNOPTIC OUTLINE

FOREWORD (1 page) Briefly defines purpose of the pamphlet and intended reader. Describes general organization of pamphlet and summarizes contents of each part. Discusses how the pamphlet should be used. Provides cautions concerning limitations of material contained in the pamphlet.

PART I OVERVIEW AND PHILOSOPHY (29 pages) - The purpose of Part I is to raise the reader's awareness of the whys and hows of preparing procurement data packages for MM&T projects, but stops short of the detailed instruction for package preparation.

CHAPTER 1. INTRODUCTION TO PART I (2 pages) - Introduces the MM&T Program and its uniqueness, the need for a well prepared procurement data package, and the importance of the project engineer in the total process.

CHAPTER 2. MANUFACTURING METHODS AND TECHNOLOGY PROGRAM (7 pages) Provides background information on the MM&T Program and highlights unique aspects, constraints, and potential problem areas as they relate to procurement data packages.

2.1 Introduction (2 pages) - Briefly describes the background and objectives of the MM&T Program and summarizes its importance at ERADCOM. Addresses policy and fiscal constraints of the program and outlines industrial participation. Discusses the different types of projects funded under the program.

2.2 Major Issues (5 pages) - Discusses key issues which affect the overall success of an MM&T contract such as providing for usable end products at appropriate breakpoints, data rights, and deliverables needed for technology implementation.

CHAPTER 3. PROCUREMENT DATA PACKAGES (10 pages) - Provides an overview of procurement data packages as they relate to ERADCOM MM&T projects.

3.1 Introduction (2 pages) - Discusses purpose and use of procurement data packages and describes contents. Discusses the merits of a well prepared procurement data package and its impact on the total procurement process.

3.2 Types of Procurement Data Packages (4 pages) - Discusses the different types of procurement data packages used in MM&T projects such as competitive and sole source. Will use "tree charts" to depict the contents of various types of procurement data packages.

3.3 Major Issues (4 pages) - Discusses key issues which must be considered when preparing procurement data packages for MM&T projects and major problem areas such as completeness, timeliness, coordination, sole source justification and data rights.

CHAPTER 4. PROJECT ENGINEER'S RESPONSIBILITIES (10 pages) - Defines the roles and responsibilities of the project engineer and provides procedures to be used in preparing a procurement data package.

4.1 Introduction (2 pages) - Briefly comments on the importance of the project engineer in the preparation of a procurement data package. Identifies major participants and their inputs to the package.

4.2 Duties and Tasks (4 pages) - Explains the responsibilities of the project engineer as they relate to specific tasks involved in the preparation of a procurement data package. Summarizes these responsibilities along with those of other participants, in chart form. Presents a flow diagram which depicts a generalized approach which can be used in the preparation of procurement data packages.

4.3 Major Issues (4 pages) - Identifies key issues and responsibilities which require special attention. Discusses typical problems encountered in preparation of procurement data packages for MM&T projects.

PART II PREPARATION GUIDELINES (69 pages) The purpose of Part II is to provide the project engineer with detailed instructions and examples for preparing procurement data packages for MM&T projects. Emphasis will be placed on package content, options available for specific clauses and selection rationale.

CHAPTER 5. INTRODUCTION TO PART II (5 pages) - Discusses purpose and organization of Part II. Describes the contents of MM&T procurement data packages. Will include "tree charts" and tables to indicate the applicability and level of use of specific procurement data package elements.

CHAPTER 6. STATEMENT OF WORK (32 pages) - Discusses preparation of statements of work for MM&T projects. Emphasizes those aspects which provide major options or significant potential problems.

6.1 Introduction (2 pages) - Summarizes the purpose of the statement of work and defines the contents for a typical MM&T project. Describes those features which have a major effect on project success.

6.2 Technical Requirements (15 pages) - Identifies those technical requirements that are normally included in a statement of work and

explains the purpose of each. Presents sample clauses and explains possible options and selection criteria. Identifies those items which are not appropriate for inclusion into the statement of work. (This section will be further subdivided during pamphlet preparation).

### 6.3 Testing and Quality Assurance Requirements (5 pages)

Discusses testing and quality assurance requirements typically included in statements of work for ERADCOM MM&T projects. Includes sample clauses and selection rationale.

6.4 Data Requirements (5 pages) Identifies and describes those data requirements which are pertinent to MM&T projects and provides sample clauses and selection rationale. Will include both technical and managerial data such as drawings and specifications, test data, prototype equipment, interim and final reports, and monthly status reports.

6.5 Major Issues (5 pages) - Focuses project engineer's attention to those areas of the statement of work which are the most important in meeting the goals of the MM&T Program. Summarizes typical problems encountered.

## CHAPTER 7. CONTRACT DATA REQUIREMENTS LIST AND DATA ITEM DESCRIPTIONS

(13 pages) - Provides project engineer with information concerning

preparation and utilization of Contract Data Requirements List (CDRL) and Data Item Descriptions (DIDs) for ERADCOM MM&T projects.

7.1 Introduction (2 pages) - Describes purpose of CDRLs and DIDs and their relationship to MM&T projects and the procurement data package.

7.2 Contract Data Requirements List (5 pages) - Discusses types of contract data which are applicable to MM&T projects. Provides a checklist to ensure deliverables are consistent with statement of work tasks and project objectives. Contains example CDRL.

7.3 Data Item Descriptions (4 pages) - Identifies those standard DIDs which are applicable to MM&T projects and required modifications. Discusses options and selection rationale. (Sample DIDs will be presented in appendix).

7.4 Major Issues (2 pages) - Focuses on typical problem areas in preparing CDRLs and DIDs.

CHAPTER 8 OTHER PROCUREMENT DATA PACKAGE CONTENTS (19 pages) - Provides pertinent information on preparation and utilization of other documents included in an MM&T procurement data package.



8.1 Introduction (3 pages) - Describes and discusses other types of information that are normally included in procurement data packages for ERADCOM MM&T projects.

8.2 Contract Data (3 pages) - Includes information on other contract data needed in a procurement data package such as security checklist (DD254) and transportation requirements.

8.3 Financial Data (3 pages) - Describes information on financial data required in procurement data packages, such as Independent Government Cost Estimate and funding documents.

8.4 Source Selection Data (4 pages) - Discusses such items as sole source justification, list of potential sources, and proposal evaluation plan.

8.5 Special Considerations Data (3 pages) - Summarizes other types of information commonly included in MM&T procurement data packages such as special notes and instructions to offerors.

8.6 Major Issues (3 pages) - Focuses on problem areas encountered in preparing the items mentioned above.

PART III APPENDICES (32 pages) - Part III contains specific examples and references of interest to the project engineer.

(Additional appendices may be added during pamphlet preparation).

APPENDICES

A. BIBLIOGRAPHY (5 pages) - Contains appropriate references organized by subject area.

B. SAMPLE STATEMENT OF WORK (10 pages) - Provides a complete sample statement of work for an MM&T project.

C. CONTRACT DATA REQUIREMENTS LIST (2 pages) - Presents example CDRL for case used in Appendix B.

D. DATA ITEM DESCRIPTIONS (15 pages) - Contains DIDs for case used in Appendix C plus additional DIDs as appropriate.

## APPENDIX

### B

#### ERADCOM HANDBOOK

(NOTE: This Appendix contains only a portion, Chapters  
1 through 5, of the ERADCOM handbook)

**PREPARATION OF MANUFACTURING  
METHODS AND TECHNOLOGY (MMT)  
PROCUREMENT DATA PACKAGES**

**Prepared For:**

**US ARMY  
ELECTRONICS RESEARCH AND DEVELOPMENT  
COMMAND**

**MARCH 1982**



**TECH TRAN CORPORATION**

## FOREWORD

The Manufacturing Methods and Technology (MMT) Program plays an important role at the US Army Electronics Research and Development Command (ERADCOM) by providing a means of translating emerging manufacturing technology into proven production processes and equipment. The program results in reduced acquisition costs and leadtimes, improved efficiency and responsiveness of the defense industrial base, and the ability to meet environmental safety and energy conservation requirements.

A major factor in the successful accomplishment of an MMT project is the procurement data package, which provides the formal link between the technical manager and procurement personnel. The procurement data package is an essential element in the procurement process because it communicates all of the technical requirements, procedures, and justifications necessary for the solicitation request. The package plays a significant role in obtaining the best possible contract and can have a major affect on the outcome of the project. Incomplete or inaccurate procurement data packages can result in extended time delays during procurement, subsequent project inefficiencies and increased costs.

The key individual in the preparation of procurement data packages for an MMT project is the project engineer. In addition to being the technical point of contact for the MMT project, the project engineer is also responsible for defining in detail the work which is to be accomplished and it is his\* responsibility to ensure that the unique requirements of MMT projects have been incorporated into the procurement data package.

The purpose of this pamphlet is to provide ERADCOM project engineers with the information and perspective needed to properly prepare procurement data packages for MMT projects. The pamphlet has been written for the project engineer who has at least an introductory-level understanding of the procurement process. Thus, the pamphlet concentrates on those unique or difficult aspects of MMT procurement data packages as opposed to an in-depth discussion of procurement procedures.

The pamphlet is divided into three parts. Part I, Overview and Philosophy, provides the project engineer with an introduction to MMT project goals and constraints, the contents of procurement data packages, an understanding of his responsibilities, and key issues affecting the success of an MMT project procurement.

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\* Throughout the pamphlet, the project engineer is referred to in the masculine gender to simplify the text and provide a document that is easier to read. This is not meant to infer that all project engineers are male. For example, when the word "his" is used, the reader should assume that it means "his or her."

Part II, Preparation Guidelines, contains the detailed information and examples needed by the project engineer to prepare an MMT procurement package. The Appendices contained in the third part provide the reader with an assortment of reference material including a sample Statement of Work, Data Item Descriptions, Evaluation Plan, and Sole Source Justification, together with preparation instructions for some of the forms normally included in the procurement data package.

Part I is intended for limited use as a source of general information for a project engineer who is new to, or has not been recently involved in, an MMT project procurement. In contrast, Parts II and the Appendices are intended to be working tools for repetitive use by all project engineers during the actual preparation of procurement data packages.

Although a variety of regulations, manuals, and specifications are referenced within this pamphlet, the project engineer is cautioned that the information contained herein should not be construed as official policy. This pamphlet provides only a recommended approach to the preparation of procurement data packages.

Because policy and procedures change frequently, it is impossible to insure that a pamphlet of this type is always up-to-date. It is intended that this pamphlet be continually reviewed and updated; however, when inconsistencies or doubts exist as to the correct procedures, the project engineer should check with the responsible authority for clarification and guidance.

Readers are encouraged to recommend changes that would improve the contents of future versions of this pamphlet. Comments or suggestions should be forwarded to: Commander, US Army Electronics Research and Development Command, ATTN: DRDEL-PO-S, 2800 Powder Mill Road, Adelphi, MD 20783.

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## **PART I**

### **OVERVIEW AND PHILOSOPHY**

## Chapter 1 Introduction

### 1-1. Procurement Data Package

One of the most important activities of a project engineer for an MMT project is the preparation of the procurement data package. The package plays an essential role in the overall success of the project because it specifies the work to be accomplished by the contractor, determines overall project costs and schedules, and dictates end products to be received. The procurement data package also fulfills other important functions, such as providing source selection information and justification, and communicating special requirements to the Contracting Officer.

### 1-2. Contractual Effort

All procurement data packages should reflect the specific needs and circumstances of the contractual effort, and this is particularly true for MMT projects. In order for the project engineer to prepare an effective procurement data package, he must have a working knowledge of the unique features of the MMT Program; the contents of procurement data packages for MMT projects; and his roles and responsibilities in the planning, preparation, and coordination processes.

### 1-3. Reader Awareness

Part I is aimed at providing the reader with the why's and how's of procurement data package preparation. It identifies those unique constraints and major problem areas which are peculiar to MMT projects. By raising the reader's awareness of these issues, Part I provides the project engineer with a better understanding and perspective of how his activities relate to those of others involved in the procurement process. This awareness and understanding enables the project engineer to more effectively utilize the information and guidelines in Part II and the Appendices on a routine basis.

### 1-4 Chapter Descriptions

A brief background of the Army's MMT Program is presented in Chapter 2, together with a discussion of typical MMT projects and their effects on preparation of procurement data packages. Chapter 3 examines the different types of procurement data packages and their appropriate contents. In Chapter 4, the roles and responsibilities of the ERADCOM project engineer are defined, and a generalized approach which can be used in preparing a procurement data package is presented. The final section of each of these chapters is dedicated to identifying and discussing the major issues and associated problems the project engineer should consider in the preparation process.

## Chapter 2

### Manufacturing Methods and Technology Program

#### 2-1. Scope

This chapter provides background information on the MMT Program and highlights unique aspects, constraints, and potential problem areas as they relate to procurement data packages.

#### 2-2. Introduction

a. As defined in AR700-90, the MMT Program provides for the development or improvement of manufacturing processes, techniques and equipment to provide for the timely, reliable, and economical production of defense materiel for current manufacturing problems or future acquisition. The primary objectives of the program are to reduce acquisition costs, improve materiel performance and reduce production leadtime.

b. MMT projects are funded from Procurement appropriations meeting the following criteria:

(1) Satisfy current or anticipated materiel acquisition requirements.

(2) Be based on technology or equipment concepts demonstrated in research or laboratory work prior to initiation of the MMT project.

(3) Result in new, significantly improved, or more economical processes, techniques, equipment or production systems.

(4) Result in generic processes, techniques or equipment which are capable of supporting a variety of weapon systems or components.

c. The MMT Program at ERADCOM has grown significantly in recent years and additional future growth is projected. (In fiscal year 1982, funding was about \$10 million, representing 8 to 10 individual MMT projects). The ERADCOM MMT Program encompasses a wide spectrum of manufacturing technology needed to produce the following types of items: detectors, displays, electron tubes, frequency control devices, integrated electronics, lasers, optics, power sources and discrete solid state devices.

d. The MMT Program has become an important factor in ERADCOM's overall mission. Individual MMT projects serve as a means of translating emerging manufacturing technology that has been demonstrated in an R&D environment into implementable production processes and equipment. As the MMT Program continues to expand it will become a critical element affecting the producibility of ERADCOM's future systems.

e. The role of the MMT Program in the development and acquisition of ERADCOM systems should be clearly understood by the project engineer. AR700-90 places constraints on the types of effort that can and cannot be undertaken as MMT projects. For example, MMT projects cannot be used for basic research in new manufacturing technology. Similarly, MMT projects should not provide for full-scale implementation of new processes or equipment. To understand the role of an MMT project in establishing new or improved production techniques, it is useful to examine the life cycle of a new manufacturing technology.

f. A manufacturing technology typically has a discernable life cycle such as the one shown in Figure 2-1. A complete cycle is normally composed of separate phases for research, scale-up, implementation, and use of the technology. Each phase is characterized by a specific set of parameters, such as objectives, relative cost, risk, and funding sources.

g. In the research phase, the technical feasibility of utilizing the technology as a production process is established or proven in a laboratory environment. During the scale-up phase, the major objective is to demonstrate the full scale commercial feasibility of the technology. Once commercial feasibility has been shown, the technology is then implemented and used in a normal production environment.

h. The major emphasis of the MMT Program is the scale-up phase of the life cycle. It is important to note that the scope of a MMT project does not encompass the research phase, nor does it provide for the actual implementation and use of the technology. The objective of an MMT project, as specified in AR700-90, is to support scale-up to full production of technologies shown to be feasible in a laboratory environment. It is also important to point out that although there are distinct similarities between life cycles of a manufacturing technology and a major weapon system, the manufacturing technology is not directly linked to any one weapon system development. In fact, the life cycle of a manufacturing technology can occur at any point in a particular weapon system development.

i. Although an MMT project does not provide for implementation, of the technology, it must take into consideration implementation requirements. The contractor's efforts and associated deliverables must demonstrate the commercial feasibility of the technology and provide the data needed to implement the technology in follow-on production facilities contracts. To this end, some of the more important data requirements for MMT projects are process plans and analyses, implementation requirements, tooling and equipment designs, test data, and technical reports. To successfully foster implementation, these data requirements should emphasize full disclosure of the technology and address such issues as production costs and yields.

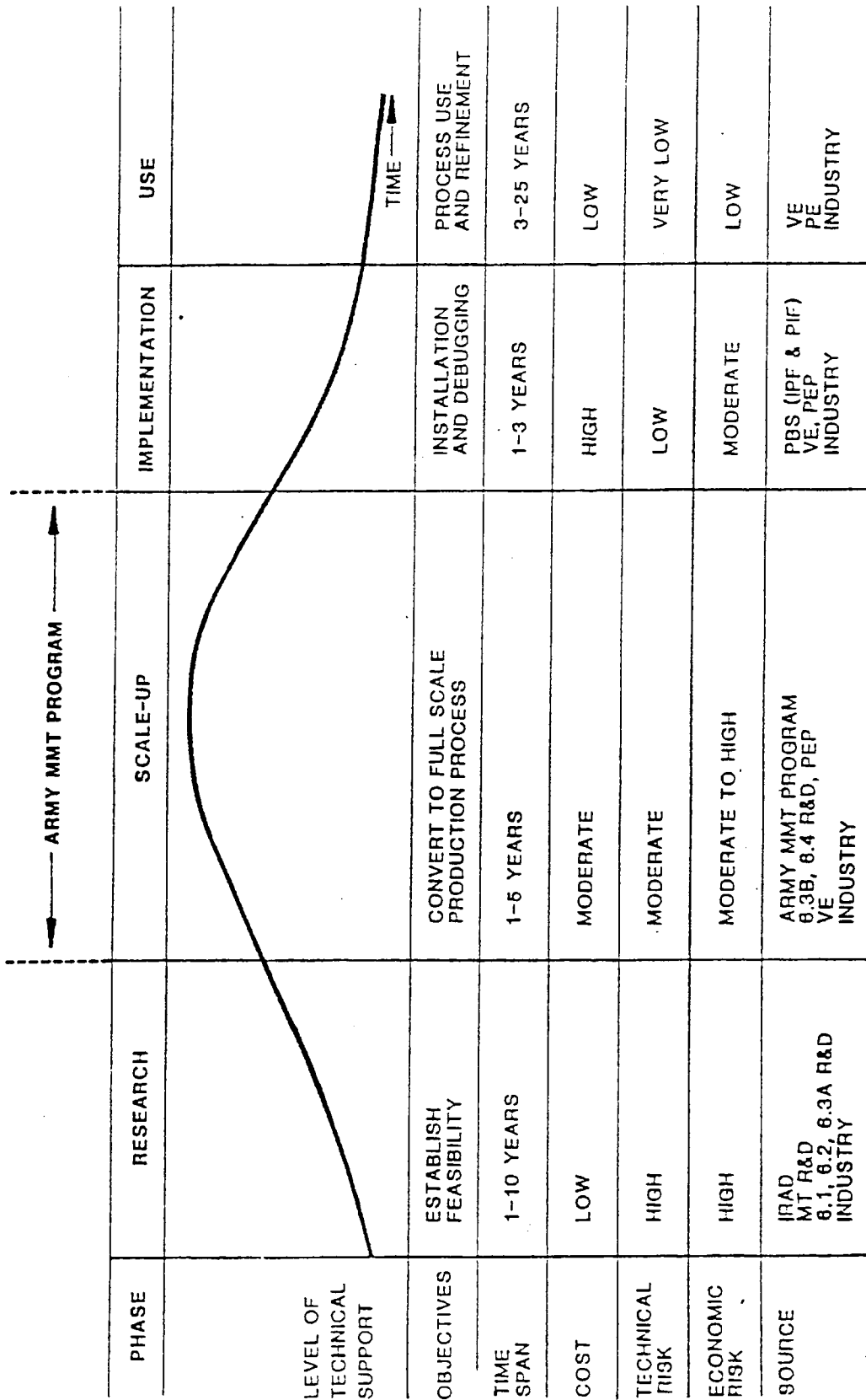


FIGURE 2-1. MANUFACTURING TECHNOLOGY LIFE CYCLE

j. Because MMT projects are funded using Production Base Support budget lines as opposed to end item budget lines for a specific weapon system, they must support technology which is generic in nature. At the same time, however, specific implementation targets for the new technology are required. Thus MMT projects should be structured from the standpoint of both timing and technical scope, to satisfy the information needs of the implementation targets.

### 2-3. Typical MMT Project

a. No two MMT projects are identical and the specific requirements and overall structure varies for each project. However, an example of a "typical" MMT project is needed to discuss the unique aspects, constraints, and potential problem areas inherent in such projects. The example project developed in this chapter will be used throughout the pamphlet to provide a common basis for illustrating the issues faced by the project engineer in preparing a procurement data package.

b. MMT projects are often divided into five distinct phases, as illustrated in Figure 2-2. Each phase is further subdivided into tasks which the contractor is required to accomplish in the successful completion of the project. The start-up phase insures that the technical and administrative requirements of the contract have been correctly interpreted by the contractor, and that the project engineer understands exactly what it is the contractor is going to do. The five tasks in the engineering phase are used to obtain a preliminary design and an initial evaluation of the technology. The confirmatory phase, which is also composed of five tasks, refines the design of the process and/or production equipment and insures that the technology is suitable for production of components. In the pilot run phase, the capabilities of the pilot production line are demonstrated and rate, yield, and cost data are collected. The completion phase is composed of those tasks which document the work accomplished under the contract and provide for technology transfer and implementation.

c. Actual phases during the execution of an MMT project only represent a portion of the entire life of an MMT project. To understand the relationship of the procurement data package to project execution, one has to examine the entire project life cycle. A typical MMT project cycle is depicted in Figure 2-3. The cycle usually spans a seven to twelve year time period and encompasses a planning, an execution, and an implementation phase. The planning phase encompasses the normal steps of P-16 preparation and obtaining budgetary approval for the project. The project approval milestone marks the beginning of the procurement process, which is part of the execution phase. The procurement process includes the preparation of the procurement data package, the release of a request for proposal, the proposal evaluation and the selection of the successful bidder. The procurement process and the role of the procurement data package are discussed in more detail in Chapter 3. The MMT contract is awarded at the conclusion of the procurement process, and this

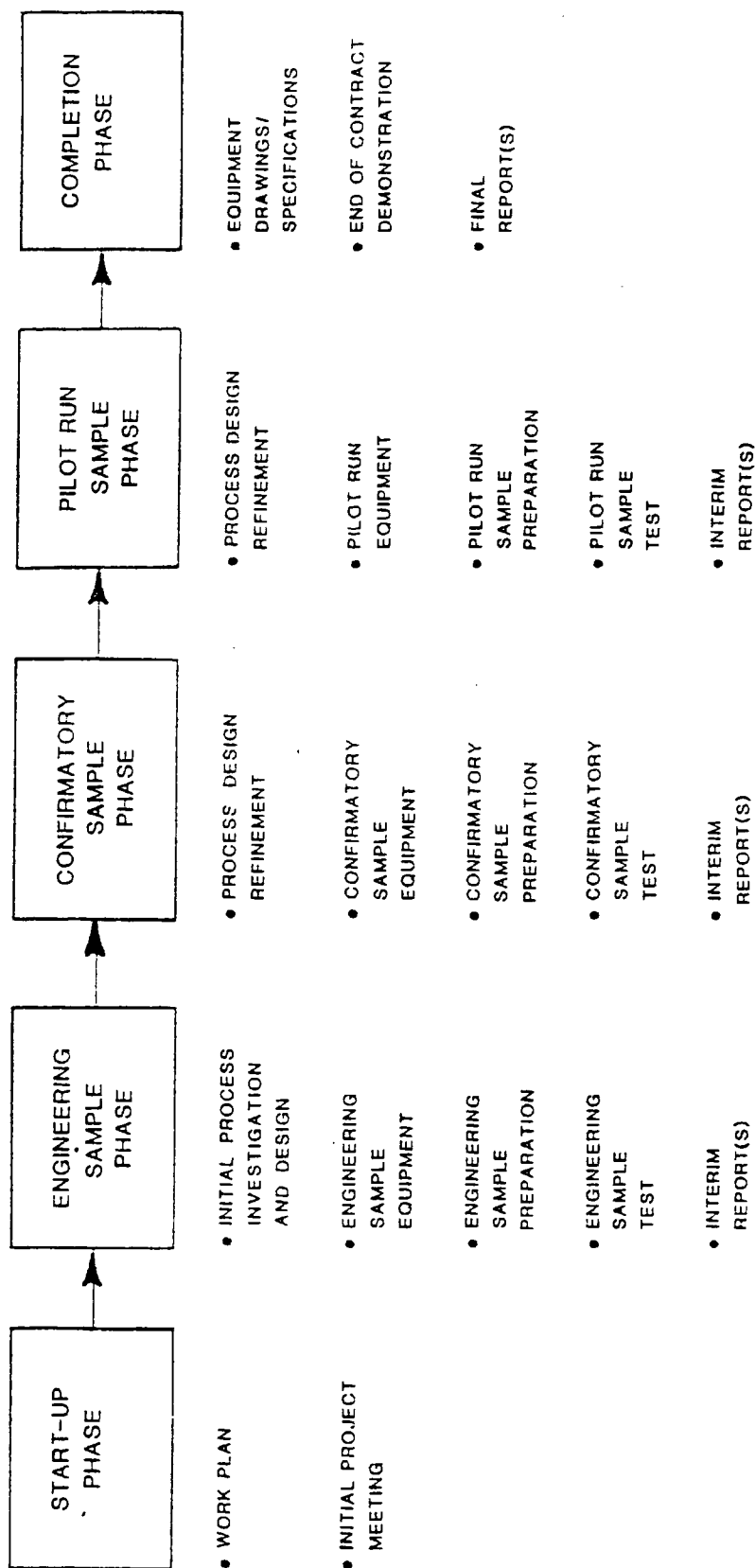


FIGURE 2-2. EXAMPLE MMT PROJECT EXECUTION PHASES AND TASKS



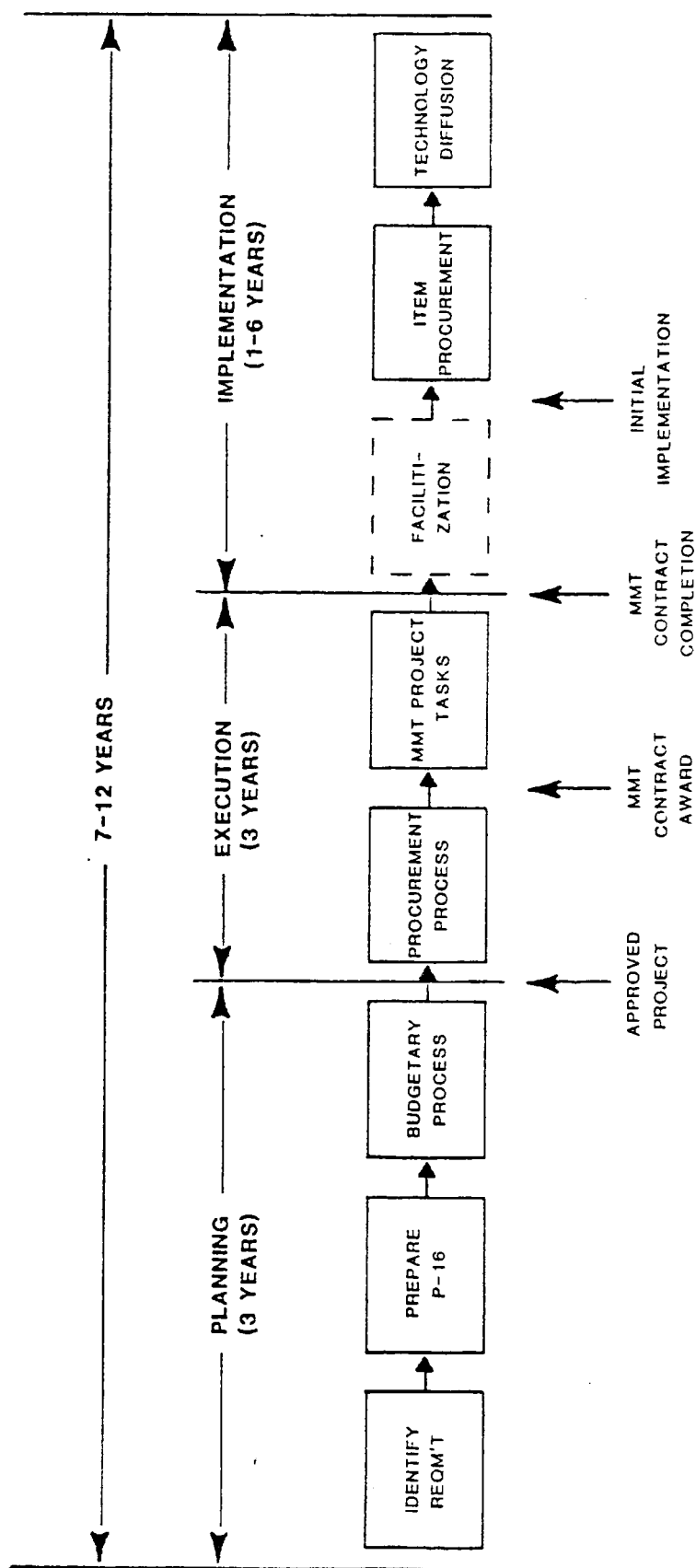


FIGURE 2-3. TYPICAL MMT PROJECT CYCLE

milestone marks the beginning of the MMT project tasks which were depicted in Figure 2-2.

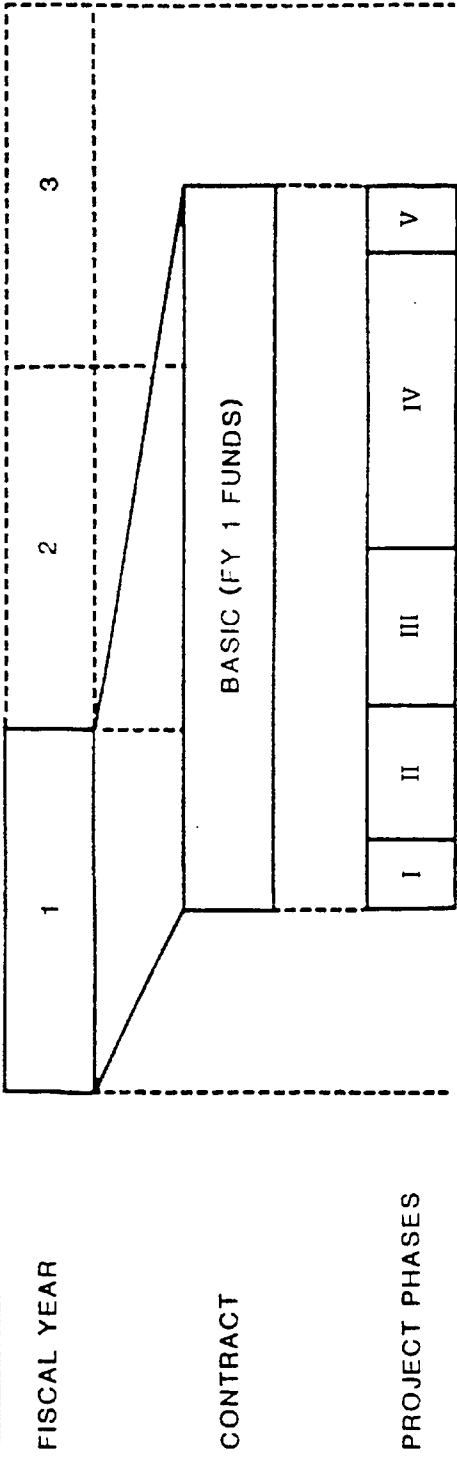
d. Following the contractor's successful completion of the MMT project tasks, the implementation phase is initiated. Strictly speaking, the implementation phase is not part of the MMT project for funding purposes. It is included in Figure 2-3 to illustrate how technology developed under an MMT project becomes used within the Defense Industrial Base. The first step of the implementation phase is that of facilitization. It is shown in a dotted rather than solid form to indicate that, in some cases, a formal implementation contract on the part of the Government may not be required; frequently, the results of MMT projects are implemented by contractors without Government assistance. However, some type of facilitization process (contractor or government funded) must take place for the MMT project to attain its ultimate goals. MMT projects may be linked to Provisioning for Industrial Facilities (PIF) or Initial Production Facilities (IPF) projects, which provide for the necessary industrial facilitization. Once the technology has been initially implemented, it can be used for production of ERADCOM end items. As the Army and other military and civilian organizations continue to utilize the new technology, it becomes diffused throughout industry. This production implementation and subsequent diffusion of the technology results in reaching the objectives of the MMT Program by reducing costs and decreasing acquisition times for military systems and materiel. To this end, ERADCOM periodically reports on the implementation status of MMT projects for five years after project completion.

#### 2-4. MMT Project Funding

a. In general, there are two types of funding strategies which are utilized for MMT projects: single and multiple-year funding. The specific strategy is selected when the P-16 is submitted to the budgetary review process, and this selection has a direct effect on how the project will be structured. Figure 2-4 illustrates the two funding strategies and how the MMT project is structured for each.

b. For single-year funding, the total funds required for the project are authorized in one fiscal year. When single-year funding is employed, the five phases (Figure 2-2) of the project are contained in one basic contract effort. For the example used in Figure 2-4, the basic contract would cover two calendar years. For multiple-year funded projects, only those funds required to complete the work in one calendar year are authorized in the first fiscal year. The funds for a year's work beyond the first calendar year are then authorized in subsequent fiscal years. By reducing the funds required for any specific fiscal year, it is possible to initiate more projects in any given year for the same overall program value.

SINGLE YEAR FUNDING



MULTIPLE YEAR FUNDING

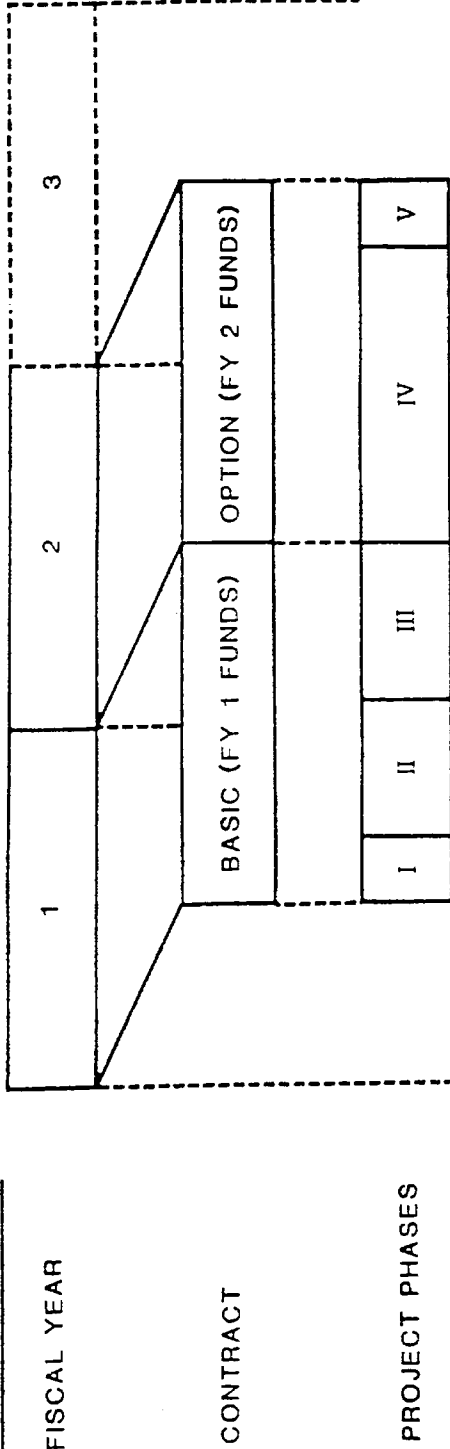


FIGURE 2-4. ALTERNATE APPROACHES TO FUNDING/CONTRACTING OF MMT PROJECTS

### CAUTION

The decision to structure a project into a multiple-year funded effort must be in compliance with AR 37-42 "Full Funding of Army Programs" and each phase must result in a stand alone, useful project.

c. When multiple-year funding has been specified in the P-16, the MMT project is normally subdivided into two or more distinct parts. In the example used in Figure 2-4, the first part is a basic effort which usually contains the planning, engineering, and confirmatory sample phases (Phase I, II and III ). The pilot run and completion phases (Phase IV and V) are contained in a contract option which can be exercised by the Government.

d. In addition to permitting funding for more projects, the multiple-year funding strategy provides a natural review point for terminating unsuccessful projects, and results in better contractor accountability. It becomes incumbent on the contractor to demonstrate sufficient justification for the project to be continued into the option. For those projects which do not warrant continuation into the last two phases, the project should be terminated.

## 2-5. Major Issues

There are several major issues stemming from inherent objectives and constraints of MMT projects which the project engineer must consider when preparing the procurement data package. The purpose of this section is to identify these key issues and discuss pertinent information and potential problem areas associated with each of them. The project engineer should give careful consideration to these major issues during his planning activities and assess the relative impact each may have on his project.

a. **Implementation of Results.** The key to the overall success of any MMT project is that the resulting technology, processes, equipment, etc., be implemented and disseminated. Although the objective of an MMT project is to foster implementation of the technology, the project does not provide for direct facilitization or procurement of end item requirements. Thus the MMT project tasks, schedule and deliverables should be structured so that all information necessary for full-scale production implementation is obtained, while stopping just short of actual implementation.

b. **Objective of Procurement Data Package.** The project engineer should be sure that the procurement data package for the MMT project does as follows (these parts are discussed in more detail in Part II):

(1) Specifies those tasks and deliverables needed to establish the technical and commercial feasibility of the technology, and bring about implementation of results.

(2) Is based on demonstrating the feasibility of the technology for clearly defined and suitable implementation targets.

(3) Is time phased to meet the needs of related follow-on Provisioning of Industrial Facilities (PIF) or Initial Production Facilities (IPF) projects, if appropriate.

c. Project Engineer's Responsibilities. One of the project engineer's responsibilities is to ensure that the MMT project and corresponding procurement data package are structured to minimize risk and cost and maximize the likelihood of implementation and use of the technology.

d. Data Rights. A major obstacle which stands in the path of technology implementation is the contractor's claim to proprietary data rights.

(1) From the contractor's viewpoint, proprietary data is advantageous because it provides a competitive edge in future acquisitions. However, from the Government's viewpoint, proprietary claims act as inhibitors to the competitive process of technology dissemination and use.

(2) The project engineer should be aware of two different ways in which the contractor's claims can influence his project. First, a contractor can claim proprietary data rights to processes he has developed in the course of performing the MMT project. Second, he can claim that he has incorporated processes for which he already has proprietary rights. Both of these cases result in problems when other companies try to implement the results of the MMT project in subsequent Government contracts.

(3) The project engineer must face this issue in the planning stages of his project. First, he must decide how critical the issue of data rights is to his project. There are instances, such as sole source contracts or contracts in specialized or limited competition areas of industry, that the costs and efforts required to preclude the contractor from these claims are not warranted. In general, however, these instances are rare.

(4) Second, the project engineer should require that prospective contractors submit as part of their proposals: 1) exact information concerning proprietary processes they plan to use during the contract, and 2) what processes to be developed during the contract they feel should be granted proprietary rights. By informing the potential contractors that the issue of data rights is important to the goals of the project and discouraging the use of proprietary data in the proposals evaluation factors, the project engineer can decrease the negative effects that this issue has on his project. Being forewarned of which areas data rights will be involved can also increase the project engineer's options in managing the execution phase of the project.

(5) Finally, the project engineer should work closely with the Contracting Officer in establishing the requirements for potential contractors to properly identify their proprietary data claims. Solicitation of the Contracting Officer's input ensures that the details of the data rights issue are properly addressed in the Notes to Contracting Officer, the evaluation plan, and other appropriate sections of the procurement data package. By obtaining a better appreciation of the impact the claims will have on the project's success, the Contracting Officer is better equipped to include specific instructions to prospective contractors in the Notes to Offerors. The Contracting Officer can also more effectively coordinate the RFP and proposal evaluation phases of the project if he is well informed on the importance of this issue.

d. Funding. At various points in the MMT project, the project engineer may be required to adapt to significant changes in project funding.

(1) These changes may be brought about through the normal events of a contract (e.g., exercising an option) or by such unprogrammed events as budgetary cuts, or cost overruns due to technical difficulties and delays. It is not uncommon for the authorized funding for an MMT project to be different than that originally requested during the initial project planning. Thus, the project engineer may have to restructure the scope of the project to match available funds. When doing so, consideration should be given to the natural breakpoints that exist within an MMT project's execution.

(2) A generalized graph of the value received and funds expended for an MMT project is shown in Figure 2-5. During most of the project, the funds expended exceed the value of information received if the project were to be terminated at that point. For the example shown in the figure, half the total funds were expended prior to the production of the confirmatory samples, but very little technical value had been received up to that point. For a typical project, the major gains in value occur during the production of test samples and during the demonstration of production rate and yield capabilities.

(3) Two main factors are illustrated by a graph such as this. First, it shows that a significant cost is incurred prior to receiving any appreciable value from an MMT project. Therefore, the project engineer should insure that sufficient funds have been authorized and obligated to reach at least the first major value increase point. Secondly, the graph illustrates that there are intervals during the project for which it is possible to expend significant levels of funds without receiving a marginal increase in technical value. When such factors as inflation, cutbacks, etc. alter the funding constraints of a project such that the next increase in value cannot be reached, the remaining authorized funds should not be "dumped" into the project without careful analysis.

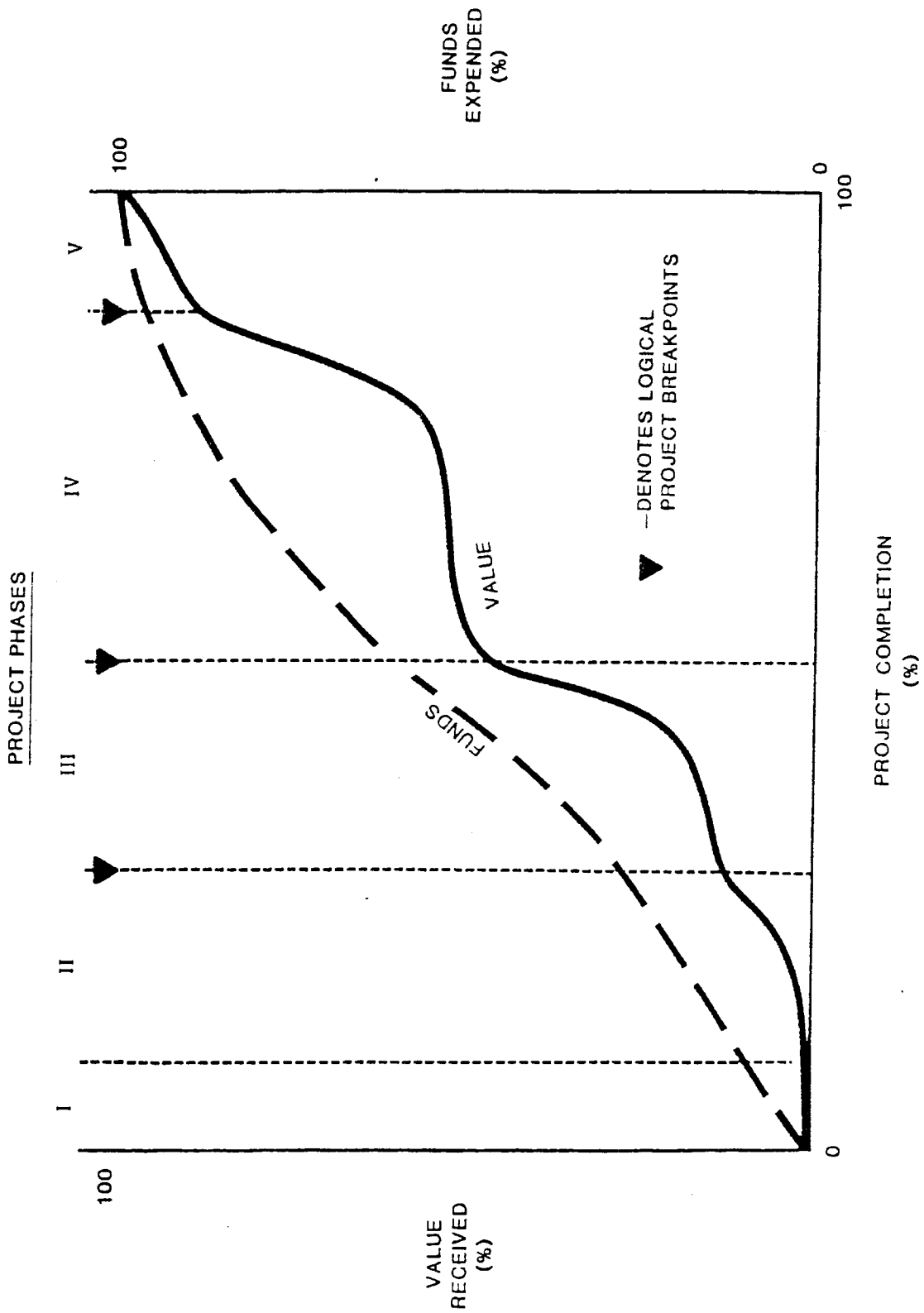


FIGURE 2-5. VALUE RECEIVED VERSUS RESOURCE EXPENDITURE

(4) If premature termination of the project is necessary, the action should be taken at one of the three logical breakpoints depicted in Figure 2-5. The MMT project phase structure which was shown in Figure 2-2 results in at least three major breakpoints at the conclusion of Phases II through IV. By designing his project such that major contractor deliverables are linked to these breakpoints, the project engineer can achieve at least a portion of his objectives if his project is curtailed or terminated because of funding requirements. Because information is available earlier in the project, a severe cutback in funds does not completely destroy the progress made to that time. Preliminary data and findings which would not normally be available if received at the end of the contract can be used at a later date and/or disseminated to industry.

e. Management. Effective management of an MMT project is realized only through a continuing series of trade-offs or compromises.

(1) This is especially true when planning and preparing procurement data packages. The requirements of obtaining the necessary data must be balanced with the associated costs. The cost-benefit tradeoffs that typically must be made when the project engineer is preparing the procurement data package include the following:

- (a) Deliverables, data, reports, etc., required.
- (b) Quantities of test samples required in the various project phases.
- (c) Testing requirements, methodologies, and criteria.

(2) The project engineer must also be sensitive to such issues as cost overruns and schedule slippages. Getting increased funding for cost overruns is always difficult, and can severely limit the effectiveness of the project. Similarly, schedule slippages can result in a missed opportunity to implement and utilize the new technology. The effects of both the cost overruns and schedule slippages can be decreased by the project engineer's active management of the project. But to accomplish this, the procurement data package must reflect the necessary managerial tools, such as status reporting for both technical and financial progress during the contract's execution.

f. Contract Type. The type of contract which is to be issued has a significant bearing on what information will be included in the procurement data package. Whether the contract will be for a competitive or sole source procurement and whether it will be a fixed price or cost-plus type are questions which should be addressed and resolved prior to beginning the preparation of the procurement data package. Although decisions on these matters directly affect the project engineer's efforts, he is not the responsible authority tasked to make the decisions; the selection of contract type is made by the



Procurement/Contracting personnel. Proper planning and coordination with these individuals will enable the project engineer to prepare the correct information and necessary justifications.

g. Avoiding Inappropriate Language. Because of the unique objectives and criteria for MMT projects, along with the fact that such projects are funded with procurement appropriations as opposed to RDTE appropriations, the use of certain terms are considered more appropriate than others in the procurement data package. Terms such as "analyze, establish, evaluate, construct, and assemble" should be used in lieu of words like "design and develop," which imply some type of RDTE funded effort. The word "study" should also be avoided because of the requirements necessitated by the Army Study Program. Taking the extra effort to insure that nonappropriate terms or language are not included in the data package during the preparation process will result in fewer difficulties during review, approval, and conversion to a formal solicitation.

h. Joint Service Projects. As participants in the Tri-Service Manufacturing Technology Advisory Group (MTAG), Army project engineers may serve as technical managers of Joint Service Projects. When so tasked, the project engineer must insure that he includes representatives of the other participating services in the proposal evaluation, source selection, management review, and other key functions of the project.

i. Government Furnished Equipment. On occasion, MMT projects require the use of Government Furnished Equipment (GFE) or Government Furnished Material (GFM). In these cases the project engineer should identify the appropriate GFE/GFM in the procurement data package, along with disposition instructions after contract completion. The project engineer is also responsible for reserving the GFE/GFM for use during the project and arranging for its shipment to the contractor.

## Chapter 3

### Procurement Data Packages

#### 3-1. Scope

This chapter provides an overview of the procurement process and background information on procurement data packages as they relate to ERADCOM MMT projects. The contents of the different types of packages are highlighted and potential problem areas are discussed.

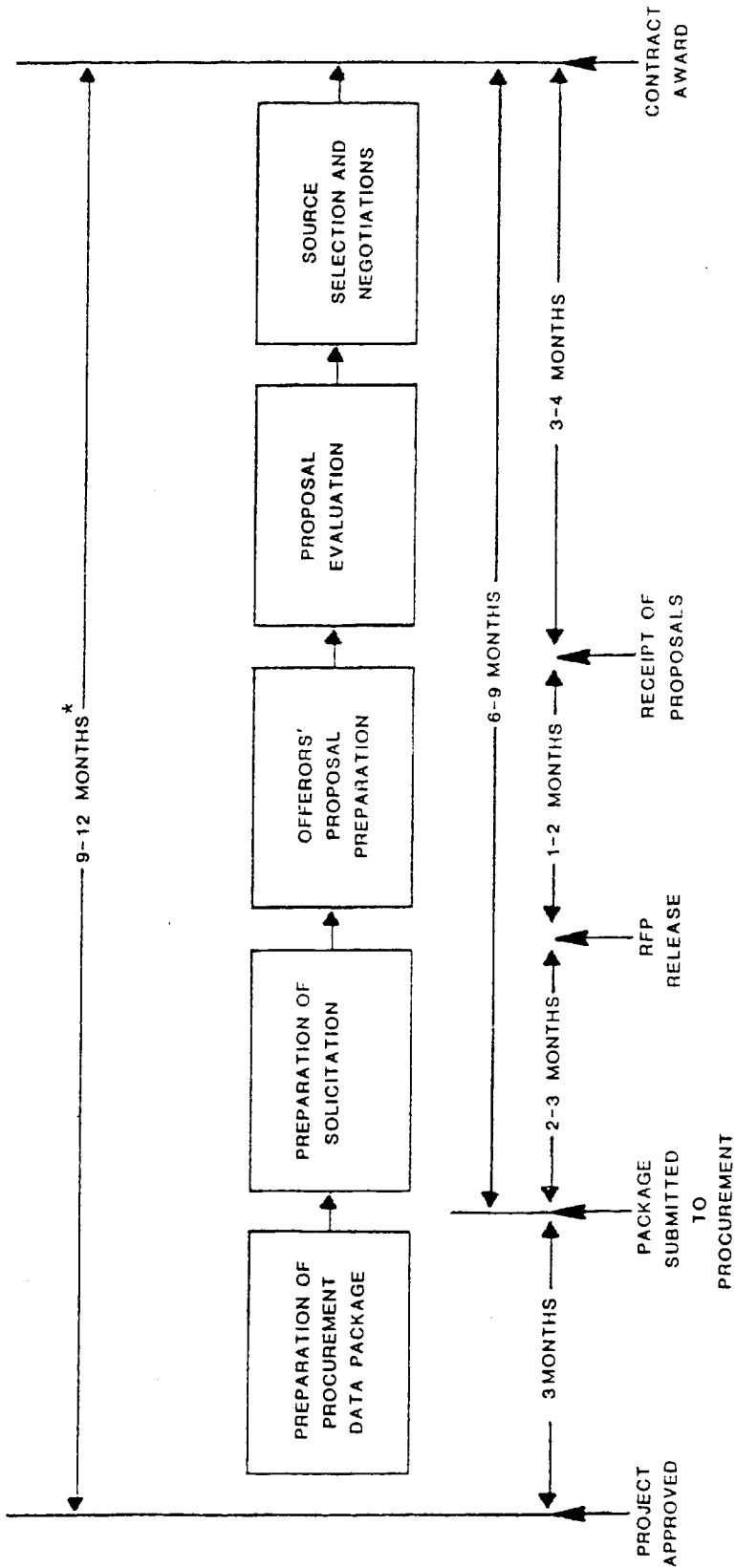
#### 3-2. Introduction

a. The typical procurement process for an MMT project is shown in Figure 3-1. In general, the total process from project approval to contract award normally takes from nine to twelve months with variations encountered depending on the nature of the project, procurement office workload, etc..

b. The first step in the process is the preparation of the procurement data package by the project engineer. This step takes approximately three months, and once assembled, the package is submitted to Procurement. The Contracting Officer and Contracting Specialist use the information contained in the package together with other inputs to prepare the Request for Proposal (RFP). The RFPs are normally released two to three months after Procurement receives the project engineer's package. Following the RFP release, the offerors are given one to two months to submit their proposals. When all the proposals have been received, they are formally evaluated and the best proposal is selected. After final terms, conditions, etc., are negotiated between Procurement and the selected bidder, the contract is awarded.

c. The driving force behind the entire procurement process is the procurement data package. Its purpose is to initiate the procurement action and to act as the formal link between the technical manager and the contracting and procurement personnel. The contents of the procurement data package include data and information needed in the proposal solicitation and project contract, source selection requirements, and financial and supporting information. The package is utilized to communicate the technical requirements Procurement needs to generate the solicitation request. It also specifies the information and procedures used in the proposal evaluation and contractor selection activities. Finally, the description and specification of the work to be accomplished by the contractor during the contract are contained in the package.

d. The necessity for a well-prepared procurement data package cannot be over-emphasized. Because it directly affects all major aspects of the procurement process and project execution, the package must be complete and accurate. If not, the nine to twelve month procurement



\*NOTE: ACTUAL TIMES MAY VARY DEPENDING ON PROCUREMENT WORKLOAD, TYPE OF PROCUREMENT AND CONTRACT, NATURE OF MMT PROJECT AND SIMILAR FACTORS.

FIGURE 3-1. TYPICAL MMT PROCUREMENT PROCESS

process can be drastically delayed. Secondly, the package contents significantly influence the number and quality of contractors who will submit a proposal. Unclear tasks or evaluation criteria may cause highly qualified contractors to submit a proposal which is not acceptable or, in some cases, to decline entirely from submitting a proposal. Lastly, a well prepared package has a definite impact on the outcome of the project. Packages which are prepared to obtain the data and information necessary to support the MMT Program implementation goals are much more likely to result in a successful project which benefits the needs of the Army.

e. The next two sections of this chapter contain a breakdown of the contents of a procurement data package for different types of solicitations and a discussion of the major issues and problem areas he should consider when preparing a procurement package. By having a better appreciation of the package requirements and factors which merit his consideration, the project engineer can prepare and assemble a more complete and accurate package.

### 3-3. Types of Procurement Data Packages

a. The contents of a procurement data package for an MMT project can be grouped into the following four general categories:

- (1) RFP/Contract Data.
- (2) Financial Data.
- (3) Source Selection Data.
- (4) Special Considerations Data.

b. The elements contained in the first category are, as the name implies, utilized directly in the Request for Proposals and/or the actual contract. These data include the technical requirements and project tasks, detailed specification on the type, number, and frequency of deliverables, and other pertinent information as required. Funding and cost information is contained in the Financial Data, while pertinent evaluation procedures and justifications are contained in the Source Selection Data. The Special Considerations Data category includes the remaining notes and forms necessary for package coordination and information transmittal.

c. Although the four general categories are contained in all procurement data packages, the elements needed to satisfy the package requirements do vary depending upon the solicitation process that will be used for the project. Figure 3-2 depicts the contents required for a competitive solicitation, while Figure 3-3 is for a sole source solicitation.

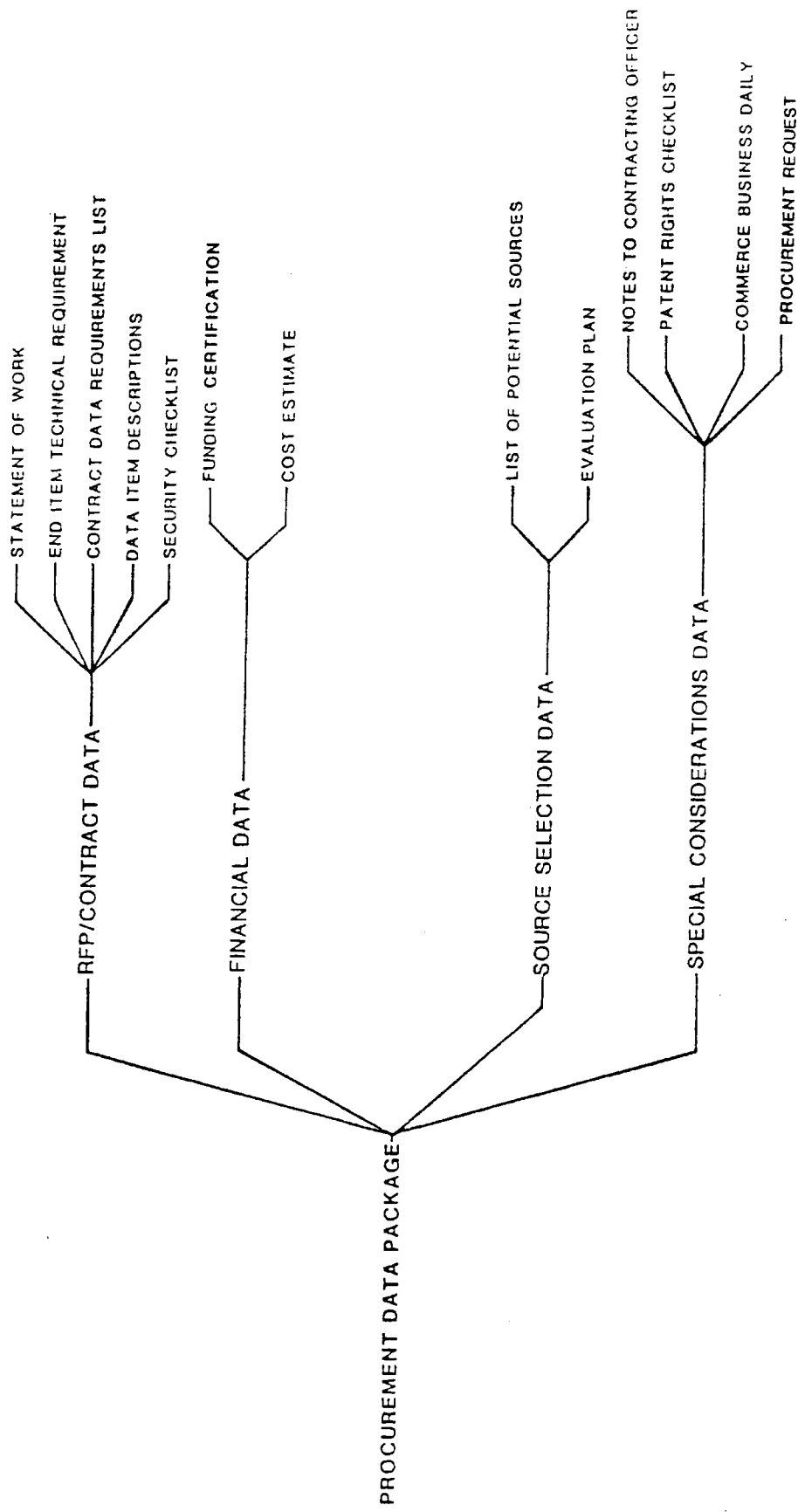


FIGURE 3-2. CONTENTS OF PROCUREMENT DATA PACKAGE FOR COMPETITIVE SOLICITATION

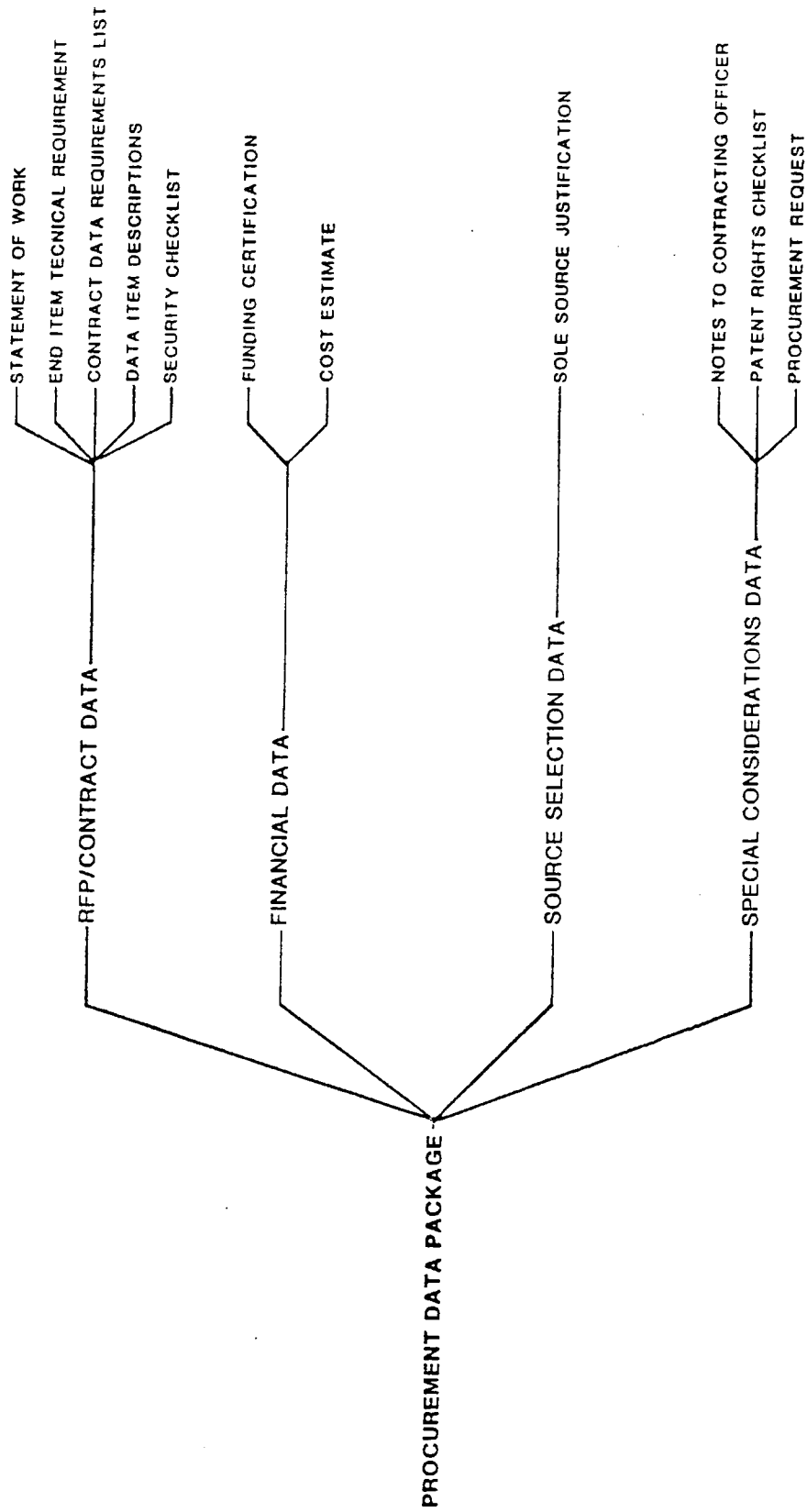


FIGURE 3-3. CONTENTS OF PROCUREMENT DATA PACKAGE FOR SOLE SOURCE SOLICITATION

d. The RFP/Contract Data and Financial Data are essentially the same for both types of packages and the elements contained in these categories are self explanatory. The major difference between the two packages exists in the Source Selection Data. In a competitive procurement, the project engineer should provide Contracting with a list of potential contractors who are competent in the general areas of the project, to which the Contracting Officer may add additional sources. Together with this list, the project engineer must submit the detailed evaluation procedures, factors, and scoring methodology required to select the best proposal. These two elements are not required in a sole source solicitation but are replaced by the sole source justification which provides the facts and conclusion necessary to support a noncompetitive procurement action. There are also some minor differences in the Special Consideration Data such as the Commerce Business Daily Synopsis which may be included in a competitive solicitation but is not required for a sole source package.

e. The elements shown in Figure 3-2 and 3-3 are those that should be considered as the typical requirements for a complete procurement data package. The project engineer should insure that he includes any additional information which is peculiar to the particular laboratory or Procurement office involved in the procurement action.

f. Each of these elements has its own characteristics and level of importance. A qualitative assessment of the elements, based on information obtained from individuals involved in the MMT Program at the three major ERADCOM participating laboratories, is presented in Figure 3-4. The project engineer should use this chart in his overall planning activities to better allocate his time and efforts in preparing the elements for his package.

### 3-4. Major Issues

The four major issues which relate to the procurement process and the preparation and assembling of the procurement data package are timeliness, coordination, completeness, and tailoring. These issues are presented for the project engineer's consideration in the following paragraphs.

a. Timeliness. The timeliness issue can be divided into two areas.

(1) First, the project engineer must be sensitive to the time requirements necessary to obtain an MMT contract. It is not simply a matter of submitting the procurement data package one day and having a contract a few days or weeks later. As shown in Figure 3-1, it requires from six to nine months, or longer, from the time Procurement receives the package until a contract is issued. It is difficult to reduce this interval because of mandated statutory requirements and, therefore, the project engineer should make allowances for it in his overall project planning. If there are key target dates to be achieved, he should permit sufficient time for the procurement process

ELEMENT	APPLICABILITY		CRITICALITY		
	MANDATORY	MAY BE REQUIRED	MAJOR INFLUENCE ON OBTAINING CONTRACT	MAJOR INFLUENCE ON SUCCESS OF CONTRACT	MAJOR INFLUENCE ON OVERALL PROJECT
STATEMENT OF WORK	X		X	X	X
END ITEM TECHNICAL REQUIREMENT		X		X	X
CONTRACT DATA REQUIREMENTS LIST	X		X	X	X
DATA ITEM DESCRIPTIONS		X		X	X
SECURITY CHECKLIST		X			
EVALUATION PLAN	X		X	X	X
FUNDING CERTIFICATION	X				
COST ESTIMATE		X	X	X	X
LIST OF POTENTIAL SOURCES		X	X		
SOLE SOURCE JUSTIFICATION		X	X	X	X
NOTES TO CONTRACTING OFFICER		X	X	X	X
PATENT RIGHTS CHECKLIST	X			X	X
CBD SYNOPSIS		X			
PROCUREMENT REQUEST	X				

FIGURE 3-4. CHARACTERISTICS OF PROCUREMENT DATA PACKAGE ELEMENTS



and adjust the starting time of his preparation activities accordingly.

(2) The second area is the issue of "Short of Award" funding authorization. This action is applicable to MMT projects and can be used to reduce the time required to complete the procurement process. In many instances, it is highly probable that a particular MMT project will be funded even though actual funding has not yet been appropriated. For situations such as these, the project engineer can obtain a "Short of Award" authorization from the appropriate financial management office at the laboratory. This document is submitted in lieu of the actual funding citation as part of the procurement data package. The authorization permits procurement action up to, but not including, award of the actual contract. It is, therefore, possible to save a considerable amount of time in the process or build in a buffer if a critical suspense date is imposed on the MMT project by other weapons systems requirements.

b. Completeness. More problems and time delays are associated with incomplete procurement data packages than any other factor. Incomplete, inconsistent, or inaccurate procurement data packages directly affect the solicitation process, the evaluation and source selection process, and the success of the MMT project. Although it is sometimes necessary to submit an incomplete package, these occurrences should be kept to a minimum. The project engineer should actively seek to avoid potential problems caused by an inaccurate or inconsistent procurement data package.

c. Tailoring. In many cases, project engineers will use procurement data packages from previous MMT contracts as a starting point in preparing the necessary information for new procurements. Although this may minimize the effort needed to prepare the new procurement data packages, care should be taken to insure that any previously used or standard inputs truly reflect the needs of the new project. It is the project engineer's responsibility to include in the procurement data package only those requirements, tasks, data, criteria, etc. that are applicable and cost-effective.

d. Status Monitoring. During the procurement process, the procurement data package is routed to various offices for review, input and approval actions. If problems are encountered, these actions can significantly delay award of a contract. It is, therefore, in the project engineer's best interest that he be aware of the status of the procurement data package and regularly monitor its progress throughout the procurement process. In this way, if a problem does arise, the project engineer will be aware of it much sooner and will be better able to rectify it than if he waits to be contacted through normal channels. Developing this informal coordination approach can result in a much smoother procurement cycle.

## Chapter 4

### Project Engineer's Responsibilities

#### 4-1. Scope

This chapter defines the roles and responsibilities of the project engineer and provides procedures to be used in preparing a procurement data package.

#### 4-2. Introduction

a. The project engineer is the key individual involved in the life cycle of an MMT project from the initial drafting of the P-16 to documenting the implementation results after the project is complete. He is the technical expert during the procurement/contracting process and normally assumes the responsibilities of the technical project manager in the project execution phase.

b. One of the most important functions of the project engineer is the preparation of the procurement data package. For many reasons, the overall success of an MMT project is directly proportional to the quality of the procurement data package. As the technical focal point for the MMT project, it is the project engineer who assumes the major responsibility for preparing the procurement data package. These responsibilities include: updating and converting the information contained in the P-16 to specific tasks and requirements; preparation of many of the elements included in the the procurement data package; and interacting with supervisory staff and support personnel to obtain the necessary inputs, reviews, and approvals.

c. The actual methods and technique involved in preparing and coordinating a procurement data package vary significantly as a function of the laboratory, project, and individuals involved. There is, however, a generalized approach which incorporates the basic and essential requirements necessary to obtain a well-prepared procurement data package. In the following section, this generalized approach is examined, and the specific responsibilities and interactions of the project engineer as they relate to the preparation of the procurement data package are presented. In the final section, the key issues and potential problems to which the project engineer should pay particular attention are discussed.

#### 4-3. Generalized Approach and Responsibilities

a. The flowchart contained in Figure 4-1 depicts a general approach which can be utilized in preparing a procurement data package for an MMT project. The approach begins with an "in house" planning meeting. Normally this meeting is used to review and update the project objectives and milestone requirements and to discuss issues such as

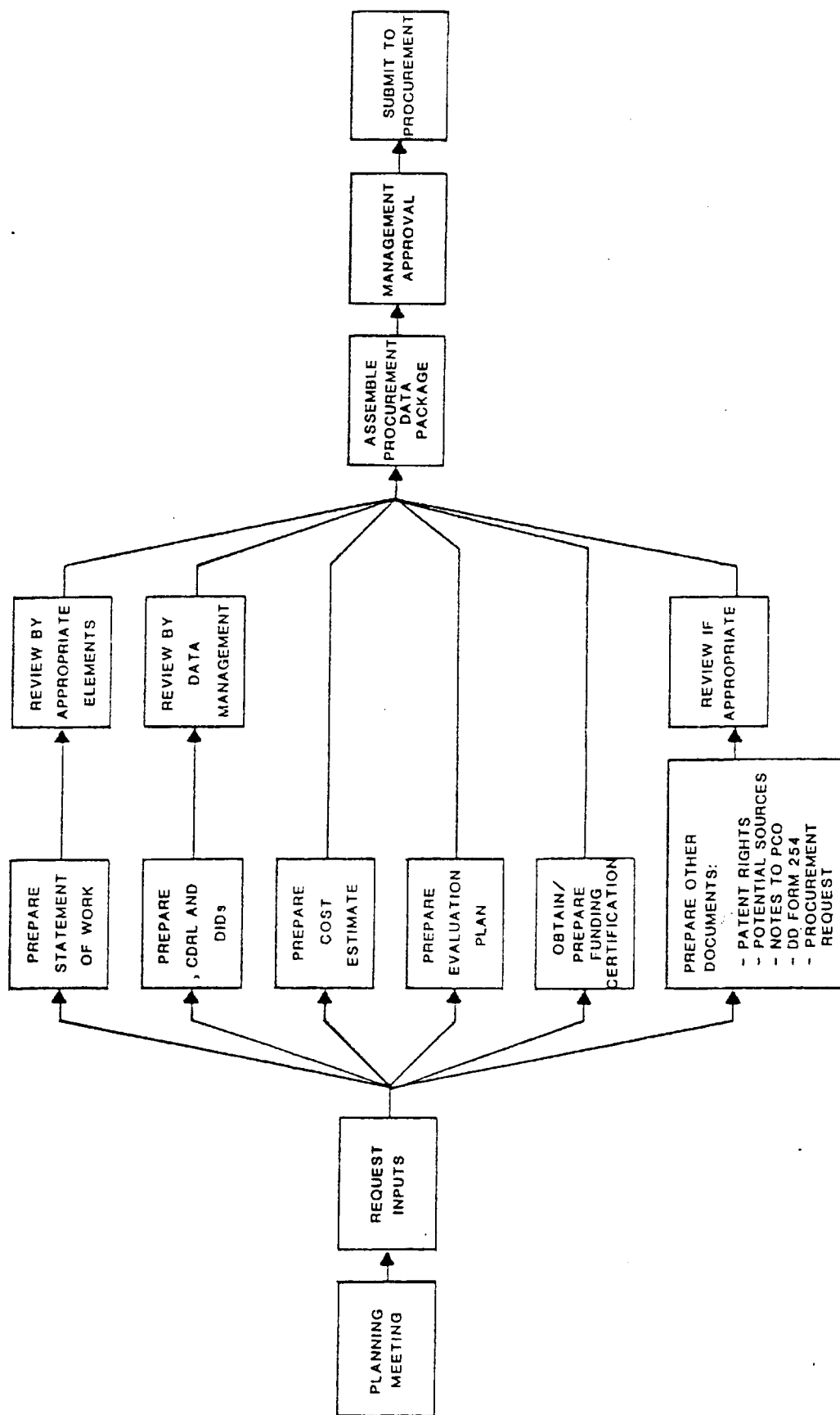


FIGURE 4-1. PROCUREMENT DATA PACKAGE PREPARATION FLOWCHART

contract deliverables, sample numbers, testing requirements, evaluation criteria, and contract type. As a result of the meeting the project engineer identifies specific technical and administrative information he must have to prepare his data package. These inputs are requested in the second block of the flowchart.

b. Following the request for inputs, the flowchart branches into a group of tasks which are performed in a somewhat parallel fashion. Each of these tasks is characterized by its own mode of preparation and effort required to complete it. The chart presented in Figure 3-4 has been expanded in Figure 4-2 to provide the project engineer with an idea of what level of effort is required to prepare each element. His efforts range from simply filling in a checksheet to generating a completely new document. Time requirements to prepare the elements range from less than half a day to greater than two days.

c. After each element is prepared, and reviewed if applicable, the package is assembled and checked for completeness, accuracy, and organization. The total package is then approved by laboratory management-level personnel before it is formally submitted to Procurement.

d. The responsibilities of the project engineer and other major participants involved in this generalized approach are contained in the chart depicted in Figure 4-3. Clearly the project engineer has the final responsibility for all the elements in the procurement data package. To assemble his package, he must coordinate and interact with other project engineers, management and supervisory personnel, and other staff personnel. Although not depicted on the chart, the project engineer is also responsible for providing the Procurement office with additional information and/or special data that may be required during the procurement process.

#### 4-4. Major Issues

In addition to the major issues presented in Chapters 2 and 3, the key points that the project engineer should consider when preparing a procurement data package are planning, coordination, and composition and content. These issues are discussed in the following paragraphs, along with several other potential problem areas which may be encountered.

a. Planning. A necessary requirement for a well-prepared procurement data package is proper planning. Although the process depicted in Figure 4-1 appears straightforward, the problems and pitfalls are numerous. Therefore, the planning activity should begin prior to the initial project meeting and should be used to develop a "roadmap" for the entire project. The planning should include a review of recent MMT projects, discussions with other experienced project engineers, and meetings with individuals outside the laboratory such as Contracting, Legal, Small Business, Patent Rights, etc., when

ELEMENT	APPLICABILITY		CRITICALITY			PREPARATION MODE			EFFORT REQUIRED		
	MANDATORY	MAY BE REQUIRED	MAJOR INFLUENCE ON OBTAINING CONTRACT	MAJOR INFLUENCE ON SUCCESS OF CONTRACT	MAJOR INFLUENCE ON OVERALL PROJECT	TOTALLY NEW PREPARATION	REVISE PREVIOUS VERSION	USE STANDARD VERSION	MAJOR (1-2 DAYS)	MODERATE (1.5-2 DAYS)	MINOR (1-1.5 DAYS)
STATEMENT OF WORK	X		X	X	X	X			X		
END ITEM TECHNICAL REQUIREMENT		X		X	X	X		X	X		X
CONTRACT DATA REQUIREMENTS LIST	X		X	X	X	X				X	
DATA ITEM DESCRIPTIONS		X		X	X		X	X		X	
SECURITY CHECKLIST		X						X			X
EVALUATION PLAN	X		X	X	X	X	X			X	
FUNDING CERTIFICATION	X							X			X
COST ESTIMATE	X		X	X	X	X				X	X
LIST OF POTENTIAL SOURCES		X	X			X					X
SOLE SOURCE JUSTIFICATION		X	X	X	X	X			X		
NOTES TO CONTRACTING OFFICER		X	X	X	X	X				X	
PATENT RIGHTS CHECKLIST	X			X	X			X			
CBD SYNOPSIS		X				X					X
PROCUREMENT REQUEST	X							X		X	X

FIGURE 4-2. EXPANDED CHARACTERISTICS OF PROCUREMENT DATA PACKAGE ELEMENTS

ITEM	PROJECT ENGINEER	SUPERVISOR	OTHER PROJ ENGR	PROD ENGR QA, ETC	DATA MGMT	INDUSTRIAL SECURITY	FISCAL	PCO
INITIAL PROJECT MEETING	ARRANGE/ ATTEND	ATTEND	ATTEND	ATTEND				
STATEMENT OF WORK	PREPARE	REVIEW	INPUT	INPUT/ REVIEW				
CDRL	PREPARE			INPUT/ REVIEW	INPUT/ REVIEW/ APPROVE			
DIDs	SELECT/ MODIFY/ GENERATE				INPUT/ REVIEW/ APPROVE			
EVALUATION PLAN	PREPARE							
SECURITY CHECKLIST	PREPARE					REVIEW/ COORDINATE		
FUNDING CERTIFICATION	PREPARE						INPUT	
COST ESTIMATE	PREPARE	INPUT						
LIST OF POTENTIAL SOURCES	PREPARE	INPUT						
SOLE SOURCE JUSTIFICATION	PREPARE	INPUT/ REVIEW						REVIEW
NOTES TO PCO	PREPARE							
PATENT RIGHTS CHECKLIST	PREPARE							
CBD SYNOPSIS	PREPARE	.						PREPARE/ REQUEST/ REVIEW
PROCUREMENT REQUEST	PREPARE							

FIGURE 4-3. PROCUREMENT DATA PACKAGE PREPARATION RESPONSIBILITIES

appropriate. Effective planning should enable the project engineer to identify potential problem areas and possible bottlenecks at the earliest possible date and take appropriate steps to minimize adverse effects.

b. Coordination. Of equal importance to planning in the overall preparation of the procurement data package is the issue of coordination. The project engineer must assume an active role in insuring that he obtains the inputs he needs for his package. His coordination efforts should also include a high degree of interaction with the other major participants, as shown in Figures 4-1 and 4-3, in order to obtain timely review and approval of the procurement data package elements.

c. Composition and Content. It is the project engineer's responsibility to define the requirements, specifications and procedures needed for the MMT project in the procurement data package. This responsibility is best satisfied by the project engineer generating comprehensive and concise elements such as the Statement of Work and Evaluation Plan as opposed to writing actual contractual clauses. It is the responsibility of Contracting personnel to convert these technical requirements into the actual solicitation and contract. When special requirements exist or there is information the project engineer feels should be made available to the offerors or included in the solicitation, he should include them in the Notes to Contracting Officer. In most instances this procedure is much more efficient than the project engineer attempting to write the actual paragraph or section which will be contained in the solicitation.

d. Other Problem Areas. Several other problem areas may be encountered in the preparation of the procurement data package. These include incomplete or insufficient data, inconsistencies between elements, and incorrect language usage.

(1) Insufficient justification for sole source procurement is one of the most significant problems. In general, this problem stems from the project engineer providing incomplete or insufficient facts to support the noncompetitive solicitation request. Because competitive contracting is preferred, the justification must be precise and factual in its support of a sole source contract.

(2) Inconsistencies between requirements not only delay the procurement action, but can also impact the success of the project. One example which occurs frequently is when a general specification or standard requirement is included in the package. In many instances, there are distinct differences in the requirements contained in a general specifications and those contained in the elements, such as the Statement of Work, prepared by the project engineer. Therefore, it is important that the project engineer know exactly what is contained in the general specifications, standards, manuals, and clauses he plans to incorporate into his project. He must insure that they are consistent with the requirements of the other elements and

that what is specified is definitely required for the project.

(3) The final major problem is that of language usage. Just as there is a set of terms which is applicable to the MMT Program, there are certain requirements imposed on the elements by the procurement process. A common example concerns the Statement of Work. In its preparation, the project engineer should state that "...the contractor shall...." not "...the contractor will...". Correcting these types of errors is time consuming and can be easily avoided during document preparation.



## **PART II**

### **PREPARATION GUIDELINES**

## Chapter 5

### Introduction to Part II

#### 5-1. Purpose

The purpose of Part II is to provide the project engineer with detailed instructions for preparing procurement data packages for MMT projects. In so doing, it is assumed that the project engineer has performed the suggested planning, coordination, and receipt of inputs discussed in Part I. Further, it is assumed that the project engineer has a comprehensive understanding of the goals of the MMT Program, the objectives of his project, and the relationship of his project to other Government procurement efforts. The intent of Part II is to assist the project engineer in converting his planning efforts and technical understanding into the required procurement data package elements. At the same time, Part II is intended to insure that each element is properly prepared and contains the minimally required information.

#### 5-2. Elements

The elements shown in Figure 5-1 are addressed in the following chapters of Part II. This figure combines the requirements of both competitive and sole source solicitation. Because the Statement of Work normally requires a significant effort to prepare and has a major effect on the overall project success, Chapter 6 provides a detailed breakdown of this element including information, tasks, etc. specifically required to satisfy the objectives of the MMT Program. Chapter 7 addresses the Contract Data Requirements List (CDRL) and Data Item Descriptions (DIDs). The purpose, type, and contents of the CDRL are discussed, and the standard DIDs together with tailoring and modification instruction are presented in this chapter. The remainder of the procurement data package elements shown in Figure 5-1 are contained in Chapter 8. Figure 5-2 contains a cross reference table which can be used to quickly locate the section of the pamphlet which discusses a specific element and the appendix which contains examples, preparation instructions, or additional information. The procurement data package preparation checklist contained in Appendix K is provided to aid in conceptualizing the broad spectrum of considerations that must be addressed prior to and during the preparation process.

#### 5-3. Recommended Procedures

It is important to point out that the instructions and guidelines contained in the next three chapters are recommended procedures only. They should not be misconstrued as policy or regulatory in nature. The intent of this document is to present the requirements normally required for MMT projects. The project engineer is not restricted in any way from using other approaches to satisfy the requirements

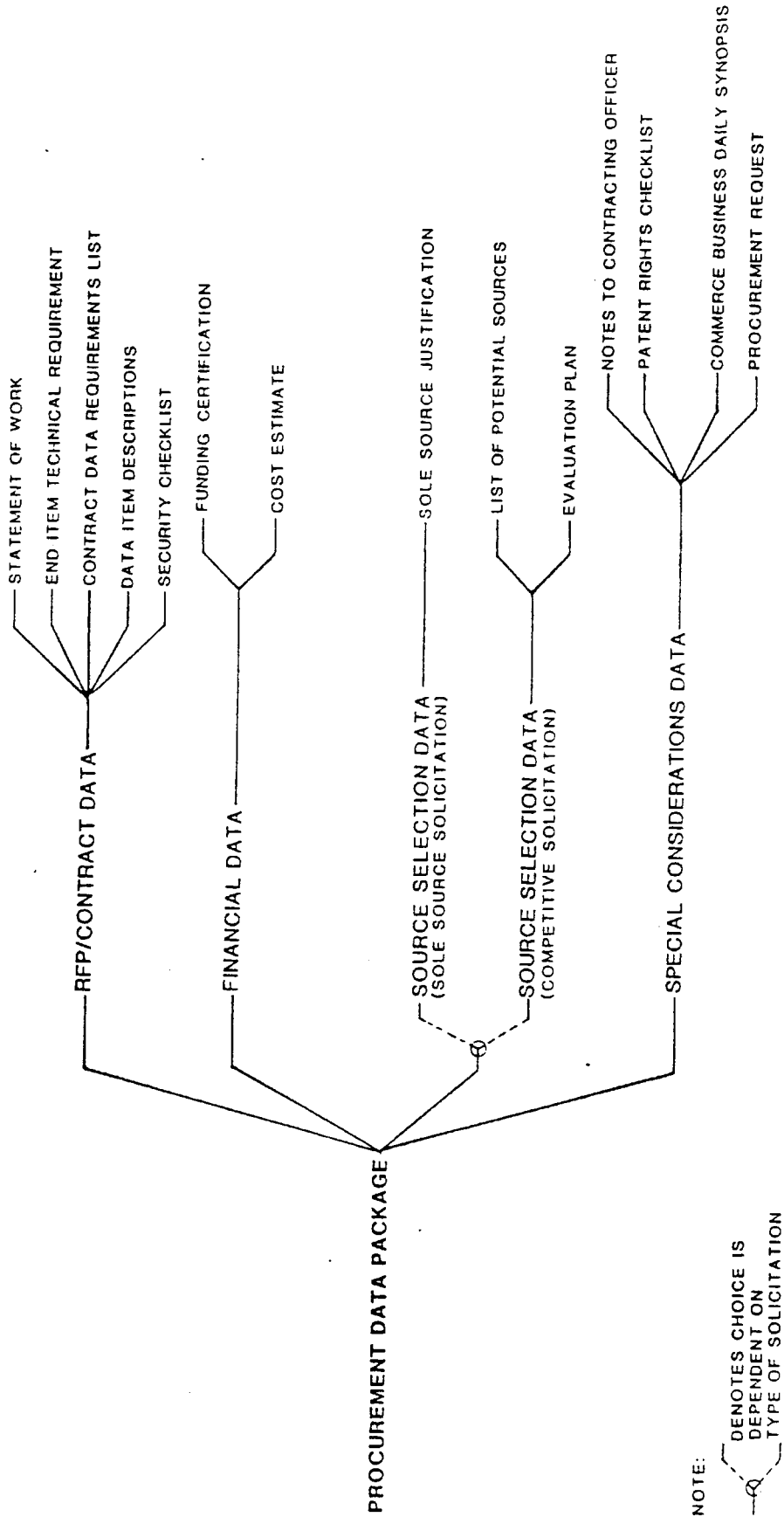


FIGURE 6-1. CONTENTS OF PROCUREMENT DATA PACKAGES

<u>TOPIC</u>	<u>DISCUSSED IN PARAGRAPH</u>	<u>EXAMPLE OR PREPARATION INSTRUCTION IN APPENDIX</u>
<u>RFP/CONTRACT DATA</u>		
1. STATEMENT OF WORK		A
INTRODUCTION	6-3.	
APPLICABLE DOCUMENT	6-4.	
TECHNICAL REQUIREMENTS	6-5.	
START-UP PHASE	6-6.	
ENGINEERING PHASE	6-7.	
CONFIRMATORY PHASE	6-8.	
PILOT RUN PHASE	6-10.	
COMPLETION PHASE	6-11.	
2. END ITEM TECHNICAL REQUIREMENT	8-3.a.	
3. CONTRACT DATA REQUIREMENT LIST	7-3.	C, D
4. DATA ITEM DESCRIPTION	7-4.	E, F
5. SECURITY CHECKLIST	8-3.b.	G
<u>FINANCIAL DATA</u>		
6. FUNDING CERTIFICATION	8-4.a.	
7. COST ESTIMATE	8-4.c.	
<u>SOURCE SELECTION DATA</u>		
8. SOLE SOURCE JUSTIFICATION	8-5.a.	H, I
9. LIST OF POTENTIAL SOURCES	8-5.e.	
10. EVALUATION PLAN	8-5.f.	J
<u>SPECIAL CONSIDERATIONS DATA</u>		
11. NOTES TO CONTRACTING	8-6.a.	
12. PATENT RIGHTS CHECKLIST	8-6.b.	
13. COMMERCE BUSINESS DAILY SYNOPSIS	8-6.c.	
14. PROCUREMENT REQUEST	8-6.d.	

FIGURE 5-2. CROSS REFERENCE TABLE

contained in the following chapters. For example, some ERADCOM laboratories use the Electronic Research and Development Command Industrial Preparedness Procurement Requirement No. 15 (ERADCIPPR) as an attachment to the Statement of Work. However, the use of such a document in the procurement data package does not eliminate the project engineer's responsibility for ensuring that the information contained therein is current, relevant, nonconflicting with other requirements, and results in the procurement of data which meets minimum ERADCOM needs.

#### 5-4. Limitations

For several reasons, the information contained in Part II should not be considered as all encompassing. The MMT Program and procurement data package requirements are dynamic in nature and, therefore, continually subject to change. Such factors as contracting and procurement requirements, management initiatives, and individual preferences drastically affect the structure and content of the procurement package. Because it would be impossible to reflect these changes in a real-time basis, Part II should be considered as a static picture of these dynamic requirements.

#### 5-5. Chapter Descriptions

The information contained in Chapters 6, 7, and 8 is presented so that the project engineers will have sufficient latitude to include those requirements which are peculiar to the individual laboratories. In cases where discrepancies exist between information contained in the following three chapters and higher level directives, the project engineer is encouraged to rectify the differences prior to assembling his package.

## APPENDIX

## C

MANUFACTURING TECHNOLOGY HORIZONS

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Volume 1, Number 2

manufacturing technology

# HORIZONS<sup>TM</sup>

THE DIGEST OF MAJOR DEVELOPMENTS IN MANUFACTURING PROCESSES AND EQUIPMENT

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## LET US HEAR FROM YOU

Readers having comments on new developments they would like considered for publication should contact: Editor, *Manufacturing Technology Horizons*, 134 N. Washington St., Naperville, Illinois 60540 (Telephone 312/369-9232).

## PRIMARY METALS

### SUPER RIGID ALLOYS

Rutgers University has developed a new technique for increasing the rigidity of some metallic alloys including alloys of aluminum and copper. The procedure involves aging alloys under mechanical stress at an appropriate temperature. Time, pressure and temperature depend on the specific alloy being processed. During the stress-heating process a large number of very thin alternating layers of atoms of each metal composing the alloy become closely bonded and aligned to each other. The atomic-bonding brought about in this way creates intense stresses between atoms and yields a material of high rigidity.

Increases in stiffness of between 30 to 50 percent have been demonstrated in such alloys as aluminum-zinc and copper-nickel-tin. The effect does not occur in steels. Ongoing investigations are being carried out to identify additional alloys for which the procedure is effective. Additional process development will be necessary to determine the particular ranges of stress and temperature appropriate for each potential industrial application. The greatest potential for this technology is in the automotive and aeronautical industries where materials of high stiffness and low weight are much sought after. Lighter weight alloys processed by this technique could also be used to replace steel in a variety of industrial environments.

For more information, contact: Professor Thomas Tsakalakos, Department of Mechanics and Materials Science, College of Engineering, Rutgers University, P.O. Box 909, Piscataway, New Jersey 08854 (telephone: 201/932-1766). 82-C40

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### ELECTROMAGNETIC INGOT CASTING

Kaiser Aluminum has developed a new method of casting aluminum alloy ingots using electromagnetic forces to hold the molten material away from the ingot during pouring and cooling. The process was originally developed in Russia, and has been refined and improved by Kaiser. As the molten material is poured into the mold, electromagnetic fields are applied with increasing intensity to the four sides of the mold to counter the hydrostatic pressure of the molten material. Holding the alloy away from the mold wall as it cools produces very smooth surfaces on the ingot and provides more uniform distribution of alloying constituents. Up to four billets can be poured at once with the electromagnetic equipment. Each billet is five feet wide, two feet thick and up to 300 inches long.

The major benefit of the electromagnetic casting process is reduced scrap due to the elimination of ingot scalping and less edge trimming. The final rolled material also has a better surface and has improved mechanical properties, particularly fracture toughness of high strength alloys. The process has been licensed to one other company and is available for further licensing.

For further information, contact: Mr. Tom Pritchett, VP Research and Development, Kaiser Aluminum and Chemical Corp, 300 Lakeside Drive, Oakland, California 94613 (telephone 415/462-1122). 82-041

### NEW CHROMIUM MOLYBDENUM STEEL

Oak Ridge National Laboratory is promoting a new ferritic steel for use at elevated temperatures and in hostile environments. The alloy is a modified version of 9Cr-1Mo alloy, but incorporates small quantities of niobium and vanadium to provide enhanced mechanical strength and long-term high temperature stability. Addition of these elements enables control of precipitates and grain structure which leads to the improved characteristics. The new structural steel also possesses good toughness, adequate oxidation protection and good resistance to stress corrosion cracking.

Initial impact of the alloy is expected in the energy conversion field in such applications as boiler tubes, pressure vessels and other critical components of high temperature systems. There is also interest in the use of this steel as tubing for deep, sour well environments where corrosion resistance is especially valuable.

Costs of the new super chrome-moly alloy are expected to be competitive with conventional 9Cr-1Mo alloy, 2 1/4 Cr-1Mo alloy and type 304 stainless steel. Fabrication using the new material is not expected to present any serious difficulties. The only limitation is that preweld and postweld heat treatments similar to those for 2 1/4 Cr-1Mo are required. ASME Boiler and Pressure Vessel Code approval of the alloy is expected in late spring or early summer of 1982. A number of firms are now beginning to produce the alloy. These include: Carpenter Technology Electralloy Corporation, Quaker Alloy Casting Company, and, in Japan, Sumitomo and NKK.

For more information, contact: Mr. Peter Patriarca, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge Tennessee 37830 (telephone: 615/574-5101). 82-042

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### FORGING

#### IMPACT FORGING.

Macrodyne has developed a high-velocity impact forging process, initially introduced by General Dynamics in 1955, to produce metallurgically advanced forgings from stainless steel and alloys of nickel, cobalt, columbium, titanium and aluminum. The process makes use of the quick release of energy stored in compressed gas to drive a ram. Presently, the system has an energy capacity of up to 500,000 ft/lbs, with an impact speed of over 600 inches per second. The process also permits adjustment in the amount of energy transmitted to the workpiece.

The new forging equipment costs less than that of conventional equipment delivering the same amount of energy, and forging speed is 8 to 10 times faster. The process is currently being used to produce titanium blades and vanes for jet engines and high strength maraging steel and stainless steel alloy parts.

For more information, contact: Trish Bennett, V.P. Administration, Macrodyne Industries, Inc., 4465 Wilshire Boulevard, Suite 303, Los Angeles, CA 90010 (telephone: 213/930-1043). 82-043

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### EXTRUSION

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### ALUMINUM EXTRUSION

Holton Machinery (England) has recently introduced a new series of machines for continuous extrusion of aluminum from rod, powder, shot and chopped scrap. Referred to as the CONFORM process and based on patents held by the United Kingdom's Atomic Energy Authority, the machines employ one or more rotating, grooved, extrusion wheels which frictionally grip the incoming feedstock and create sufficient heat and pressure to force the material through tungsten carbide dies to form the extruded products. The incoming raw material is unheated and the equipment can extrude wire, rod, tubing and solid profiles. The process can also be used to clad wire and tubing. Although aimed primarily at aluminum, copper and brass have also been extruded by the new process. Four different machine sizes are offered with throughputs up to 2000 kilograms per hour.

This innovative approach to extrusion has several advantages, including a 30 percent reduction in energy requirements due to elimination of feedstock preheating, significantly lower operating manpower costs and reduced scrap. Several machines are in operation in England and West Germany.

For more information, contact: Mr. D. C. Godwin, Sales Manager, Holton Machinery Ltd., Units 6 and 7, Holton Heath Trading Park, Holton Heath, Poole, Dorset, BH16 6LF, England (telephone: 0202-624620). 82-044

### FORMING

#### SUPERPLASTIC FORMING AND DIFFUSION BONDING

British Aerospace (United Kingdom) has developed a new process for forming complex structural components from titanium alloy sheets. The process permits intricately shaped housings, frame members, fairings and pressure-door shells for aircraft to be made in titanium alloy (Ti 6Al 4V), complete with integral stiffeners and ribs by starting with only flat sheet material. The process simultaneously utilizes the combination of two existing processes, super plastic forming and diffusion bonding.

To fabricate the structures, titanium alloy sheets are cut to the appropriate size. Internal stiffeners are formed from "core"

sheets which are seam welded where ribs are desired. The core sheets are placed between outer surface sheets and the entire multi-layer stack is then edge welded to form a gas-tight assembly. The entire assembly is then placed in a specially designed press with an appropriate die cavity and heated to about 950°C. The structure is formed by blowing hot argon into the assembly, and gas pressure is maintained until diffusion bonding has occurred.

British Aerospace is currently using the superplastic forming and diffusion bonding technique to supply parts for the European A310 Airbus. The process is expected to result in significant cost savings and should be widely used in the future.

For more information, contact: British Aerospace, Ltd., Filton House, Filton, Bristol, BS99 7AR, England (telephone: 0272-693831). 82-045

#### ADAPTIVE BRAKEFORMING

Massachusetts Institute of Technology (MIT) has developed a prototype system for adaptive brakeforming of sheet metal with automatic springback compensation. The system uses a transducer built into the forming die to measure the bend angle during forming and springback. This information is fed into a microprocessor, which compares the unloaded bend angle with the desired value and calculates the amount of overbend needed to achieve the proper angle after springback. The system goes through an iterative forming and measurement process until the correct bend angle has been obtained. The system is capable of producing bends within 0.1 degree accuracy and normally requires only two to three press strokes to reach the desired angle. An approach using force rather than angle transducers was tried, but only achieved 0.5 degree accuracy.

The new system would be particularly suitable for small lot production where set-up time is a major cost factor. In addition to reducing production costs, use of the system should also result in improved quality because variations in workpiece springback are automatically compensated for. However, the concept has not yet been used on a commercial basis.

For more information, contact: Mr. Blair Allison, Department of Mechanical Engineering, MIT, Cambridge, MA 02138 (telephone: 617/253-2226). 82-046

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## WELDING

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### ADVANCED NARROW GAP WELDING

Westinghouse has come up with several ways to improve narrow gap welding based on a recent examination of the process. It was determined that instability of the arc is caused by contaminated shielding gas, induction of air into the shielded region, turbulence of the heated gases and electromagnetic disturbances. Shielding gas contamination problems were reduced by replacing standard tubing materials with stainless steel and using certified premixed helium-argon gases. Induction of air into the shielded region was reduced by improved head design. Turbulence of the heated gases was reduced by improving the arc stability. Arc instability problems, caused by two dimensional heat flow on the initial pass of the weld head through the gap, were reduced by welding toward the ground lug, using lower welding current and moving the weld head slower.

Compared to previous methods, these techniques result in welds that have less porosity, more uniformity and better weld-to-wall tie in. These improvements are obtained at a cost of slower welding, top quality gas fittings, and certified premixed gases.

For further information, contact, Dr. Israel Stol, Westinghouse, R&D Center, 1310 Beulah Road, Pittsburgh, Pennsylvania 15235 (telephone: 412/256-3223). 82-047

### LASER WELDING SHIELD

The U.S. Army has developed a laser welding shield capable of doubling the amount of energy transmitted to a workpiece during laser welding and machining operations. The welding shield, machined from a block of copper to produce a polished hemispherically shaped dome used to cover the workpiece, redirects laser energy reflected from the surface of the workpiece back onto the workpiece in the vicinity of the laser weld. The use of the shield improved the effectiveness of the laser welding in both aluminum and steel. The shield provides for better utilization of the laser's energy and should be suitable for use in a variety of laser applications in welding, cutting and heat treating.

For more information, contact: W. K. Patterson,

U.S. Army Missile Command, Attn: DRSMI-RLM, Redstone Arsenal, Alabama 35898 (telephone: 205/876-2710) or John Melonas, EH42, Bldg 4711, NASA Marshall Space Flight Center, Alabama 35812 (telephone: 205/453-0011). 82-048

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## COATINGS AND FINISHES

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### SEALING OF ANODIZED ALUMINUM

Grumman Aerospace and Boeing have devised a new procedure for sealing chromic acid anodized aluminum parts. The process consists of placing an anodized workpiece into a bath of hot (200°F) deionized water containing hexavalent chromium at a concentration of 45 to 80 parts per million. The resulting surface has both excellent corrosion resistance and improved paint adhesion properties when compared to conventional hot water sealing. Conventional sealing techniques can only provide corrosion resistance or paintability, but not both. Other advantages of the new process include improved sealing consistency and simpler process control, which lead to reduced production costs.

The sealing process is currently being used by Grumman in the production of components for Boeing's 767 aircraft, and other Boeing subcontractors are also adopting the process. The technique should see widespread use on any chromic acid anodized aluminum parts requiring corrosion resistance and paintability.

For more information, contact: Mr. Luis Trupia, Grumman Aerospace Corporation, Mail Station C08-09, Bethpage, New York 11714 (telephone: 516/454-8375). 82-049

### COMPOSITE ELECTROLESS PLATING

Surface Technology is developing unique surface coatings which can greatly reduce wear and improve lubricity. The basic approach, called composite electroless plating, takes the form of a layer of an electrolessly plated matrix, usually a nickel alloy, with finely dispersed particles throughout. These particles may be diamond, silicon carbide, aluminum oxide, boron nitride or fluoropolymers, depending upon the particular properties desired in the coating. For example, a recently introduced coating called NYE/LUBE incorporates lubricating particles within the coating to reduce friction. Surfaces of the plated coatings may be finished

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to make them more "friendly" to the material with which they come in contact.

The coatings have been proven in such diverse field applications as carbide twist drills, chain saw cutting chains, forming rolls, textile machinery and components, and pump sleeves and gears. Though cost of the wear resistant composite electroless plating is approximately twice that of electrolytic plating of hard chromium, in some cases, lifetimes of plated components have been extended by as much as five to ten times. In addition to manufacturing the coatings and providing plating services, STI is also seeking licensees for the composite electroless plating technology and is especially interested in overseas licensing. The company is willing to help people set up overseas and will assist in identifying applications and markets.

For more information, contact: Dr. Nathan Feldstein, Surface Technology, Inc., Box 2027, Princeton, New Jersey 08540 (telephone: 609/452-2929). 82-050

#### WEARSURFACING POWDERS

Metallurgical Industries has developed a new family of wearsurfacing powders based on titanium carbide. Their TiCoat powders are composites consisting of titanium carbide dispersed in a matrix alloy which may be iron-, cobalt-, or nickel-based. Plasma transferred arc methods are used to apply the wearcoat in thicknesses ranging from 0.02 inches to 0.125 inches. TiCoat T-92, the most common of the family using an iron-chromium-carbon matrix has a Rockwell C hardness of 50. No post application heat treatments are used.

The new powders are expected to serve as alternatives to hardfacing with tungsten carbide. They are more wear resistant than tungsten carbide-nickel alloy wearsurfaces. On a weight basis, titanium carbide powders are cost competitive with tungsten carbide, but in use they can be more cost effective. Lower specific gravity means that as much as 40 percent additional coverage per unit weight is possible. Likely applications include agricultural cutting tools, pressure hammers, plastic processing equipment, and coal picks.

For more information, contact: Mr. Gil Saltzman, Metallurgical Industries, Inc., One Coldstream Way, Tinton Falls, New Jersey 07724 (telephone: 201/542-5800). 82-051

#### TINPLATING

The International Tin Research Institute (England) has developed a new plating solution for coating metals or plastics with tin. The solution contains tin chloride as the source of tin, titanium chloride as a reducing agent, and several buffering and complexing agents. When a suitably prepared metal or plastic substrate is placed in this solution, its activated surface catalyzes deposition of the tin. Once a tin layer has been formed, this layer itself continues to catalyze the deposition process. Metals are prepared by degreasing and acid pickling; plastics require sensitizing by means of etching and treatment with tin chloride and palladium chloride. Coatings deposited by this method are similar to those obtained with conventional matte electrodeposition and possess good solderability.

To date, this autocatalytic tin plating procedure remains a laboratory process. A number of issues must be addressed before commercial viability is assured. These include rate of deposition, solution stability, and process costs. However, samples of steel, copper, aluminum alloy and nickel have been coated successfully as have such plastics as polypropylene and acrylonitrile-butadiene-styrene (ABS). Because the method is autocatalytic, tin continues to be deposited even after the substrate surface is completely covered. This means thicker tin coats and improved solderability and shelflife for components relative to those treated by existing immersion processes. Even coverage of intricate shapes and applicability to plastic substrates are additional advantages.

For additional information, contact: International Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex UB6 7AQ, England (telephone: 01-977 4254). 82-052

#### PLASTICS

##### LINEAR SHEET THERMOFORMING EQUIPMENT

M. L. Shelley & Partners (England) has developed a series of linear sheet-fed multistation thermoforming machines. A combination of mechanical and vacuum grippers is used in conjunction with a shuttle system to cycle sheets through the machines. The system employs four stations: load, heat, mold, and eject and

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has three sheets in process at a time. Particularly unusual is the use of an upper heater assembly which moves on the transport shuttle with the sheet as it is being transferred from the heating to the molding station (to minimize heat loss) and which then moves back to heat the next sheet.

Advantages of the equipment include faster cycle time, conservation of floor space and conservation of raw materials by minimizing edge waste. The new design should compete well against rotary equipment as well as against single station machines and in-line machines for cut-sheet processing.

For more information, contact: M. L. Shelley & Partners, Ltd., St. Peter Road, Huntingdon PE18 7HE, England (telephone: Huntingdon 0480-53651). 82-053

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## MATERIAL HANDLING

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### PRODUCT IDENTIFICATION BAR CODES

The American National Standards Institute (ANSI) is about to issue a standard for product identification bar codes. The new standard, referred to as ANSI MH10 X-1981, is based on the "3 of 9" bar code originally developed by Intermec. It is expected that this standard will be adopted rapidly. For example, the U.S. Department of Defense is expected to require use of the standard code on all packages shipped to them after the standard has been issued.

For more information, contact: American National Standards Institute, 1430 North Broadway, New York City, New York 10018 (telephone: 212/354-3300). 82-054

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## MACHINE COMPONENTS

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### MACHINE TOOL GRINDING ATTACHMENTS

GBI International Industries has developed unusual grinding attachments for lathes and milling machines. These attachments finish workpieces to between two and four micro-inches, regardless of the basic accuracy of the machine tool. The grinding attachments have no power

source of their own. In the lathe version of the attachment, two grinding wheels are used, one as an idler to drive the other wheel which does the actual finishing. In the milling machine version, the rotation of the spindle shaft provides the power to turn the finishing wheels. In these versions the grinding wheels are resiliently mounted to compensate for machine tool "sloppiness".

The attachments are commercially available at a cost of about \$600. Major advantages include the ability to perform precision grinding using standard lathes and mills, and reduced grinding costs because the parts can be ground or polished without removing them from the machine tool.

For more information, contact: Peter M. Budzilovich, GBI International Industries, Inc., 1804 Plaza Avenue, New Hyde Park, New York 11040 (telephone: 516/775-0344). 82-055

### INFRARED CAMERA

RCA has developed a sensitive solid state infrared camera for remote temperature profiling. The camera contains a 64 X 128 element array of platinum silicide detectors on a silicon substrate, along with charged coupled device readout registers. The camera is sensitive enough to detect temperature differentials of a fraction of a degree, but is not damaged by high temperatures.

This development is an appreciable improvement both in sensitivity and the number of picture elements available in previous imagers. In addition to temperature measurement, the camera should also be suitable for flaw detection because of its sensitivity and rapid response rate. RCA expects to market the camera after specific needs have been determined.

For more information, contact: Dr. Henry Kressel, Solid State Research, RCA Laboratories, Princeton, New Jersey 08540, (telephone 609/734-2000). 82-056

### MERCURY ROTARY CONTACTS

Meridian Laboratory has developed sealed mercury rotary contacts to replace conventional sliprings in rotating machinery. Referred to as Rotocon, the new design utilizes mercury to provide electrical continuity between the stationary and rotating contacts. The mercury contacts have low resistance and capacitance, can be used to transfer both power and control

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signals in the same unit, and are suitable for continuous use in harsh environments. Tests have shown that the contacts are insensitive to vibration and corrosive effects, can be easily retrofitted to existing industrial equipment, and are unaffected by mounting orientation.

Originally designed for oil well and underwater applications, the mercury contacts are currently being evaluated by several manufacturers of automated machine controllers. The low noise and reported 95% energy efficiency rating make the device well suited for implementation in automated industrial equipment such as robots and numerically controlled machine tools.

For more information, contact: Mr. Carlo Krause, Meridian Laboratory, 2415 Evergreen Road, P.O. Box 156, Madison, Wisconsin 53562 (telephone: 608/836-7571). 82-057

#### VISION RECOGNITION SYSTEM

Cognex has developed a sophisticated inspection system for reading numbers, letters and other characters printed, etched, embossed or inscribed on a variety of product surfaces. The system, known commercially as DataMan, incorporates advanced image enhancement and optical character recognition technology along with algorithms based upon research in human character recognition. The system consists of a DEC 11/23 minicomputer and a high resolution camera along with a monitor and keyboard. Characters as small as .020 inches, even when subject to conditions of poor contrast, varying light intensity, or character degradation, are located, recognized and communicated to a host computer or controller. Up to 15 characters per second can be read by the system.

This system represents a significant improvement over existing vision systems, which generally are limited to shape recognition capabilities. Suitable applications for the system include inventory monitoring, material handling, quality assurance, and automated manufacturing. The system has been installed for such applications as reading semiconductor wafer serial numbers and inspecting packaging label numbers. A complete system can be purchased for approximately \$30,000.

For more information, contact Dr. Robert J. Shillman, Cognex Corporation, 1505 Commonwealth Avenue, Boston, Massachusetts 02135 (telephone: 617/254-1231). 82-058

#### TEST AND INSPECTION

##### COMPUTER AIDED INSPECTION

The National Bureau of Standards has begun development of methods for using computerized data bases to direct inspection systems to measure the dimensional properties of workpieces. The main thrust of the development is towards a fully automated inspection system which will derive and execute testing strategies directly from computer-aided design (CAD) data bases. Initial efforts are to develop an inspection language which will permit a user to input inspection procedures through a workstation using existing part data. A translator will refer to this part data to convert inspection language programs into commands that a 3-D mechanical coordinate measuring machine can execute. Later efforts will be to develop a system that will automatically generate inspection procedures and inspection station control requirements based on inspection goals placed in the CAD data base itself and provide the user with results of the inspection activities.

To date, the research is still in the earliest stages. Plans call for the development of a prototype system that will be used in the National Bureau of Standards' Automated Manufacturing Research Facility.

For more information, contact: Ted Hopp, National Bureau of Standards, Metrology A127, Washington, DC (telephone: 301/921-2461). 82-059

##### DETECTION OF FLAWS IN COMPOSITES

Massachusetts Institute of Technology (MIT) is developing a non-destructive thermal test to find flaws in fiberglass composites. This reasonably inexpensive testing technique uses heat sensitive cholesteric liquid crystal material which highlights temperature differences by color changes. The material is applied to the surface under investigation as a sprayed on liquid or a coated plastic sheet. When the composite material is heated on the opposite side by a uniform flux heat lamp, defects appear on the coated side as contrasting colors in the liquid crystal. Defects which can be detected include impurities in the resin, poor resin mixing, incorrect lay up, voids, air bubbles and inadequate curing. The non-

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**SPECIAL FOCUS:****POWDER METAL INJECTION MOLDING**

One of the more interesting and potentially valuable new manufacturing technologies being developed today is injection molding of metal powders. This emerging technology has many possible applications for metal parts that are now being machined, cast and forged. Although powder metal injection molding is not suitable for production of all metal parts, it should see wide usage in the future, particularly for high volume parts having very complex geometries. In fact, this technology is already being used to manufacture small gears and sprockets, and aerospace components.

**PROCESS FUNDAMENTALS**

Metal powder injection molding is basically a three step procedure. Starting with a feedstock of fine metal particles in a plastic binder, parts are injection molded in a manner similar to plastics injection molding. These part preforms, which are about 20 percent larger than the final part, are then processed in a heated chamber to remove the plastic binder. During the last step of the process, the parts are sintered much like traditional powder metallurgy parts. The final parts have a density of about 95 to 98 percent of that of wrought material, are fully annealed, and usually require no additional machining.

Powder metal injection molding has many process variables which greatly influence the properties and quality of the finished part. It is the balance among these process variables that determines exactly how successful a production effort will be. The most critical consideration is the starting raw material. Almost all other processing variables relate back to this key issue of materials selection.

Powder particle size and distribution, for example, are significant factors. In conventional powder metallurgical operations powders are typically in the range of 30 to 200 microns. Often there is a fairly broad distribution of particle sizes within this range and powder shape is not always uniform.

Metal powder injection molding systems, however, generally use much finer particles (1 to 15 microns) with a narrow distribution of particle sizes and a uniform shape. Small, uniform particles provide several advantages, including more intricate part geometry, thinner walls, hermetically sound parts, relatively low molding

pressures and reduced equipment erosion.

Besides particle size, the other critical element in successful powder metal injection molding is the binder material. In fact, this is the key to determining many process parameters and will influence the type of operation used in the second phase (binder removal). It is the plastic binder that makes possible the use of very fine metal powders. The polymer acts to increase lubricity between particles, greatly improving flow characteristics and assuring uniform filling of mold cavities.

The binder is usually thermoplastic so that recycling of mold scrap is practical. The binder must be compatible with the metal being processed and neither react with it nor degrade it. The binder must be capable of accepting a high level of solids loading while retaining adequate molding properties. Finally, the binder must be capable of quick and simple removal from the "green" molded part prior to sintering. The metal powder/binder feedstock may be in either a pelletized form or a paste. Since success of the overall process depends so heavily on the binder system, it is this feature which is treated in the most proprietary manner by companies developing powder metal injection molding technology.

The feedstock is processed by an injection molding machine in much the same manner as plastics. But because characteristics of the feedstock are different, operating parameters vary from normal plastics injection molding practices. For example, temperature and pressure levels are usually lower for powder metal injection molding. Any commercial injection molding equipment, so long as it is capable of maintaining the necessary parameters, is suitable for use.

Mold designs are similar to those for plastics injection molding, with a few exceptions. Lower injection pressures, for example, require the use of larger gates. Carbide inserts at the gates are also recommended to prevent mold erosion. Since very little shrinkage occurs within the mold, it must also be designed for easy part release.

During the second stage of the process, the binder is removed from the molded preforms in a low temperature oven. The parts are heated to

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about 400°F and the binder is removed by evaporation, low temperature chemical reaction, melt wicking or a combination of these processes. Binder removal typically takes 24 to 48 hours. During this phase a preliminary sintering occurs so that the parts do not collapse. Some systems use a solvent extraction technique for binder removal. After the binder has been removed, the part is usually brittle, relatively weak and easily damaged.

The final process step is to sinter the part in an oven. During sintering, debinderized parts are exposed to controlled thermal profiles with temperatures ranging up to 2300°F. In addition, the atmosphere within the oven may be controlled so that parts can be treated with such gases as argon, carbon dioxide, nitrogen, hydrogen or others. Exposure to specific temperatures and atmospheres serves to increase surface free energy and improve sintering. Sintering typically takes 2 days to complete. Actual sintering temperatures and chemical treatments depend on the particular metal or alloy being processed. The sintering procedures are similar to those used in conventional powder metallurgy, and commercial sintering furnaces are usually adequate.

At completion of the process, parts are in their final shape, fully annealed, and at their final density. They may be used directly as they come from the sintering oven or undergo additional finishing operations, such as heat-treating, plating or machining. It is also possible to increase the density of the parts to near 100 percent by processes such as coining or hot isostatic pressing (HIP).

#### APPLICATIONS

To date, most applications of powder metal injection molding have been relatively small and complex components which were previously machined parts or multi-part assemblies. Examples include integral gear and drive shaft assemblies, sprockets, metal sleeves, mold inserts, small rocket nozzles, and even a specialized bone drill bit. Most of these parts have been fabricated from "soft metals" such as mild steel, although some have been produced from nickel-steel alloys, stainless steels and proprietary alloys for high strength applications.

Because the feedstock fills almost any volume, very complex geometries are possible. Sharp edges and thin (0.05 inches or less) sections may be molded directly into a part. If an extremely exotic geometry is desired beyond the

capability of conventional molds, multiple slide molds are practical. Parts can be manufactured with transverse holes, undercuts, or reentrant angles.

Assemblies normally fabricated by mating a series of parts can often be molded in one piece. Precision gears with integral drive shafts and cam assemblies are examples of powder metal injection molding applications. In fact, any application requiring that two or more parts mate precisely is a candidate for the process. General manufacturing tolerances are typically between 3 and 5 microns per millimeter (0.003 to 0.005 inches per inch of length). When required, part-to-part consistency can be held even closer.

#### ADVANTAGES

The greatest advantage of metal powder injection molding is its ability to produce complex parts to near net shape. This minimizes machining or other material removal processes and can lead to substantial cost savings in both direct labor and material. Almost all raw material waste is eliminated because any mold scrap (sprues, runners, etc.) or bad preforms can be recycled.

#### LIMITATIONS

No manufacturing process is perfect, and powder metal injection molding has its limitations. The most basic of these are the batch nature of the process and the long cycle times inherent in binder removal and sintering.

There are also constraints in the maximum size of parts that can be produced by the process. Binder removal is basically a diffusion rate limited process, no matter what approach is used. Binder material (or its products of decomposition) must diffuse outward from the center of the part to the surface for it to be totally removed. Therefore, the thicker the part, the greater the time required to completely remove the binder.

There are also practical economic limitations involved. Because of mold design and fabrication costs, the process is not suitable for small quantity production. If only simple shapes are required, or precision is not important, then other manufacturing approaches are likely to be more cost effective.

#### FUTURE DIRECTIONS

At present the majority of development work on powder metal injection molding technology

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appears to be concentrated in the United States, although there is a great deal of interest in the technology in Japan, Europe and Latin America.

Since much of the development work is proprietary in nature, few organizations are willing to openly discuss the details of their research efforts. However, some of the developers and their major research thrusts include:

Witec California - One of the pioneers in the field, Witec, sells integrated turnkey processing systems for powder metal injection molding. They also formulate and supply feedstocks. A number of custom formulated feedstocks are available including mild steels, nickel-steel alloys, chromium bearing stainless steels, and alloy M, a proprietary alloy for high strength applications.

Development efforts are ongoing in the areas of feedstock formulation, binder compositions, and definition of the processing regimens necessary to mold additional alloys. Investigations into the processing of reactive metals such as aluminum, titanium, columbium and zirconium are expected to commence during 1983.

Parmatech - Holder of the original patents for the most commonly used process, Parmatech is mainly interested in licensing the technology. They also manufacture powder metal injection molded parts on a job shop basis. Parmatech's licensees include DuPont, IBM, and Rockwell International.

Current research is ongoing in the processing of ceramics, cemented carbides, 300 series stainless steels, tungsten and other refractory metals, as well as process optimization studies.

Battelle - Battelle's Columbus Laboratories is conducting a multi-client study to develop information on the physical and chemical principles of the process. Over 25 companies in the U.S., Europe and Japan are sponsors of the study. All aspects of the technology are being investigated, including powder metal preparation, binder selection, feedstock mixing, mold design, molding parameters, binder removal, and sintering. Efforts are being concentrated on larger powders (about 15 microns) than used by Witec and Parmatech and on the use of minimum binder quantities.

- o Cabot - As an outgrowth of superalloy development work, Cabot Corporation is investigating the potential of a water soluble binder system for powder metal injection molding. The binder, which has been patented, is based on a methyl cellulose, water and plasticizer mixture.

Although developments are being pursued in almost every facet of the technology, including binders, powder metal size and new metal combinations, much of the effort is focusing on technology diffusion and expanding applications with existing processes. Penetration of existing markets is far from complete. In the long term, many avenues of development exist, including process automation; molding of parts from more than one feedstock; alternative means of processing the feedstock other than injection molding; new techniques for producing metal powders; and the formulation of entirely new alloys and powder metal blends.

Overall, the future outlook for powder metal injection molding appears promising. Its many advantages can result in significant cost savings for production of a variety of parts, and for some parts there may be no other practical fabrication techniques. Parts suitable for production by the new process can be found in almost every product and industry. All volume manufacturers should become familiar with the process and examine its suitability for current and future production.

For more information on powder metal injection molding, contact:

Allan Roshon  
Witec California, Inc.  
4898 Ronson Court  
San Diego, California 92111  
(telephone: 714/268-3681)

Parmatech Corporation  
85 Mitchell Blvd.  
San Rafael, California 94903  
(telephone: 415/499-1030)

Ken Meiners  
Materials Processing  
Battelle Columbus Laboratories  
505 King Avenue  
Columbus, Ohio 43201  
(telephone: 614/424-7603)

SPECIAL FOCUS is a regular feature covering major developments in a selected technology area.



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**LEADERS IN DEVELOPMENT:****PERA-THE PRODUCTION ENGINEERING RESEARCH  
ASSOCIATION OF GREAT BRITAIN**

When one thinks of major developers of new manufacturing technology on a world-wide basis, PERA would certainly rank among the leaders. It is one of the few research organizations dedicated almost exclusively to the development and application of new production processes and equipment. This article briefly examines PERA's history, current activities and future directions.

**JOINT INDUSTRY/GOVERNMENT UNDERTAKING**

PERA was founded in 1946 under the joint sponsorship of the British Government and a number of industrial organizations. Under the original agreement, the industrial sponsors were referred to as "subscribers," and they agreed to maintain their PERA subscriptions for a period of not less than five years. These revenues were matched by the Government on a one-for-one basis. Total funding for the first year was about \$60,000.

Since its founding, PERA's activities have proven to be of value to industry, and the percentage of revenues derived from Government block grants continued to decline until they were eliminated completely in 1974. Although PERA still receives about 50 percent of its income from the Government, these revenues represent individual contracts for specific projects.

In 1981 PERA had over 450 staff members and total revenues of about \$13 million. "Subscription" income from industrial sponsors represented about 15 percent of revenues, while another 35 percent was derived from non-government research and development projects, consulting and training activities.

**MAJOR ACCOMPLISHMENTS**

Since its founding, PERA has been responsible for a number of notable accomplishments in the manufacturing technology field. Much of PERA's earliest research, for example, was concerned with drilling. This led to the determination of optimal drill point geometries for a wide range of materials and drilling situations and resulted in significant improvement in drill performance. An outgrowth of this research was the development of the PERA Reamer, which not only provided better hole quality, but also feed rates ten times greater than conventional reamers. Further work in this area has also

produced special milling cutters that eliminate the need for roughing cuts in some machining applications.

The achievement for which PERA is probably most noted for is its development of plasma-assisted machining. Referred to as CUTFAST, the hot machining process is designed so that difficult to machine materials can be cut at much faster speeds than previously possible. The CUTFAST system employs a plasma torch which heats the workpiece immediately in front of the cutting tool. Although the heated workpiece surface greatly facilitates metal removal, the depth of heating is carefully controlled so that workpiece distortion does not occur.

Electrochemical machining (ECM) is another area that PERA has been active in, particularly in regard to improving process accuracy. Maintaining tight tolerances with conventional ECM equipment had been difficult because of changing conditions of the electrolyte due to variations in temperature and conductivity. To overcome this problem PERA developed an adaptively controlled ECM system which senses electrolyte changes and regulates input voltages so that accurate tolerances (0.3 mils) can be achieved.

Other areas in which PERA has made significant advances include cutting fluids with increased life and reduced bacteriological contamination; the application of acoustic analysis techniques for tool wear monitoring and failure prediction; and a wide variety of computer programs and support aids to improve productivity, including systems for computer aided drafting, numerical control tape preparation and verification, automated process planning and machinability data.

**CURRENT ACTIVITIES**

Over the years, PERA has evolved into an impressive and highly diversified organization offering research, consulting information and training services related to improving manufacturing efficiency. In the broadest sense, PERA interprets improving manufacturing efficiency as meaning the creation of a product or function for the lowest possible costs. Thus their activities include many types of services, such as product development, and the more traditional forms of management consulting, that go beyond the development of new or improved manufacturing technology.

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### Memberships

PERA was founded on the principle of industry membership subscriptions as a means of support, and such memberships are still a significant portion of their revenues. Over 1400 industrial organizations are now subscribing members. Until 1974, when PERA's Government block grants were eliminated, membership was restricted to companies in the United Kingdom. Since then, companies from other countries have been admitted as associate members. About 100 companies from outside the United Kingdom are now subscribers to PERA. Memberships range in price from about \$1,000 to \$50,000 per year depending on company size.

As part of their membership, subscribers receive a wide range of services. These include reports on PERA research and development; regular information on other advances in manufacturing technology and related subjects; assistance in applying research results and advice on productivity improvement; use of an inquiry service to provide solutions to specific problems; access to PERA's library and information services; and regular visits by a PERA Regional Liaison Officer. All subscribers are entitled to these services, regardless of their type of membership.

### Research and Development

Some of the areas in which PERA is currently conducting research and development include:

- o Scrap recycling - This research program is aimed at the reuse of machining chips. In the case of ferrous scrap, chips are chopped and ground using a two-stage process to convert them to small particles. These particles are then compacted in a press and sintered in a hydrogen atmosphere to remove inclusions. The resulting billets, with a density of about 85 percent of wrought material, can be used as is or can undergo further sintering for forging and extrusion operations. Overall cost savings are estimated at about 50 percent when compared to conventional remelting operations. On-going efforts are focused on non-ferrous scrap, the effects of residual oil, and forging of recycled scrap.
- o Composite powder metallurgy - Current investigations are addressing the technical and commercial feasibility of producing powdered metal parts with different materials being used in selected sections of the component. Apparently, PERA has found a means to over-

come the problem of different sintering temperatures that would normally be required when using two or more types of powder metal. Also, PERA is investigating the use of isostatic pressing techniques that would employ flexible plastic tooling for compacting powder metal parts.

- o Tool wear monitoring - PERA's earlier work in vibration analysis to estimate tool wear and predict failure in drilling operations is currently being expanded to include other types of machining, such as milling, turning, boring, reaming and tapping. PERA is also applying this vibration analysis expertise to a variety of problems in such areas as quality assurance (e.g., testing of rotating machinery) and product design evaluation (e.g., vibration analysis of new production machinery).
- o Computer-aided manufacturing - A large number of developments in this area are underway at PERA. Much of this effort involves extensions of previous developments, the application of microprocessors to production equipment, and investigations into problems that must be overcome to achieve computer integrated manufacturing. Examples of current activities in this regard include capacity planning and scheduling systems, simplified programming languages for point-to-point numerically controlled machines, work-flow analysis software for designing group technology based production systems, automated machinability data bases, and graphic simulation of robot operations.
- o Robotics - Under Government sponsorship, PERA has recently installed a robotics demonstration center and robotics laboratory. The demonstration center contains a variety of robots from ASEA, S. Russell & Sons, Hall Automation and INA Automation. Development work is also underway in automatic feeding and optical inspection of parts coupled with pick and place devices.

### Other Activities

In addition to membership benefits and research and development capabilities, PERA also offers its clients a variety of other services, including:

- o Management and technical consulting - PERA provides a wide range of management and technical consulting services to its customers. These services include assistance

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and studies in such areas as productivity improvement, work study, energy conservation, production methods, product design, value engineering and quality assurance. In the management area, these services cover such topics as production planning and control, compensation schemes, computer applications and industrial market research.

- o Manufacturing Advisory Services - Under Government sponsorship, PERA assists companies in improving productivity through the use of new or improved production processes and equipment. This assistance is provided on a cost-sharing basis with the client. In operation since 1977, the Manufacturing Advisory Service provides assistance to about 900 companies per year.
- o Robot Advisory Service - Also under Government sponsorship, the Robot Advisory Service assists companies with the introduction of programmable automation in their manufacturing operations. PERA provides each requesting company with up to 15 person-days of effort at 50 percent of normal costs. This assistance is to help companies conduct feasibility studies for robotics applications and increase industry awareness of this technology.
- o Library and information services - Information collection and dissemination is a significant activity at PERA, both for internal needs and for clients. In addition to maintaining a major technical library in production engineering and related topics, PERA publishes the PERA Bulletin and translates and markets the Soviet Engineering Research Journal. PERA also provides translation services for manuals, drawings, specifications, reports and press releases.
- o Education and training - Each year, PERA offers several hundred courses that are attended by about 5,000 executives, managers and technical specialists. These courses cover such topics as robotics, purchasing, microprocessors, international licensing and contract law.

#### FUTURE DIRECTIONS

The momentum of PERA's current manufacturing technology development efforts will carry forward into the near-term future. This would include continued work in such areas as powder metallurgy, processing of machining chips, tool wear monitoring and failure prediction, electrochemical machining, plasma-assisted machining,

robotics, and computer-aided manufacturing. PERA is also diversifying into non-manufacturing areas that could benefit from the same types of technology.

In the long term, PERA's future direction will be shaped by the needs of three groups: sponsoring members, individual clients and the British Government. Collectively these groups have similar goals concerning the development and implementation of new production technology, but differing motivations and means of achieving their goals.

As world-wide economic pressures continue to mount, PERA's efforts are increasingly shifting towards the application of existing technology on behalf of its clients. This trend is already reflected in PERA's Government-sponsored manufacturing and robot advisory services which aim to increase the implementation rate for new production technology through expert assistance and cost sharing.

Several other major trends will affect PERA's future direction. For example, PERA will probably not devote as much effort to improving machining processes in the future because of the major improvements in machining technology that have been achieved in the past 20 years and the diminishing returns of further research in this area. Future research and development will focus on areas that could provide greater returns in productivity improvement. Promising areas in this regard include programmable automation, computer-aided manufacturing, processing of new materials and materials substitution.

Considering its breadth of research and development capabilities and diversified services in consulting, information and education, along with an increasingly international customer base, PERA is well positioned to satisfy the changing needs of its clients in the future.

For more information on PERA and its activities, please contact:

Mr. John A. Phillips  
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UNITED KINGDOM  
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LEADERS IN DEVELOPMENT is a regular feature focusing on major developers of manufacturing from around the world.

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homogeneity of these imperfection changes the flow of heat through the material and appear as color variations on the liquid crystal.

MIT is still investigating the correlation between the colors, temperature and type of defects. Their goal is to develop a kit with simple graphs and tables so that non-technical personnel can determine the probable imperfections using the technique.

For more information, contact: Dr. James H. Williams, Dept. of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139 (telephone: 617/253-2221). 82-060

#### SCANNING LASER ACOUSTIC MICROSCOPE

Sonoscan has developed several new manufacturing applications for its scanning laser acoustic microscope (SLAM). The non-destructive testing instrument, which was originally employed in research laboratories, is increasingly being used in a variety of quality control applications, such as the evaluation of ceramic chip capacitors and other electronic components, evaluation of seam welds in steel or tin cans, inspection of composites, and inspection of metal components for structural defects. The SLAM generates high frequency (30 to 500 MHz) ultrasound by means of a transducer mounted on an acoustically transparent quartz block. The ultrasound is directed through the quartz to the sample, where it is attenuated by the sample's structure. After the sound wave travels through the sample, it hits a gold film coverslip and sets up a wave pattern. This pattern is detected by a scanning laser, and the beam is reflected to a photodetector, which transmits an image to a CRT. Any imperfections, such as air pockets caused by delaminations or weld faults, show up as dark spots on the image.

The SLAM is especially useful where 100% inspection of high reliability components is required. It is being tested for use in ceramics and glass inspection (surface damage, bonding and joining, variations in material properties, and crack detection), in polymer inspection (composites, coatings, bonding and joining, and fractures), in metal inspection (bonding and joining, powder metallurgy, fractures, metal coatings, and metal property variations), and in electronics inspection (capacitors, solid state devices, bonding, thick film resistors).

For more information, contact: Dr. Lawrence W. Kessler, Sonoscan, Inc., 530 East Green Street, Bensenville, Illinois 60106 (telephone: 312/766-7088). 82-061

#### FLOW MEASUREMENT

The National Bureau of Standards has developed a new flowmeter that accurately measures the rate of flow of fluids (gases, liquids, or multicomponent fluids) in pipes, tubes, or ducts. Referred to as a long-wavelength acoustic flowmeter, it incorporates a loudspeaker connected to the pipe with two microphones or pressure sensors mounted either upstream or downstream from the speaker. The microphones are separated from each other by a distance of at least six pipe diameters. The loudspeaker generates sound consisting of two superimposed sine waves with frequencies in a two to one ratio. The wavelength of the higher frequency component equals the distance between the microphones. When these frequencies are set correctly, the difference in phase of the signal detected by each microphone at each frequency is measured to determine such properties as average volume flow rate, speed of sound in the fluid, average fluid density, average temperature, and mass flow rate.

The flowmeter uses sound with a wavelength much longer than the length of the pipe, tube, or duct. As a result, all measurements are independent of the flow, temperature, and density distribution of the fluid. The measurements are absolute, with no flow calibration required. Other significant advantages of the flowmeter include the absence of projections or obstructions in the fluid, the ability to measure flow in either direction, and the ability to perform well in a relatively high noise (mechanical and electrical) environment. Suitable applications for the device are in the petroleum and chemical processing industries, where existing methods often require the use of mixers for multicomponent fluids. The flowmeter is not yet commercially available and the technology can be licensed on a non-exclusive basis.

For more information, contact: James Potzick, National Bureau of Standards, Fluid Engineering Division, Washington, DC 20234 (telephone: 301/921-3681). 82-062

#### INSPECTION OF PIPE CORROSION

Battelle has developed a non-destructive method for detecting and measuring corrosion of steel pipe covered with insulation. The system is

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based upon the use of high energy (1000 kilovolts) x-rays to produce images of pipes. These images are intensified, projected on a fluorescent screen, and viewed on a monitor using a television camera. Under conditions of severe corrosion, 50 feet per minute of pipe can be inspected. Presently, insulated steel pipe in plants can only be inspected for corrosion by removing a portion of the insulation, which is time consuming and costly.

The technical feasibility of the system has been demonstrated, and Battelle plans to evaluate the concept under conditions likely to be encountered during actual usage. This includes safety considerations, and the development of a mounting system that will allow the system to move along the multiple pipe systems normally found in plants, and economic implications. Battelle also plans to examine other possible applications of the system, such as the detection of pits on the inside of pipes.

For more information, contact: Osmar Ullrich, Engineering and Manufacturing Technology Department, Battelle Columbus Laboratories, 505 King Avenue, Columbus, Ohio 43201 (telephone: 614/424-5838). 82-063

Robot is a real-time, five-axis rectangular coordinate robot for fully automated gas-metal-arc welding of both simple and complex welds. It can be used for single or multi-pass welding in straight or weave patterns. The system features two innovative developments: an automatic search function to locate the weld joint and correctly position the weld torch relative to the work piece, and an arc current sensor to determine the center of the weld and compensate for movement of the work piece during welding. For more information, contact: Westinghouse Electric Corporation, Industry Automation Division, Hightower Office Building 400, 400 Media Drive, Pittsburgh, Pennsylvania 15205. 82-065

Automatix Inc. also introduced a robotic arc welder with seam tracking capability. The Automatix system uses a vision sensor consisting of a laser combined with a TV camera. The laser detects the location of the weld line and the TV camera produces an image of the weld. The optical guidance signal is provided to the robot, which makes corrections based on part-to-part variations. For more information, contact: Mr. Philippe Villers, President, Automatix Inc., 217 Middlesex Turnpike, Burlington, Massachusetts 01803 (telephone: 617/273-4340). 82-066

## ROBOTICS

### ROBOTS VI CONFERENCE

The Society of Manufacturing Engineer's Robots VI Conference, which was held in Detroit, Michigan on March 1-4, 1982, featured exhibits by over 95 equipment manufacturers and suppliers of robotics services. Several new industrial robot developments were introduced at the exhibition.

IBM presented a programmable, multi-functional manipulator for light assembly, fabrication, testing and materials handling. The system, known as the RS1, features tactile and optical sensing. The manipulator is a six-axis rectangular coordinate device with a parallel gripper. The work envelope is rectangular, with dimensions of 18"x58"x17". For more information, contact: IBM Advanced Manufacturing Systems, 1000 N.W. 51st Street, Boca Raton, Florida 33432 (telephone: 305/998-4191). 82-064

Westinghouse introduced a new arc welding robot with on-line seam tracking. The Series 7000

Bendix Corporation presented its new line of robots, including a six-axis, spherical coordinate, highly accurate robot. The AA-160 robot has a 102" reach and a full backward and forward tilt capability so that a fully spherical work envelope is achieved. The robot has a positioning accuracy of  $\pm .004$ " and a repeatability of  $\pm .002$ ". Load capacity is 45 pounds. For more information, contact: Bendix Robotics Division, 21238 Bridge Street, Southfield, Michigan 48034 (telephone: 313/352-7700). 82-067

A number of significant research developments were also presented during the conference.

The Naval Surface Weapons Center described its development of magnetoelastic/magnetostrictive force feedback sensors for machine tools and robots. Materials which exhibit magnetoelastic properties are being used for force sensing. These are materials which, when subject to external tension or compression forces, show corresponding changes in their internal magnetic field. To act as sensors, the magnetic domain lines are set to be perpendicular to the long axis of the material. As a force is applied to the material, these lines rotate toward the axis at a rate proportional to the force. This

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change in the internal field is measured and used for feedback. The basic research for the concept has been successfully completed and prototype designs are now being constructed. For more information, contact: John M. Vranish, Naval Surface Weapons Center, White Oak, Silver Spring, Maryland. 82-068

The Universite des Sciences et Techniques de Lille 1 (France) described the development of a three-fingered gripper with proximity sensors. The gripper consists of three independent fingers each having two degrees of freedom and arranged symmetrically around a wrist. Pneumatic proximity sensors in each finger allow the gripper to track the contour of an object without touching it. With a total of eighteen sensors in the fingers, the gripper is capable of grasping and transporting a variety of irregularly shaped objects. A prototype has been constructed and tested. For more information, contact: Michael Edel, Universite des Sciences et Techniques de Lille 1, Villeneuve D'Ascq, France. 82-069

General Dynamics described an innovative approach to teaching robot orientation for hole drilling using tactile feedback. The approach uses a four-tined probe to align a drill perpendicular to the surface at the proper position. Three tines are around the edge of the circular probe, and one is in the center. A target ring consisting of four insulated plates with signal wires must be contacted by the probe such that circuits in all tines are completed, indicating a correct alignment. If signals are not received simultaneously from all tines, an adjustment is made until the tool is correctly aligned. For more information, contact: D. Mark Lambeth, General Dynamics/Fort Worth Division, Fort Worth, Texas. 82-070

#### ROBOT PROGRAMMING LANGUAGE

Under U. S. Air Force sponsorship, McDonnell Douglas has developed a high level programming language for robots. Referred to as Machine Control Language (MCL), the language is an extension of the numerical control programming language APT, with significant added capabilities such as real-time logical control and coordination of multiple devices. Although primarily considered to be an off-line programming language for robots, MCL can direct the operation of an entire manufacturing work cell, consisting of multiple robots, processing equipment, vision systems and sensors. MCL software and documentation is available from the Air Force for \$150.00.

For more information, contact: Mr. Lonnie Brown, McDonnell Douglas Corporation, P.O. Box 516, Dept K314, St. Louis, Missouri 63166 (telephone: 314/232-7826) or Lt. Gordon Mayer, Air Force Wright Aeronautical Laboratories, Attn: AFWAL/MLTC, Wright Patterson AFB, Ohio 45433 (telephone: 513/255-5317). 82-071

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### COMPUTER AIDED MANUFACTURING

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#### GRAPHICS EXCHANGE SPECIFICATION

The National Bureau of Standards (NBS) and over 45 other organizations are continuing efforts to develop an interface specification for communication of part definition data between different CAD/CAM systems. The team is reviewing, modifying and expanding the capabilities of the earlier version of the Initial Graphics Exchange Specification (IGES) released in 1980. IGES Version 1.0, developed under U. S. Air Force sponsorship, has been accepted as a standard for the digital representation for communication of product definition data by the American National Standards Institute (ANSI). Changes being made to IGES Version 1.0 will result in improved capabilities in the area of non-geometric data, such as material types, tolerances, surface finishes, and associativities (the relationships among data entities).

IGES Version 2.0, expected to be available for public review in late 1982, will also include extensions for communication data used in printed wiring electronic product designs.

For more information, contact: Bradford Smith, National Bureau of Standards, Manufacturing Systems Group, Metrology Building, Room A-353, Washington, DC 20234 (telephone: 301/921-3091). 82-072

#### COMPUTER AIDED GEAR DIE DESIGN

Under a U. S. Army sponsorship, Battelle has developed a set of computer programs for designing preform and finishing dies for gears formed by precision forging and powder metallurgy. The package permits simulation of the motion of Gleason gear cutting machines to determine the geometry of gear teeth. This allows the exact tooth form of hypoid gears, bevel gears and pinions to be defined. Then, using finite element programs for stress

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analysis and temperature distribution, the necessary correctional calculations are made, based on the effects of various manufacturing parameters. The end results are design diagrams and information necessary to manufacture both forging dies and electrodes for electrical discharge machining to produce the dies.

Use of the new computer programs should result in lower gear manufacturing costs by simplifying design and fabrication processes and reduced machining requirements. Battelle expects the software to be commercially available later this year.

For more information, contact: Taylan Alton, Battelle Columbus Laboratories, 505 King Avenue, Columbus, Ohio 43201 (telephone: 614/424-7737 or 7859), or David Pyrcce, US Army Tank-Automotive Command, Attn: DRSTA-RCKM, Warren, Michigan 48090 (telephone: 313/574-5814). 82-073

#### COMPUTERIZED PLANT LAYOUT

The Georgia Institute of Technology has developed an interactive color graphics plant layout system which encourages the entry of human insight and experience into a facilities planning model. With the aid of the computer, users interface with color coded special representations of plant layout problems to make decisions that guide the optimization procedures contained in the computer software.

The advantage of the human-aided optimization system is that plant layout information can be quickly modified by the user and the results of these modifications are then rapidly analyzed and displayed on the color graphics terminals. It then becomes possible for modification of solutions and models to continue until the user and the computer arrive at some mutually acceptable approximation of the best plant layout.

For more information, contact: H. Donald Ratliff, Production/Distribution Research Center, School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta, Georgia 30332 (telephone: 404/894-2300). 82-074

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## ELECTRONICS PRODUCTION

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#### SOLDERING RESEARCH

The National Physical Laboratory (United Kingdom) has initiated a major research program to improve the reliability of automatic soldering techniques used in the electronics industry. The objective of the program, which is sponsored by the UK Government and a number of private companies, is to improve soldering efficiency and reliability through both detailed analyses of defects and scientific research into problem areas. Specific problems being investigated include: voids and blowholes in plated through holes; insufficient solder in holes; the relationship between hole size and component lead diameter; mechanical properties of solders near their melting points; non-wetting and de-wetting; aged solder surfaces; solder contamination; and in-service failures due to soldering defects. Program sponsorship is open to any company operating in the United Kingdom.

For more information, contact: Dr. Colin Lea, National Physical Laboratory, Teddington, Middlesex TW11 0LW, England (telephone: 01-977-3222). 82-075

#### ELECTROPLATING PROCESS CONTROL

UPA Technology has recently introduced a microprocessor-based system for determining the additive concentration and contamination levels in copper plating baths for printed wiring boards. Referred to as QUALIDERM, the system utilizes a patented cyclic voltammetric stripping (CVS) technique which first plates copper onto a platinum electrode and then measures the charge required to strip the electrode when it is rotating and stationary. From the CVS charge data, the automated system provides a direct indication of the effective additive concentration which determines the solution's ductility and tensile strength properties and detects the level of contaminants present in the copper bath. Concentration and contamination levels are displayed via a digital readout or optional XY recording. The new system is reported to be cost-effective and easy to operate.

Significant benefits from the system include improved product reliability and increased yields, especially for plated-through holes of multilayer boards. One user of the technology has reported a 10% increase in production yields of complex multilayer printed wiring boards. UPA is currently involved in development efforts with other PWB manufacturers to expand the

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process control technology to solder and tin baths.

For more information, contact: Dr. Jacques Weinstock, UPA Technology, Inc., 60 Oak Drive, Syosset, New York 11791 (telephone: 516/364-1080). 82-076

#### LASER IMAGING OF PHOTORESISTS

Under U. S. Air Force sponsorship, Westinghouse has developed an automated system for direct laser imaging of photoresists in the production of printed wiring boards. Referred to as the Laser Pattern Generator (LPG), the system utilizes information directly from a digitally encoded data base to control the laser imaging process. The new system is compatible with either positive or negative photoresists, and imaging time is independent of design complexity.

Major benefits of the LPG system include the elimination of photographic artwork, and reduced production leadtimes for first samples and design changes. The present system is capable of imaging a 18 X 24-inch printed wiring board in four minutes with an alignment accuracy of plus or minus one mil. Future advances in performance and throughput are contingent upon anticipated improvements in photoresist characteristics and availability of less expensive laser scanning equipment. The system is also being evaluated by Westinghouse and the Air Force for possible implementation into a totally automated electronics assembly line.

For more information, contact: Richard Decker, Westinghouse Defense and Electronics Systems Center, Baltimore, Maryland 21224 (telephone: 301/995-5826) or Helen Kavanaugh, Aeronautical Systems Division, Office of Public Affairs, Wright Patterson AFB, Ohio 45433 (telephone: 513/255-2725). 82-077

#### WAVE SOLDER MACHINE ADJUSTMENT

Hexacon Electric has introduced an improved device for adjusting and monitoring flux and solder parameters of wave soldering machines. Referred to as the Lev Chek, the device is a tempered glass plate with a heat resistant calibration grid. The device is similar in shape to a printed wiring board and can be attached to the conveyor mechanism to check and maintain the wave soldering machine's performance. Parameters which can be measured and/or adjusted include uniformity of flux orifice adjustments for either foam or wave fluxers, solder

immersion depth and wave shape, and length of immersion. In addition, the uniformity of oil and undesirable turbulence can be detected using the device.

The calibration grid permits minor changes in machine parameters to be noted quickly and easily, thus avoiding costly touch-up procedures resulting from improper machine adjustments. The inexpensive device is simple to use and results in increased soldering consistency and reliability.

For more information, contact: Nick Ruscignuolo, Hexacon Electric Company, 161 West Clay Avenue, Roselle Park, New Jersey 07204 (telephone: 201/245-6200). 82-078

### MICROELECTRONICS

#### SEMICONDUCTOR WAFER POLISHING

The Massachusetts Institute of Technology is developing a hydroplaning process for polishing the surface of semiconductor wafers to improve electronic device yields. The new system utilizes a rotating, teflon-coated polishing disk to which a chemical etchant is continually applied and evenly distributed by centrifugal force. Surface polishing is achieved by attaching wafers to a free-spinning optical flat which is floated (hydroplaned) on the moving etchant. Material removal rates of up to 28 micrometers per minute have been attained with surface flatness to within 0.3 micrometers. The prototype equipment can polish six, one-inch diameter wafers simultaneously.

Initial tests of the hydroplaning polishing process have demonstrated significantly improved yields of semiconductor devices by providing a more uniform wafer surface with fewer defects. Originally designed as a manually operated system, efforts are currently being initiated by MIT to automate etching and rinsing to provide consistent quality and unattended operation.

For more information, contact: Michael J. Manfra, Massachusetts Institute of Technology, Lincoln Laboratory, 240 Wood Street, Lexington, Massachusetts 02176 (telephone: 617/862-5500 Ext. 5586). 82-079

#### THIN FILM DEPOSITION

The Naval Research Laboratory has discovered a



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new technique for deposition of luminescent and semiconductive thin films. Using photo-induced selective condensation of gaseous reactants, the process yields thin films of antimony-doped material that have never been produced before. Gaseous antimony pentafluoride and halogen compounds are mixed in an evacuated chamber at room temperature. When ultraviolet light from a xenon is passed through a window into the chamber, a thin film is deposited on the inside surface of the window. The resulting film is both electrically conductive and photo-luminescent. Five orders of magnitude in resistivity change can be obtained by varying the film thickness and luminescence in the blue region.

The process appears to be highly efficient, simple and inexpensive, but further development work is needed to assess film uniformity, thickness limitations and possible resistivity ranges. Since the films are moisture sensitive, coating methods must also be developed. By replacing the xenon lamp with a UV laser, semiconductive films with micron-sized dimensions may be possible.

For more information, contact: John F. Giuliani, Code 6170, Naval Research Laboratory, Washington DC 20375 (telephone: 202/676-2536). 82-080

#### LOW TEMPERATURE OXIDE DEPOSITION

Hughes Aircraft has developed a new process for low temperature deposition of insulating oxide coatings on semiconductor substrates and electro-optical devices. The process utilizes a photochemical vapor deposition technique in which selective wavelengths of light are absorbed by process gases to form silicon dioxide or other metal oxides such as aluminum and titanium. Actual process temperatures are dependent on substrate material and generally range from 50 to 300°C.

The new process is easily integrated into existing semiconductor manufacturing facilities and is currently being offered by Hughes under non-exclusive licensing agreements. With significantly reduced temperature requirements over conventional oxide deposition techniques, the new process is particularly useful for production of temperature sensitive devices. Other benefits include increased reliability, higher component yields, and improved electrical characteristics, especially in variation of breakdown voltages.

For more information, contact: Mike Murphy, Hughes Aircraft Company, P.O. Box 90515,

Building 100, Mail Slot A664, Los Angeles, CA 90009 (telephone: 213/670-6356). 82-081

#### PULSED-PLASMA X-RAY SOURCE

Maxwell Laboratories and Physics International Company are independently developing a pulsed-plasma x-ray source for use in semiconductor lithography and x-ray microscopy. Referred to as a gas-puff or gas-jet plasma source, the innovative technique generates x-rays by discharging electrical energy through short bursts of gas which have been forced through a special shaping nozzle. The electrical energy converts the cylinder-shaped gas puff into a compressed plasma which emits x-rays. The wavelength of the emitted energy can be optimized to the intended application of the source by changing the gas composition. Wavelengths ranging from the visual spectrum to approximately four angstroms have been achieved.

The development represents a significant increase in average power and efficiency over electron bombardment x-ray sources. The reduced costs, higher throughput capabilities, elimination of diffraction effects, and improved resolution should have a major impact on VSHIC and VSLI manufacturing. Geometries in the 0.5 micron range should be attainable using currently available photoresists and electron-beam-generated photomasks. X-ray microscopy capabilities are also being evaluated for industrial material analysis applications requiring x-rays for characterization and chemical composition determination. Both companies are currently involved in testing and engineering efforts to improve reliability and producibility.

For more information, contact: Mr. Jay S Pearlman, Maxwell Laboratories, 8835 Balboa Avenue, San Diego, California 92123 (telephone: 714/279-5100) or Dr. James Glaze, Physics International Company, 2700 Merced Street, San Leandro, California 94577 (telephone: 415/357-4610 X 7113). 82-082

#### CONTAMINATION DETECTION IN PROCESS GASES

UTI Instruments has developed a system for detecting contaminants in carrier, implant and silicon source gases used in the production of semiconductor wafers. Referred to as QUALI TRACE, the system utilizes a dedicated minicomputer, a hard-wired vacuum logic processor, a closed ion source and signal/noise enhancement techniques to inspect and monitor

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content and purity of gases such as argon, silane, and phosphine which are critical to wafer processing and yield.

The detection system is fast, simple to operate and provides a high degree of repeatability and accuracy in measuring a majority of contaminants as specified by the SEMI Gas Standards Committees. Advantages of the system include improved process quality and reduced costs associated with contaminated gas mixtures.

For more information, contact: Susan Dahle-Fuller, UTI Instruments Company, 325 North Mathilda Avenue, P.O. Box 519, Sunnyvale, California 94088-3519 (telephone: 408/7738-3301). 82-083

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## BOOKS AND REPORTS

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### MANUFACTURING/INDUSTRIAL ENGINEERING SOFTWARE

Both the American Institute of Industrial Engineers (AIIE) and the Society of Manufacturing Engineers (SME) have recently announced the introduction of software packages to solve problems commonly encountered by industrial and manufacturing engineers. AIIE is developing a set of 40 programs for use in industrial engineering applications such as economic analysis, production control, project management, work measurement, forecasting, operations research, statistical analysis, plant layout, quality control and many other areas. The programs will come with complete documentation including detailed program descriptions, source listings, operating instructions and practical case examples. They are written in BASIC for use on TRS-80 or Apple microcomputers. SME has issued a 250-page publication, Basic Programming Solutions For Manufacturing, which covers the use of microcomputers to solve problems in cost estimating, learning curves and launching costs, machine capability studies, equipment justification, analysis using computer graphics, process planning, and more.

For more information, contact: Greg Balestero, American Institute of Industrial Engineers, 25 Technology Park, Norcross, Georgia 30092 (telephone: 404/449-0460) or SME's Publication Sales Department, One SME Drive, P.O. Box 930, Dearborn, Michigan 48128 (telephone: 313/271-1500 X 346). 82-084

### REINFORCED PLASTICS

Technology Conferences has recently published the proceedings from a conference on reinforced plastics which took place in December, 1980. The 114-page document contains seven papers on various aspects of reinforced plastics fabrication and use. Of particular note is a paper by A. H. Steinberg of Allied Chemical which describes the relatively new process of melt flow stamping. In melt flow stamping, a thermoplastic sheet is heated to a temperature above its melting point and then formed in a matched metal die under moderate pressure. The sheets processed in this manner generally contain long (greater than 10mm) reinforcing fibers which provide higher strength and less creep than normal thermoplastic molding compounds.

For more information, contact: F. D. Tabrisky, Technology Conferences, P.O. Box 842, El Segundo, California 90245. 82-085

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## OTHER INTERNATIONAL NOTES

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### JAPAN TOURS

The Technology Transfer Institute is organizing two industrial study missions to Japan on advanced batch manufacturing systems and CAD/CAM technology. The missions will include plant tours and discussions with representatives from Japan's Ministry of International Trade and Industry. The batch manufacturing systems mission will depart May 21, 1982, and will be led by Dr. George Hutchinson of the University of Wisconsin. The CAD/CAM mission is scheduled to leave May 29, 1982, and will be headed by Daniel Appleton, President of D. Appleton Company.

For more information, contact: Rak Hun Choi, Technology Transfer Institute, Suite 1411, One Penn Plaza, New York, New York 10119 (telephone: 212/947-2648). 82-086

Past issues of *Manufacturing Technology Horizons* are available for \$10 per copy.

APPENDIX

D

EXAMPLES OF MICOM SUMMARIES

USING STANDARD FORMAT

Prepared by: Joe Morgan

Date: 15 April 82

### Project 316B - Production of Circuit Board Heat Pipes

**BACKGROUND:** In the design and fabrication of military-grade Printed Circuit Boards (PCBs), a major consideration and limiting factor is the ability to dissipate heat. The disadvantages exhibited by conventional cooling techniques include 1) a decrease in the number of components which can be mounted on the PCB; 2) less than optimal circuit layout, especially for high frequency applications; 3) special hardware required to dissipate high localized heat; 4) increased temperature-related failure rates; and 5) inability to increase component packaging density without unacceptable increases in weight and volume requirements. An alternative to conventional cooling methods utilizes heat pipe techniques to overcome these disadvantages. The heat pipe is an enclosed shell housing a wick arrangement and a working fluid. Heat pipes use the evaporation/condensation cycle of the working fluid for heat transfer. The cooling capability of circuit card heat pipes is equivalent regardless of component layout, and heat pipes are able to handle high power densities without special spreader plates. The effectiveness of the heat pipe concept to overcome the disadvantages of conventional techniques has only been demonstrated with custom-made devices. To promote widespread and regular use of heat

pipe technology in the production of PCBs for military applications. MICOM initiated an MM&T project to provide mass production techniques for circuit board heat pipes.

**OBJECTIVE:** The objective of this project was to establish reliable and economical manufacturing methods and techniques for circuit card heat pipe production. In achieving this objective a comprehensive investigation and evaluation of alternative processes and materials was performed to increase device yields and reduce costs.

**ACCOMPLISHMENTS:** A major accomplishment of this project was the establishment of a pilot production line which demonstrated that reliable, cost effective heat pipes for printed circuit cards can be manufactured on a volume basis. This capability was achieved through extensive analysis, testing, and evaluation of competing processes and materials. Tradeoffs in performance and cost resulted in the selection of acetone for the fill fluid, sintered stainless steel for the wick material and a copper alloy for the shell material. Selected manufacturing processes included stamping, tack welding, brazing and both cold and hot weld pinch-off techniques. Heat transfer capability was maximized through the selection and refinement of an integrated heat pipe module design, and alternative methods for attaching heat pipes to various types of printed circuit boards were generated. A test station was fabricated, and test procedures, fixtures, and performance parameters were developed which

permitted cost effective verification of heat pipe cooling capabilities. Environmental testing of prototype units indicated no degradation in performance characteristics occurred from either vibration or shock. Detailed process specifications together with plant and equipment drawings for a production facility capable of producing 4000 heat pipes per week were also generated. A unit cost analysis for the manual-semiautomatic manufacturing process was provided. Recommendations for future efforts versus potential benefits were also included.

**BENEFITS:** The demonstrated ability of producing a cost-effective circuit board cooling system with approximately a five-fold increase in heat transfer capability has and will continue to have a significant impact on the design and development of military electronics. The mass production techniques provided by this process have made heat pipes a feasible alternative for the Air Force F-16 LANTIRN program. An adaption of the integrated heat pipe concept is being used to solve a critical cooling problem in the F-16's navigation and target acquisition systems. Cooling of the volume constrained, high power density ceramic chip carrier circuitry used in these systems could not have been achieved with conventional technologies. Other system developments utilizing the technology and processes of this project include a MERADCOM high power, solid state switching circuit, and the Navy ADCAP and F-18 programs. Manufacturers of commercial electronic equipment are also seriously considering the cooling techniques to solve heat related problems in

high density circuitry such as computer memories. Further benefits from heat pipe technology can be achieved through additional investigations in the areas of automated equipment and alternate materials which would improve production yields and lower unit costs. More work is also required in improving the temperature dissipation characteristics at the circuit board/card cage interface.

Prepared by: Joe Morgan

Date: 25 Jan 62

Project 3227 - Low Cost Production Methods for Handling  
Hybrid Chips Via a Tape Carrier Lead Frame

BACKGROUND: Fabrication of military hybrid microcircuits requires the electrical connection of numerous integrated circuit (IC) chips to the hybrid substrate. In the mid-1960's, this was accomplished by bonding tiny gold wires to the chip and then to the substrate. These wire bonding techniques are time consuming and do not permit the IC's to be pretested or burned-in prior to final assembly. Faulty chips reduce hybrid production yields and the wire bonding techniques do not provide the high reliability characteristics necessary for military applications. Both of these factors increase hybrid microcircuit production costs.

An alternative approach to wirebonding is Tape Automated Bonding (TAB). TAB techniques are more complex and consist of a series of processes including: plating bonding "bumps" on the IC; plating metallic leads on lead frame tape; inner lead bonding of the IC to the tape; attaching the chip to the substrate; and outer lead bonding of the leads to the pads on the substrate. Utilization of this technology for military hybrids requires expanding the R&D efforts which have proven the feasibility of these processes to a full production capability.



**OBJECTIVE:** The objectives of this project were to establish manufacturing methods, equipment, and procedures for utilizing tape automated bonding techniques in the production of military hybrid microcircuits. A major goal of the project was to incorporate preassembly testing techniques which would increase overall production yields. Emphasis was placed on implementation of automated processes to improve component performance and reliability characteristics and minimizing production costs.

**ACCOMPLISHMENTS:** During the project, the contractor established the manufacturing methods, tooling, fixturing, testing and costs required to implement TAB technology in a production environment. The contractor improved and refined existing techniques for both inner lead and outer lead bonding which have subsequently been incorporated by the bonding equipment manufacturer. Other improvements in the lead frame plating equipment varied the amount of gold plated along the lead fingers. This provided increased performance and reduced material costs. Finally, the design of a slide carrier and integration of other equipment facilitated burn-in and pretesting of individual IC chips prior to hybrid assembly. The production capabilities developed under this project were demonstrated in a pilot production run of a synchronous counter shift register used in a precision guidance assembly for a B-52 aircraft.

**BENEFITS:** TAB technology and the MM&T processes provide numerous benefits over standard chip and wire bonding techniques. One of the most significant benefits is the improved reliability of hybrid circuits, especially in harsh environments. TAB techniques result in better IC heat dissipation properties and the hybrids are capable of withstanding higher G forces. The technology demonstrates improved performance characteristics at high frequencies or high switching speeds. The ability to pretest and burn-in chips prior to assembly dramatically increases hybrid yields and reduces costs and leadtimes associated with rework due to defective chips.

To date, only the project contractor has implemented this technology in the production of military hybrid microcircuits. The major impediments to wider utilization are the high initial costs for equipment and tooling and the low production quantities normally required for military devices. The technology is currently being implemented by producers of high volume commercial products. Although it is difficult to precisely determine the extent to which the WICOM MM&T project results have influenced these efforts, it is known that numerous commercial electronics manufacturers have queried the project contractor for more information on these processes.

The contractor is currently utilizing the TAB processes in the production of hybrid circuits for a classified military project. Although little is known about the hybrid, it is clear that the TAB processes are being used because of the project's extremely high

reliability, speed, and thermal requirements which cannot be met using other methods.

In the future, TAB will have an uphill fight against ceramic chip carriers which is another replacement technology for wire bonding processes. Before TAB will become economically feasible for military hybrid production, it will be necessary for semiconductor manufacturers to supply custom IC chips preassembled on lead frame tape. Although American manufacturers show little inclination towards doing this, there has been increasing interest shown in TAB technology by Japanese semiconductor manufacturers. Another factor which could influence utilization is the new hybrids currently in development which require VSLI or VHSIC chips. TAB technology has shown itself capable of providing lead frames with 2 mil leads on 2 mil spacings which should be adequate for use with these new ICs.

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The results of this project have the potential of making a significant impact on manufacturing of military grade hybrid microcircuits. This potential warrants future dissemination and implementation efforts by MICOM.

## APPENDIX

### E

#### EXAMPLES OF MICOM SUMMARIES

#### USING DATA BASE FORMAT

Project 3133 - Production of Lithium Ferrite Phase Shifter  
for Phased Array Radars

PROJECT SUMMARY: Manufacturing processes and materials established during this project demonstrated the potential to significantly reduce production costs of phase shifters used in phased array radar systems. By replacing the more expensive yttrium oxide garnet material used in the manufacturing of the phase shifter's torroid, an estimated ten-fold decrease in raw material costs is achieved. The less expensive lithium ferrite material also demonstrated a three to four-fold increase in power handling capability. An assessment of the reproducibility and an evaluation of the electrical operating parameters of the torroid were performed on a pilot production run of 200 components. These units demonstrated the capability of replacing the more expensive torroids currently used in the Patriot Missile System with only minor modifications to electronic circuitry. Direct replacement is considered possible with three to four months additional development to further refine the production processes. The lithium ferrite torroids have not been substituted for the rare earth oxides primarily because of the lack of performance and reliability data. The improved performance at lower costs of the lithium ferrite material is being seriously considered for—and if selected should provide significant benefits to—future Army and Navy ballistic missile air defense systems. Newly developed ultrasonic measurement techniques which were incorporated into the production processes permitted more precise inspection and verification of torroid wall thickness. Implementation of the inspection techniques by the contractor for incoming

inspection and by the torroid supplier for production line quality assurance has provided recognizable benefits in product reliability and yields.

**PROBLEM STATEMENT:** Current methods and materials used to manufacture torroids for phase shifters in Army missile phased array radar systems result in high component costs, decreased performance, and low production yields.

**SOLUTION STATEMENT:** Establishing the feasibility of utilizing lower cost materials for phase shifter torroids and enhancing current inspection techniques will provide improved phase shifter performance characteristics and lower acquisition costs of present and future Army missile systems.

Project 3134 - Manufacturing Methods for Production  
of Field Effect Electron Emitters

PROJECT SUMMARY: A new class of materials for use as an emission source for high power electron tubes was made available by enhancing oxide-metal growth and fabrication techniques. Manufacturing methods and procedures were established to provide production quantities of field effect emitters from a eutectic composite of urania with current handling capabilities as high as  $1\text{A}/\text{cm}^2$ . Refinement and optimization of the growth techniques produced urania ingots with extremely high levels of uniformly distributed, submicron diameter tungsten fibers. Field emitters made from this material require no heater and ancillary equipment, thus the response time of an electron tube can be reduced to near zero. In addition, these emission sources are extremely rugged and can withstand wide variations in temperatures with little change in electrical characteristics. Production rates and yields were improved by the fabrication of ingots with a two-fold increase in diameter and by maximum utilization of standardized machining, brazing and etching techniques. Current density increases were achieved through investigations of emitter structures and formation of tungsten pin tip geometries. An evaluation of the prototype emitter's performance characteristics was also performed. The results of this project have been utilized to provide sufficient quantities of newly designed field array devices for an Air Force R&D project, and to produce a low voltage emitter device in a follow-on MICOM MM&T project. No full-scale implementation of the technology has yet been realized for electron tubes, but emitters produced with the prototype equipment and processes are currently

being studied for a commercial application. The emitter is used to inject electrons into diesel fuel to increase engine efficiency as much as 30 percent by electrostatically spraying fuel into the combustion chamber. Because the field effect emitter is considered as one of the best alternatives to thermionic cathodes, the most significant benefits of the project will be realized on future military radar and communication systems that will require higher power and/or operating frequencies.

**PROBLEM STATEMENT:** Thermionic emitters used as electron emission sources for high power electron tubes are nearing the upper limit of their current density capabilities. To meet further increases in power and/or frequencies, new technologies must be developed.

**SOLUTION STATEMENT:** Oxide-metal field effect emitters have the potential to satisfy future performance requirements of electron tubes. Manufacturing methods must be established to provide reproducible ingots of eutectic material in order to increase emitter production rates and yields.



APPENDIX

F

EXAMPLES OF MICOM  
EFFECTIVENESS REPORTS

EFFECTIVENESS REPORT  
(RCS DRCHT-303)

1. Project No. 3171 Subtask No. 0 2. Command MICOM  
 3. Funding FY's 1978 4. Title MM&T: Development of Automatic Monitoring and  
Control System for Wave Soldering Machines  
 5. Project Engineer Mr. Lloyd Woodham 6. AUTOVON 746-1572

7. Implementation Status (Check One):

IMPLEMENTATION

Previous Survey

- ☒ Implementation Completed  
☐ Implementation In-Process  
☒ Implementation Planned  
☐ Available for Implementation

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

NON-IMPLEMENTATION

- ☐ Effort Continued Under Another Project  
☐ Not Economically Feasible  
☐ Requirements Changed  
☐ Unsuccessful Project

8. Tech Transfer Media:

- ☒ Tech Report  
☐ Handbook Distribution  
☒ Technical Article Publication

- ☒ Technical Presentation  
☐ Government Demonstration  
☒ Government/Industry Demonstration

9. Tech Transfer Comment (When, Where, How):

See Attachment.

10. Implementation Comment: Implemented as standard wave soldering method at Westinghouse. Equipment is provided GFE for use on all defense contracts at Westinghouse, Baltimore, MD. Equipment and processes being refined for planned installation at Westinghouse, College Station, TX. Electrovert is using part of technology in redesign of ~~the~~ production model of wave soldering machine to be available in late 1982.

11. Status of This Implementation: ☒ Actual ☐ In-Process ☐ Planned ☐ Available

a. Implementation Method (Check One):

Government Facility

Contractors Facility

- ☐ Self-Implementing  
☐ Government Facilitization  
☐ Directive  
☐ Specification Change  
☐ Other Government Agency Initiative  
☐ Other (Specify Below)

- ☒ Self-Implementing  
☐ Contractural Language  
☐ Government Furnished Equipment  
☐ Contractor Initiative  
☐ Specification Change  
☐ Other (Specify Below)

## EFFECTIVENESS REPORT (Cont'd)

b. End Items/Components Supported: DIVADS, RPV, F-16, ALQ-130 and all future systemsc. Type Facility:        GOGO        GOCO   X   COCOd. Location (City & State): Baltimore, MD/College Station, TXe. Actual or Planned Implementation Date: 1980/when completedf. Government Facility or Contractor Name: Westinghouseg. Contract Number: Varioush. Implementation Cost: FYDP 0 MOB        i. Savings: FYDP (\$5,619K) MOB       

j. Manufacturing Processes, Techniques or Methods Supported by This Implementation:

Automated control of wave soldering PCBs, automated production of PCBs, and ECAM processes.

k. Benefits of Implementing MMT Results (Rank in order of significance, limit to three benefits):

<u>1</u> Cost Reduction	<u>2</u> Improved Product Quality/Reliability
<u>      </u> Standardization	<u>      </u> Improved Material
<u>      </u> Ability to Produce	<u>      </u> Sole Source Elimination
<u>      </u> Lead Time Reduction	<u>      </u> Energy Conservation
<u>      </u> Pollution Abatement	<u>      </u> Safety/Health Improvement
<u>      </u> Improved Readiness	<u>      </u> Improved Mfg Equip Reliability/Availability

TABLE 1

Savings Year	Annual Savings*		Discount Factor	Discounted Savings	
	FYDP	MOB		FYDP	MOB
	\$ K			\$ K	
1	1,100		0.954	1,049	
2	1,100		0.867	954	
3	1,100		0.788	867	
4	1,100		0.717	789	
5	1,100		0.652	717	
6	1,100		0.592	651	
7	1,100		0.538	592	
8			0.489		
9	(7,700)		0.445	(5,619)	
10			0.405		

Total Discounted Savings - (5,619K)\*\*  
Initial Savings Year - 19 81

\*If actual data is not available, provide estimated values (in parenthesis)

\*\* Estimate based on Westinghouse yearly production of 60,000 military PCBs at Baltimore, MD.

Government/industry demonstration at Westinghouse, Baltimore, MD,  
Sept. 80. Presentation at SME conference, Tampa, FL, Jan 81. Presentation  
at NEPCON, Feb 81. Presentation at Inter NEPCON, Brighton, England, Oct 81.  
Technical article published in NEPCON Proceedings, June 81; DARCOM T&I  
Quarterly, No. 7; and Manufacturing Technology Horizons, Jan/Feb 82. Final  
report distributed and demonstration film available.

EFFECTIVENESS REPORT  
(RCS DRGHT-303)

1. Project No. 3254 Subtask No. -- 2. Command MICOM  
 3. Funding FY's 1979-80 4. Title MM&T: Low Cost Semi-Flexible Thin Film Semiconductor  
 5. Project Engineer Mr. Bob Brown 6. AUTOVON 746-2147

7. Implementation Status (Check One):

IMPLEMENTATION

Previous Survey

- ☒ Implementation Completed  
☐ Implementation In-Process  
☐ Implementation Planned  
☐ Available for Implementation

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

NON-IMPLEMENTATION

- ☐ Effort Continued Under Another Project  
☐ Not Economically Feasible  
☐ Requirements Changed  
☐ Unsuccessful Project

8. Tech Transfer Media:

- |   |   |
|---|---|
| <input type="checkbox"/> Tech Report                              | <input type="checkbox"/> Technical Presentation                       |
| <input type="checkbox"/> Handbook Distribution                    | <input type="checkbox"/> Government Demonstration                     |
| <input checked="" type="checkbox"/> Technical Article Publication | <input checked="" type="checkbox"/> Government/Industry Demonstration |

9. Tech Transfer Comment (When, Where, How): Government/Industry demonstration at MEC, Auburn, AL, Aug 81. Technical article publication in Electronics, Aug 25, 1981. Technical report is in final preparation.

10. Implementation Comment:

Implemented as standard thin-film device production method at MEC. Refinement in processes and expansion of product line currently underway.

11. Status of This Implementation: ☒ Actual ☐ In-Process ☐ Planned ☐ Available

a. Implementation Method (Check One):

Government Facility

Contractors Facility

- ☐ Self-Implementing  
☐ Government Facilitization  
☐ Directive  
☐ Specification Change  
☐ Other Government Agency Initiative  
☐ Other (Specify Below)

- ☒ Self-Implementing  
☐ Contractural Language  
☐ Government Furnished Equipment  
☐ Contractor Initiative  
☐ Specification Change  
☐ Other (Specify Below)

## EFFECTIVENESS REPORT (Cont'd)

- b. End Items/Components Supported: Copperhead, US Air Force Active Fuse Development
- c. Type Facility:        GOGO        GOCO        X        COCO
- d. Location (City & State): Auburn, Alabama
- e. Actual or Planned Implementation Date: 1981
- f. Government Facility or Contractor Name: MEC
- g. Contract Number: Various
- h. Implementation Cost: FYDP        X        MOB
- i. Savings: FYDP (33,600) MOB
- j. Manufacturing Processes, Techniques or Methods Supported by This Implementation:  
Microelectronic circuit production, automated transistor production.
- k. Benefits of Implementing MMT Results (Rank in order of significance, limit to three benefits):

- |               |                            |               |  |
|---------------|----------------------------|---------------|--|
| <u>2</u>      | <u>Cost Reduction</u>      | <u>1</u>      | <u>Improved Product Quality/Reliability</u>        |
| <u>      </u> | <u>Standardization</u>     | <u>      </u> | <u>Improved Material</u>                           |
| <u>      </u> | <u>Ability to Produce</u>  | <u>      </u> | <u>Sole Source Elimination</u>                     |
| <u>      </u> | <u>Lead Time Reduction</u> | <u>      </u> | <u>Energy Conservation</u>                         |
| <u>      </u> | <u>Pollution Abatement</u> | <u>      </u> | <u>Safety/Health Improvement</u>                   |
| <u>      </u> | <u>Improved Readiness</u>  | <u>      </u> | <u>Improved Mfg Equip Reliability/Availability</u> |

TABLE 1

Savings Year	Annual Savings*		Discount Factor	Discounted Savings	
	FYDP	MOB		FYDP	MOB
1	7,000		0.954	6,678	
2	7,000		0.867	6,069	
3	7,000		0.788	5,516	
4	7,000		0.717	5,019	
5	7,000		0.652	4,564	
6	7,000		0.592	4,144	
7	3,000		0.538	1,614	
8			0.489		
9	(45,000)		0.445		
10			0.405	(33,600)	

Total Discounted Savings - (33,600)\*\*  
 Initial Savings Year - 19 82

\*If actual data is not available, provide estimated values (in parenthesis)

\*\*Estimate based on saving on Copperhead Missile System

APPENDIX

G

EXAMPLE OF MICOM SUMMARY  
FOR MTAG SUBCOMMITTEE HEARINGS

Prepared by: Joe Morgan  
Date: 18 Jan 82

3438 - Delidding Parallel Seam Sealed Hybrid Microelectronic Packages

Objective: The objective of this project was to develop cost-effective equipment and procedures for delidding of hybrid microelectronic packages.

Accomplishments: Three major accomplishments were achieved during the project. First, an industry-wide survey was conducted to determine package types and sealing techniques utilized for military hybrid circuits and to assess cost savings which could be realized by delidding and resealing techniques. The second major accomplishment was in the identification, modification and installation of equipment in order to establish methods for delidding hybrid circuits in a production environment. Finally, operating procedures and process specifications were developed which provide for optimum delidding results.

The industrial survey indicated that a majority of military hybrid circuits use either a butterfly or bathtub type package which is weld sealed. Modifications were made on an existing butterfly delidding machine to permit delidding of bathtub type packages. Other improvements in equipment design provided for increased thermal stability and reliability. The modified equipment also produced a cleaner, more accurate cut.

The techniques developed as part of this project focused on particle control and essentially eliminated contamination of hybrid substrate. The package is placed face down in the cutting operation so that particle contamination is confined to the hybrid lid and not the substrate. A vacuum hose is located in close proximity to the blade for particle removal and the package is clamped so that the lid is always in contact with the body of the package. The highly accurate depth adjustment permits cutting to point just short of breakthrough. The lid can then be easily removed by hand for rework or may



be left attached for protection in subsequent handling and shipping processes.

Rules of thumb for adjustment of operating parameters have been developed based on package parameters. Specific settings for a standard hybrid package are also available. Parameter adjustments provides for the minimum cycle time and therefore maximizes throughput.

Statistical testing of operating characteristics of a military hybrid circuit were performed. Performance of packages which were delidded and resealed was equal to that of a controlled group of packages which were manufactured using normal procedures. No degradation in overall yield was observed.

Benefits: The major benefits of this program were in the overall improvement of equipment and procedures which permit economical delidding of military hybrid packages. The machine manufacturer has incorporated all recommended modifications into an improved delidding machine. More than ten hybrid manufacturing companies have purchased the modified machine.

The delidding/rework/resealing procedure is more cost effective than either repackaging or reproducing processes. A considerable savings in material costs and labor are achieved. By placing this technology on the production floor, the capability to meet schedule deadlines is also enhanced.

The contractor is currently utilizing the new methods and equipment on several US Air Force contracts. He is in the process of initiating action to revise MIL-M-38510 to permit delidding of hybrid circuits by the methods developed under this contract. The contractor is also standardizing all new hybrid production, as to package type and bonding, to be compatible with the improved delidding processes.

Conservative estimates resulting from the initial industry survey indicate

cost savings on DoD contracts could be in the tens of millions of dollars yearly when the technology is fully implemented. Another area where this technology may produce recognizable benefits is in the production of medical equipment such as in implanted biomedical devices.

A final report describing the work performed under this project will be available soon.

**Persons Interviewed:**

MICOM - B. Austin  
P. Wanko

**WESTINGHOUSE**

Wyatt Luce  
(301) 765-2828

## APPENDIX

## H

EXAMPLE OF POTENTIAL MICOM

MMT PROJECT EVALUATION

## Laser Soldering of Printed Wiring Boards

**NEED:** A recognized deficiency in conventional PWB soldering techniques currently exists stemming from such factors as 1) thermal limits of board and component materials, and 2) increased circuit densities required to meet weight and speed requirements of military projects. To overcome these inherent limitations, new or improved processes to provide reliable soldering of surface-mounted components to PWBs need to be developed.

**SUITABILITY OF APPROACH:** Several factors detract from the proposed solution. First, is the anticipated problems in accurately defining the laser positioning requirements to account for variations in parameters such as circuit board height which have been encountered in other attempts at laser soldering. Next is the capability of accounting for variations in brilliance of component leads which will affect the reflectivity of the laser beam. Resolving these two factors may be possible, but may also be at the expense of throughput. The question of throughput capabilities for small-lot quantities indicative of military requirements raises some doubt as to the suitability of the proposed approach. Finally, the development efforts of a recent Navy MM&T project in the area of

vapor phase soldering techniques indicate that it is a more optimal approach to resolving current process deficiencies for surface mounted components.

**TECHNICAL RISK:** The technical risk is assessed to be medium to high based on the results of past efforts in this area and the technical difficulties which must be overcome.

**IMPLEMENTATION RISK:** Even if the project provides a technically acceptable process, the risk of other manufacturers implementing the results is considered high due to the progress which has been achieved in vapor phase soldering processes. This later technology is more in line and compatible with conventional processes.

**SUITABILITY AS MM&T PROJECT:** This project is considered highly suitable for the MM&T program, in that it would result in a new methodology for soldering surface mounted PWB devices. Advancements in automated control of soldering processes are also an important area for MM&T project in order to improve product quality and reliability.

**RELATED EFFORTS:** MICOM has performed some work in the area of laser soldering without too much success. A Dr. Wanake from a

California-based company, believed to be Applied Physics, has developed a laser soldering system which utilized a 1 Watt laser, but it is very limited as far as capability and performance.

Westinghouse is also involved in using a laser in conjunction with a robot for soldering surface mounted components as part of an Air Force Tech Mod project. A project which utilized vapor phase soldering techniques for surface mounted components has recently been completed by the Navy.

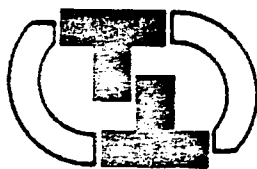
**BENEFIT TO COST:** Improvements in PWB soldering techniques which increase reliability characteristically demonstrate high benefit-to-cost ratios based on the generic nature of the technology to all Army electronic systems and the applicability throughout the military and commercial environments.

**OVERALL PRIORITY:** The overall priority of this project should be considered as medium based on the work which has recently been accomplished in vapor phase technology. If this technology demonstrates deficiencies which can be overcome by implementing laser techniques, then the priority of the project should be upgraded to high.

APPENDIX

I

FINAL LETTER FROM  
INTERSHIP SUPERVISOR



# TECH TRAN CORPORATION

134 NORTH WASHINGTON STREET, NAPERVILLE, ILLINOIS 60540 (312) 369-9232

September 7, 1982

Dr. Robert E. Young  
College of Engineering  
Department of Industrial Engineering  
Texas A&M University  
College Station, Texas 77843

Subject: Joseph A. Morgan's Doctor of Engineering Internship

Dear Dr. Young:

As you know, Joe conducted his internship at Tech Tran Corporation from September 8, 1981 to April 30, 1982. During that period, he served as an Associate Engineer with the firm and worked on several assignments under my direct supervision. In my opinion, Joe has successfully fulfilled the objectives of his internship.

During his employment at Tech Tran, Joe worked on three major assignments. First, he participated in a project Tech Tran had with the U.S. Army Electronics R&D Command to develop a project engineer's handbook for procuring manufacturing technology developments. During the project, Joe played a major role in defining the content of the handbook, interviewing project engineers, collecting secondary data, analyzing information and preparing interim presentations and final text. The client is now using this handbook on a routine basis at three laboratories.

Secondly, Joe worked on a major project Tech Tran undertook for the U.S. Army Missile Command. His primary role in the project was the investigation and documentation of a number of manufacturing technology developments funded by the sponsor, particularly in the area of microelectronics production processes and equipment.

Lastly, Joe also served as an Associate Editor for Tech Tran's Manufacturing Technology Horizons, a bi-monthly digest on new production technology. As an Associate Editor, he investigated innovative developments in production processes and equipment and drafted summaries for publication in the digest.

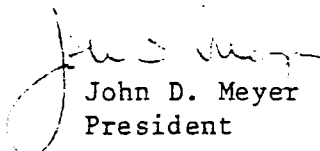


Dr. Young  
September 7, 1982  
Page 2

Collectively, I believe these assignments have given Joe the opportunity to experience some of the more pragmatic aspects of being a consulting engineer. In addition to being exposed to a variety of technologies, he was also able to involve himself in a number of real-world issues and methodologies relating to project planning, information collection and analysis, communication skills, client interaction, project management and performance under constrained resources. The contrast provided by the environment of a small firm, as compared to a large, highly structured organization, should have also provided Joe with insights which will be valuable during his career development.

Again, I believe Joe has successfully fulfilled the requirements of the internship program as demonstrated by his performance at Tech Tran. I look forward to receiving a copy of his internship report and, if possible, serving on his graduate committee during his oral examination.

Sincerely,



John D. Meyer  
President

JDM:cmk

cc: LTC Kitch  
J. Morgan

## Vita

Joseph Alan Morgan  
1203 Village Drive  
College Station, Texas 77840

Birthplace: Akron, Ohio

Birthdate: April 19, 1947

Parents: Edward J. and Juanita G. Morgan

Family: Married with two children

Education: B.S., Electrical Engineering  
California State University, 1975

M.S., Industrial Engineering  
Texas A&M University, 1980

Experience: August 1979 - Present  
Graduate Research Assistant  
Texas A&M University

September 1981 - April 1982  
Engineer (Doctor of Engineering)  
Tech Tran Corporation  
Naperville, Illinois

June 1975 - July 1979  
Test & Evaluation Officer  
4754 Radar Evaluation Squadron  
Hill AFB, Utah

August 1965 - May 1975  
Electronic Technician  
U.S. Air Force

The typist for this report was Donna J. Morgan