MEASURING AND IMPROVING PROGRAMMER PRODUCTIVITY at PHILLIPS PETROLEUM COMPANY

By
ROSEANN KAREN KUBICEK
Bachelor of Science
University of Oklahoma
Norman, Oklahoma
1965

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Name: Roseann Karen Kubicek

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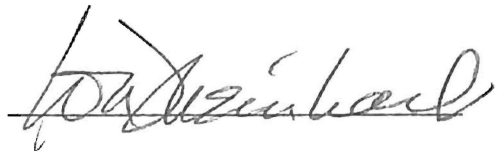
This paper is a case study of the Commercial Systems Development Division of Phillips Petroleum Company. It traces changes in the organization from 1980 - 1984 and analyzes the changes based on a theoretical foundation. Methods of measuring programmer productivity are described and project data is analyzed.

Findings and Conclusions:

After analyzing the changes made in the organization, it appears that the right decisions were made. Future changes in the organization should consider all the factors outlined in the paper, Growth Need Strength, Social Need Strength, Motivating Potential, Techniques, Tools, and Training.

ADVISER'S APPROVAL 

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Report Approved:

Adviser

Director of Graduate Studies

Head, Department of Management

PREFACE

This paper is directed at the managers and supervisors of data processing professionals. It hopefully presents a clear picture of how a data processing organization should be organized in order to increase programmer productivity. Additionally, methods to measure programmer productivity are described and the results of analysis of project data are presented.

My thanks to Dr. Wayne A. Meinhart for his patience and guidance throughout the term of this paper. I also want to express my thanks to Phillips Petroleum Company for their Educational Assistance Plan which reimburses for education expenses. Additionaly, thanks to my husband, Don, and my daughter, Karen for their encouragement and support.

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CHAPTER I

INTRODUCTION

The data processing (DP) industry, less than thirty years old, has a number of problems nationwide. Some of these problems include low productivity, high turnover, absenteeism, low company loyalty, low morale, high salaries and DP costs, shortages of qualified people, and a low level of motivation. Phillips Petroleum Company's Information Services (IS) Organization is not immune to these problems. In the last five years, 1980-1984, the total data processing costs increased 53%, while the total number of DP employees remained almost constant.

The Commercial Systems Development (CSD) Division, one of six IS divisions, provides maintenance, enhancement and development data processing services for all Staff Organizations including Comptrollers, Tax, Treasury, Human Resources, and Corporate Services. In addition, CSD provides development services for the four major Operating Groups. Maintenance and enhancement data processing services for the four Operating Groups are provided by data processing professionals in the Operating Groups.

This paper will outline changes that have been implemented during the last five years that have increased the productivity of the Commercial Systems Development Division. Additional changes will be suggested to improve and measure productivity in the future. In order for CSD to attract, train, retain, and motivate high quality data processing professionals (analysts and programmers), the work environment must be structured to meet the needs and characteristics of this group. As a supervisor in CSD, I share the responsibility with other CSD supervisors and managers for developing and implementing positive changes in our work environment.

The goal of this paper is to study and document factors that motivate data processing professionals and to describe methods to measure programmer productivity. By doing the research and writing this paper, I expect to have a better understanding of motivation factors and productivity measurement.

CHAPTER II

SURVEY OF THE LITERATURE

There is a limited number of industry recognized experts in the field of motivating and managing data processing professionals and in measuring programmer productivity. These experts have written and published a limited number of books and articles on the subject. Articles have been published in journals such as MIS Quarterly, Data Management, Harvard Business Review, and Journal of Applied Psycholoby. Four of the most widely accepted authors, J. D. Cougar, R. A. Zawacki, R. L. Nolan, and G. Parikh, are referenced in this paper. Even though some books and articles have been published, there is not a large amount of research available.

In addition to writing books and articles on the subject, the recognized experts offer consulting services to data processing organizations. Phillips Petroleum Company has used R. L. Nolan's firm Nolan and Norton. Video tapes by the experts are also available and have been ordered by Phillips for the use of the data processing personnel.

Phillips Petroleum Company participates in the American Petroleum Institutes Subcommittee on Systems and Programmer Productivity. The member companies share information at the subcommittee meetings.

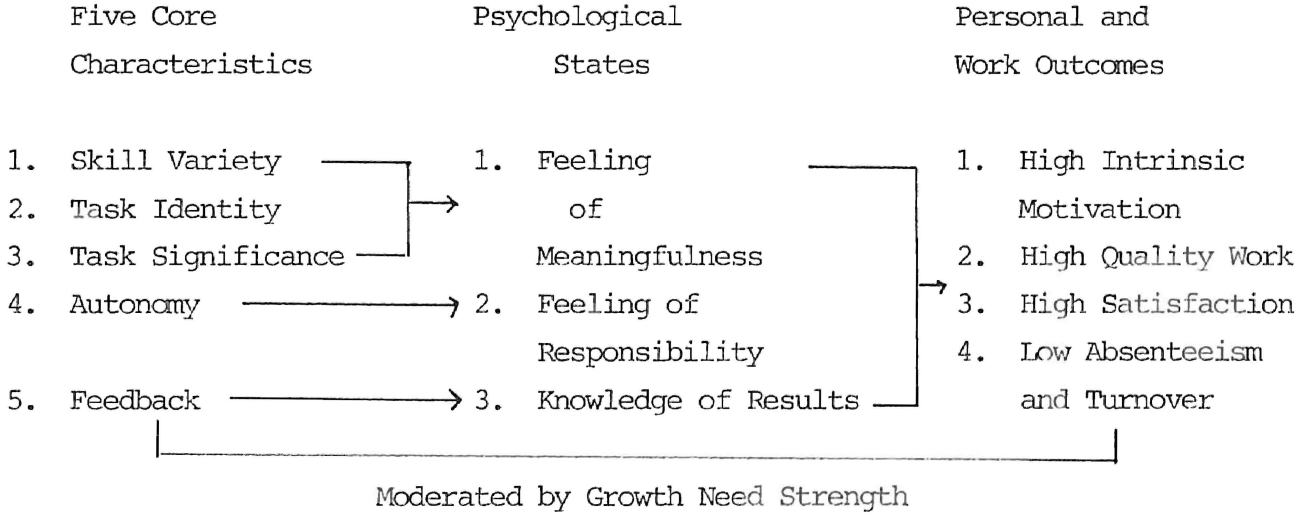
Material from all the above sources as well as from colleagues at Phillips Petroleum Company was used in writing this paper.

CHAPTER III

THEORETICAL FOUNDATION

Some of the unique needs and characteristics of the data processing professionals have been outlined by Daniel Couger and Robert Zawacki in their book Motivating and Managing Computer Personnel.[1] Over one thousand data processing professionals were surveyed in a nationwide study. The survey instrument was the Job Diagnostic Survey developed by Hackman and Oldham. The Job Diagnostic Survey is designed to measure the five core characteristics, the three psychological states, and the moderating variable as defined in Job Characteristics Theory.

The Job Characteristic Theory Model is as follows.[2]



A short definition of the variables in the model are listed below:[1,2]

Skill Variety - The degree to which a job requires a variety of different activities in carrying out the work. The activities involve the use of a number of different skills and talents of the employee.

Task Identity - The degree to which the job requires the completion of an identifiable piece of work, doing a job from start to finish.

Task Significance - The degree to which the job has a substantial impact on the lives or work of other people.

Autonomy - The degree to which the job provides freedom and independence to an employee in scheduling and doing the work.

Feedback - The degree to which the employee receives information about his or her performance effectiveness from the job, supervisors and/or co-workers.

Feeling of Meaningfulness - The degree to which the employee experiences the job to be valuable, worthwhile, and important.

Feeling of Responsibility - The degree to which the employee feels accountable and responsible for the results of his or her efforts.

Knowledge of Results - The degree to which the employee knows and understands how effective he or she is performing the job.

Growth Need Strength - The degree to which an employee has a desire to obtain growth satisfaction from his or her work.

Motivating Potential Score. A score indicating the potential of a job to motivate an employee with a high growth need.

$$\text{Motivating Potential Score (MPS)} = \frac{\text{Skill Variety} + \text{Task Identity} + \text{Task Significance}}{3} \times \text{Autonomy} \times \text{Feedback}$$

For their study, Cougar and Zawacki expanded the Job Diagnostic Survey to include other variables including goal clarity, difficulty, acceptance, participation and feedback on goal accomplishment; informal dimensions; measures of satisfaction, general, co-worker, supervisor, and pay; growth strength, need for achievement, and existence need strength; computer problem dimensions; individual recognition; and compensation dimensions. The social need strength is the degree to which an employee wants to interact and socialize with other employees, both on and off the job.

The results of the study indicates that there are some unique differences between the data processing professional and the general population. The data processing professionals have substantially higher Growth Need Strengths (GNS)

than other job categories. The data processing professional has a significantly lower Social Need Strength (SNS) than other professionals. In general, the Motivating Potential Scores (MPS) were high indicating that the data processing jobs and profession provide an opportunity for the growth needed.

In his book, Programmer Productivity,[3] Girish Parikh says that, "The key to improving programmer productivity is in the three T's: "techniques, tools, and training." There are techniques for both programmers and for managers. The programming techniques are better ways of performing the job and making the most of software tools available and the most of time. The managerial techniques include developing standards and guidelines, evaluating programmer performance and motivating programmers. Tools are the second "T" for improving productivity. There are many software tools available. There must be adequate information on how to use the tools. Data processing is a rapidly changing field. It is extremely important for programmers to be trained to use the new tools and techniques, as well as to improve the skills they already have. It is equally important for the DP managers to have training.

CHAPTER IV

ANALYSIS OF PRODUCTIVITY INFLUENCERS

Many changes have been made by Information Services and Commercial Systems Development Division management in the last five years, 1980-1984. Although the changes may have been made for a variety of organizational and environmental reasons, when the changes are analyzed based on the theoretical foundation presented in the previous chapter, it appears that the right decisions have been made. In the following sections, the changes made in each category, Growth Need Strength, Social Need Strength, Motivation Potential Scores, and on the three T's, Techniques, Tools, and Training will be outlined.

Growth Need Strength

Because of their high Growth Need Strength, data processing professionals must have every opportunity to grow in their job setting if the company and the employees are to have maximum results. As stated by Thomas Peters and Robert Waterman in their book, In Search of Excellence,[4] the single attribute that uniquely characterizes America's best run companies is their focus on motivation and development of their people. Peters and Waterman go on to say that "the manager's job is to keep the bureaucrats out of the way of the productive people". Following are several improvements that have been made in the Commercial Systems Development Division that take advantage of the Growth Need Strength of the data processing professionals:

- Reduced Bureaucratic Paperwork
- Simplified Operating Procedures
- Improved the Physical Environment
- Provided an Active Training Program
- Implemented a DP Human Resource Management Program.

Reduced Bureaucratic Paperwork

The number of reports required of the unit supervisors and project leaders has increased as Information Services has grown from a small computing organization

of fewer than 100 employees in 1960 to an organization of over 1000 in 1984. The unit supervisors and project leaders lead units and project teams of six to twelve people. In the past, they were required to prepare many different reports every month. The reports were evaluated as to their usefulness and need. Currently only four monthly reports are required. They are the report of major activities and accomplishments during the month, the projections of next month's activities, the staffing report which lists the assignments, their duration, and time required of each programmer/analyst, and the project staffing report which lists all members of the project team, their role, their time required, and the duration of the assignment.

Much of the information and data required in the reports is in the automated project/resource tracking system, PC/70. An automated reporting system has been developed to extract some of the information and data from the PC/70 System and to reformat it to produce some of the four reports. There are plans to expand the automated reporting system to produce additional parts of the required reports. The plans include having the reports transmitted electronically to the recipients rather than printing and routing paper reports. The reporting system has many special reports available from a selection menu that can be used by managers, supervisors, project leaders, and team members. Some of these reports include active projects, completed projects, projects by customer, and projects by individual programmer. Additionally, the reporting system is flexible so that future reporting requirements can be added.

Simplify Operating Procedures

Just as the number of required reports had grown, the number of required procedures had also grown. Many of the procedures started out as a means to standardize work, to provide separation of function, and to insure adequate security. Some of the procedures have been perceived by many programmer/analysts to be productivity inhibitors.

Under the leadership of the CSD Division manager, who was named the manager in 1982, many of the procedures have been studied by specially appointed task

forces. The task forces have made recommendations that have been implemented to reduce some of procedures. The task forces have been comprised of the analyst/programmers who are working with the procedures daily instead of being comprised of supervisors or individuals from Management Services who are not DP professionals.

One task force studied the Resource Access Control Facility (RACF) security procedures. Programmer/analysts can experience a delay of one hour to one day in responding to problems with production jobs if they don't have access to the data files used in production. The Security Administrator strongly recommends that programmers not have access to data files. Our CSD management supports the programmers having read, but not update, access to the major files in the applications for which they have responsibility. The task force made four broad recommendations for improvements in the training, procedures, reporting, and in the RACF software. Many of the recommendations have been implemented and others are in process or are scheduled. The CSD Division manager has asked the Security Group for a status periodically so they are aware of his interest and support in streamlining the procedures.

Another task force studied the Production Certification process required to install new jobs in production and to make changes to jobs already in production. It had taken from five to fifteen working days to install new or changed jobs in production. The task force composed of programmers, production services, and security personnel studied the procedures and recommended improvements so that jobs can now be installed in one to three days. The time required was reduced partially by giving the unit supervisor the authority to approve and sign off on many types of changes that previously required the approval of the Quality Control group.

Another task force was appointed to review the Documentation Library requirements. Many items of documentation on all programs and jobs were required to be in the secured Documentation Library. Many programmers kept a duplicate set of documentation at their desk so it would be easily available instead of checking the documentation out of the library. The task force's

recommendation of keeping a minimum amount of documentation in the Library has been implemented. All other documentation is kept at the programmer's desk. A follow-on task force is now looking at completely eliminating the documentation library in the near future because the items that are currently filed there are also stored electronically.

In addition to the specially appointed task forces, there are five Participative Action Teams (PAT) that study and recommend ways to improve the CSD environment. The PAT Teams are based on the Theory Z participative management philosophy.

Improve Physical Environment

The majority of the CSD data processing professionals are located in the seven year old Information Center (IC). Each programmer/analyst has an individual cubicle with an L-shaped desk, two hanging bins, and a file cabinet. When DP professionals were first in the IC building, the computer terminals were located in pool areas. There was one terminal for every two programmers. This resulted in having to wait for a terminal some of the time. Also, it was not convenient because the programmers often left something at their desk that they needed at the terminal. In the last two years, terminals have been installed on every programmer's desk. Also, the furniture has been rearranged in some cubicles to give more floor space and to match the programmer's arrangement preference. Improvements can still be made. The older style terminals are being replaced by newer smaller models designed with ergonomics in mind. These new models have tilt adjustments that are more convenient for people of all heights to use. As terminal tables are available, they should be moved to the cubicles so the terminals can be placed on them rather than on the desk. This gives extra desk space that many programmers want.

Provide an Active Training Program

In the rapidly changing data processing industry, it is necessary for professionals to keep up with technology by on-the-job training, self study, and formal classroom instruction. On the average, ten working days, (eighty hours), of training is scheduled for each employee per year. The actual

training scheduled is determined by the employee with his or her immediate supervisor. Several factors including skill levels, current assignments, and future assignments wanted and available are considered in scheduling the training for each individual.

There are several options for receiving training including self study video courses, terminal based instruction courses, in-house taught courses, Human Resource taught classes and outside vendor courses. A comprehensive course catalog describing each course, the audience, the skills addressed and other pertinent information has been developed and is available to all programmers. The catalog is updated as courses are changed, added, or deleted.

Also, an automated system to schedule and track the training has been developed and installed. The training plans for each individual are loaded in the system. The plans include the course and the month the course is needed. The Training Section then schedules the classes, arranges for instructors, reserves rooms, and orders the class materials needed. Notices are sent to the student and to his or her supervisor when the classes are scheduled. Additionally a training status report is produced monthly and sent to all supervisors for each person in their unit. The training plans can be revised at any time during the year as needs change. A training inventory report, showing all training each person has received since their employment, is also produced and distributed to each person and to their immediate supervisor.

Implement a DP Human Resource Management (DPHRM) Program

As outlined by Richard L. Nolan in his book, Managing the Data Resource Function,[5] there are four components of a DPHRM program; training, human resource planning, professional development, and performance management. The training component was discussed in the previous section. The performance management component is well developed through the company wide Work Planning/Performance Review (WPPR) process. Each employee, working with his or her supervisor establishes work plans and objectives. The accomplishments are reviewed periodically during the year. The human resource planning component is also well developed by the Human Resources Staff. Since performance

management and human resource planning are not unique to the DP professional, they will not be discussed in more detail in this paper.

A professional development component has been developed specifically for the DP professionals in the Data Processing Human Resource Management program. The program provides criteria for assessing the skill levels of each person in the DP job positions; entry-level programmers/analyst, junior programmer/analyst, programmer/analyst, senior programmer/analyst, and system specialist. The assessment of an employee's level on eleven skills is done jointly by the employee and his or her immediate supervisor. The employee's skill level is then compared to the standard for that skill in their job grade. If a discrepancy exists, then a decision can be made as to what kind of training and/or assignments can be made to bring the skill level up to standard.

If training is the answer, a training plan is developed and loaded into the training system as described earlier. If an assignment is the answer, the immediate supervisor schedules the assignment for the individual.

The second portion of the DPHRM program is career planning. Opportunities for DP professionals in each of the six IS Divisions as well as in the Group Organization have been identified. Charts showing possible moves for each job position have been developed and are used during employee/supervisor discussions. The employee's career goals and moves the employee is interested in are documented and entered in an automated-system. Additionally, specific knowledge areas are documented. When there are openings for DP professionals in a specific area, a list of people that have previously said they are interested in that area is produced from the automated system. This is one way candidates for different jobs, both lateral moves and promotions, are identified.

Social Need Strength

Since data processing professionals have low social need strength, special programs must be developed to insure adequate communication between co-workers and supervisors in CSD and with the end users in the Staff Organizations and Operating Groups for which computing services are provided. This need for communication skills has already been recognized by Information Services management and several programs are already in place to address this problem. Following is a short description of some formal classroom courses.

- Technical Report Writing - especially designed for data processing report and project requirements.
- Oral Presentations Workshop - a class to develop oral presentation skills using video playback.
- Effective Presentations - includes information about preparing transparencies and other visual aids.
- Effective DP Communications - a class taught by an outside vendor that highlights different communication styles.
- Advanced DP Communications - a continuation of the above course with more emphasis on oral presentations.
- Conducting Effective Meetings - a new course that stresses the responsibilities of all participants in meetings.

Specialized courses for supervisors and project leaders are also available and include Project Management, Leadership Effectiveness, and Performance Counseling. In addition video courses including Put It In Writing, Face to Face Communications, and How to Run Productive Meetings are available. Communication skills, both oral and written, are assessed in the DPHRM program and classes to address training needs are scheduled.

There are additional things being done to improve communications within the organization. (See organization chart, Appendix I). Unit and project meetings are scheduled on a regular basis to keep everyone informed of the current status of work assignments and projects. The Section, Branch and Division

Managers schedule meetings with their employees in order to communicate short and long range plans and to answer questions. In a more informal mode, unit and section social gatherings are scheduled. I have a Christmas luncheon for all employees in my section and a summer picnic for all employees and their families.

Motivating Potential Scores

In order for data processing professionals to regard their job as providing them with a growth they need, the jobs must be designed and work assignments made to include the five core characteristics outlined in the Job Characteristics Theory Model[2]. Specific actions have been taken and recommendations for each characteristic follow:

Skill Variety - A major CSD reorganization occurred in November 1982. From 1978 till then, CSD had been organized in two Branches, Systems Analysis (SA) and Systems Implementation (SI). The SA branch was responsible for the analysis tasks on major projects. The SI branch was responsible for the programming tasks on the projects. After the reorganization, the SA and SI branches were combined and CSD was organized to correspond to the Groups and Staff Organizations for which we provide DP services. So instead of having employees who work primarily as analysts or primarily as programmers, the roles have been combined and assignments are made to individuals that require both analysis and programming skills. Additionally, assignments are made that require the use of new technologies, such as online systems, telecommunications, and personal computers.

Task Identity - Instead of assigning a large project team of eight to ten to work on one large project, which was done prior to November 1982, projects have been structured to be a series of smaller incremental projects that can be assigned to a project team of two to three people. There are advantages to this technique in addition to a person doing a job from start to finish. A series of small projects are easier to plan, estimate, staff,

schedule, and complete. The end user is more satisfied as new capabilities are installed incrementally rather than waiting for the total system to be installed at a future date.

Task Significance - Communication by supervisors and project leaders is extremely important for the employee to see the importance of the work they are doing. As mentioned earlier, regular unit and project meetings are scheduled as a means to show each employee how his or her assignments fit into the overall project work. Additionally, the analyst/programmers work directly with the end user of his or her programming product to see how it fits into the overall business of the company. They are encouraged to learn the business of the end user so they will be in a better position to recommend enhancements that will improve the operating efficiency of the computer systems.

Autonomy - By restructuring a large project to be a series of small incremental projects, more autonomy and responsibility can be given to each employee. As mentioned earlier, operating procedures have been simplified as a result of task force recommendations. Peters[4] pointed out that management should not hold employees on so short a run that they cannot be creative. Controls have been relaxed, where appropriate, while employees are held accountable for results. In my section, each primary programmer tracks the actuals against the budgets for their systems. They work with the end users to set the next year's budgets for the systems.

Feedback - There is a great deal of feedback from a programming job itself. By analyzing, designing, coding, testing, and debugging a program to run successfully, an employee has a sense of accomplishment. There is also feedback from co-workers and supervisors. A quality work program whereby peers review a person's work by "walkthroughs" has been implemented. This is a technique suggested by experts such as Yourdon[6]. Feedback has also increased as emphasis has been placed on communication, leadership, and counseling skills as described earlier. The DPHRM and WPPR programs both provide a formalized forum for feedback on performance.

Techniques

Many new techniques have been installed in CSD since the reorganization in 1982. Three major programs, Project Management Strategies, Project Management Assessment, and the Quality Incentive Program will be outlined.[7]

Project Management Strategies

Prior to 1982, the emphasis was on large projects composed of five phases in the project life cycle as follows:

- Project Initiation - defining and documenting the scope of the project and benefits, estimating the time and cost of project and securing approval for the project to continue.
- System Requirements Definition - gathering and documenting information about the functions the application system must include.
- Functional Design - defining the system model, inputs, outputs, and reports.
- System Architecture and Development - designing in detail the reports, screens, inputs, outputs, controls, and the database is done during architecture. Designing and developing the programs, testing, and implementation planning are done during development.
- System Installation - activities in this phase include the system test, operation turnover, user training, start up and system acceptance, and project wrap up.

The strategy used to manage the large projects was linear. All phases were done as a part of one large, monolithic project. Instead of using only one management strategy, a contingency approach to project management is recommended, using the strategy or combination of strategies that most effectively deal with the varying project characteristics. The choice of the appropriate management strategy can increase the probability of a project being successful. Using the wrong strategy can increase the risk. Five strategies, feasibility, linear, incremental, design/construction, and evolutionary, are currently being used to manage projects. Recommended uses of the five strategies follow:

- Feasibility. If project initiation is going to take longer than two weeks or if the problem is complex and not well understood by the requester or by the project team, a feasibility project can be funded.

This allows for a realistic determination of project risk and for the definition of the scope and objectives of one or more development project.

. Linear. This strategy represents the traditional approach to project management used by most DP organizations. All phases of the project and the entire scope of the project are addressed as a single project. This approach appears to be best suited to projects that are small, highly structured, have a cooperative user, and for which there is no urgency for implementation.

. Incremental - This strategy defines a family of related projects which provide user capabilities at defined intervals. Assuming that business functions are properly defined, segregated and prioritized, this strategy can be effective in dealing with large projects that have low structure, when the project has some degree of urgency, when the environment is changeable or unstructured, or when the requirements are ambiguous at the detailed level.

. Design/Construction. This strategy involves separating the linear life cycle into two major parts - a design project and one or more construction projects. This approach appears to be best suited to projects that are large, when the environment is changeable or unstructured, when the requirements are ambiguous, when there is no pressing urgency for implementation, and when there is a cooperative user.

. Evolutionary. This strategy builds and installs a prototype or model system as quickly as possible. The system is then refined and modified to meet the users needs. This approach appears to be best suited for projects when urgency exists, when the requirements are vague, undefined, or continually changing, and when the system is innovative. This strategy uses prototyping which corresponds to the "do it, fix it, try it orientation toward action instead of the analyzing it, debating it, complicating it" described in In Search of Excellence[4].

The next two programs are used to ensure project success. There are three criteria that we try to meet on all projects; produce a quality product that satisfies the customer's requirements, complete the project on time, and complete the project within budget. Using the appropriate management strategy and the Project Management Assessment Program helps complete a project on time and within budget and the Quality Incentive program helps produce a quality product that satisfies the customers requirements.

Project Management Assessment Program

The overall objective of the Project Management Assessment Program is to provide information to the project team that will ensure project success. The reviewers are experienced project leaders that possess consulting and project management skills. There are four formal types of reviews.

- The Initial Plan review occurs after the Initiation Phase is completed and the User Requirements Phase has begun.
- A Progress Review can occur at any time. It could be a follow-up review resulting from a prior review.
- A Completion Review occurs four to six weeks prior to the end of a phase.
- A Special Review can occur at any time. This review concentrates on a specific deliverable such as a phase plan or management strategy approach.

A review normally takes two weeks. First the reviewer talks to the project leader to get the information that will be analyzed. This information includes items such as the project plan including any PERT networks, Gantt charts, schedules, project objectives, assumptions and management strategy. Also estimating worksheets, risk analysis, phase deliverables, project status reports, funding and change control forms and project correspondence are reviewed.

After the reviewer analyzes the information, he or she sets up interviews with the project leader, lead programmer, project team members, and key users. After the interviews are completed, the reviewer prepares a Review Report. The

report contains a brief summary of the project scope, a brief summary of the current status of the project, and any recommendations for the project team.

In addition to the formal reviews which are scheduled by a supervisor or project leader, any analyst/programmer can request an informal review. An informal review can review any aspect of a project. The review can be used as on-the-job training.

Quality Incentive (QI) Program

The objective of the QI program is to help ensure that a quality product that satisfies the customer's requirements is produced. The program is built on the philosophy that the supervisor is responsible for the quality of the product and of the service to the customer, and that all involved personnel are responsible for evolving the producing environments capacity to produce quality products. Prior to the major reorganization in 1982, there was a separate Quality Control group that reviewed all programs and jobs. They had the authority to approve or reject any program or job. With the introduction of the QI program the function of this group was changed from one of control to auditing. The authority to approve or reject programs and jobs was given to the unit supervisor and the producing professionals.

The Quality Incentive program is a series of "structured walkthroughs"[6] scheduled at various times during the project. The reviews may be a formal meeting, an informal individual review at one's desk, or waived if there is not a justifiable reason for having the review. The reviewers are other analyst/programmers, peers of the producer. This process in addition to helping produce a quality product, also plays an important part in training and personnel development. Other benefits include producing better documentation and providing a means to introduce new techniques, tools, approaches, ideas, and expertise into a unit. An additional advantage is that a review gives another opportunity to locate and define errors, omissions, and inconsistencies in a set of deliverables.

Tools

There are many tools available to the analyst/programmers at Phillips Petroleum Company. As new tools are available in the DP industry, individuals are assigned to evaluate the tools and to make recommendations as to their usefulness in CSD. A comprehensive Tools Catalog has been developed and is available to every DP professional both in hardcopy and by inquiry on their terminals. Additional, a monthly Technical Representatives meeting is held. The use of tools, as well as other information on hardware and software, is discussed at these meetings. A representative from each unit attends and reports back to all members of their units in unit meetings. Additionally, minutes of the meetings are printed and distributed to each analyst/programmer. The minutes are also available by inquiry on the terminals.

A current project, the development of an automated analyst/programmer workbench[8], is an effort to tie the tools available together on the programmer's terminal and to help define what additional tools are needed. The basic philosophy of the workbench is to automate functions, not just to provide tools. The high-level programming functions that are to be automated are:

- develop a module
- conduct integration testing
- conduct system testing
- put a job in production
- maintain a module

These functions are the most common ones performed by the analyst/programmers. When a function is automated, not only the technical steps, but also the procedural or administrative steps associated with the function will be automated.

Another aspect of the workbench is to continue to eliminate as much paper as possible. This is not just "electronic mail" in the sense of just sending memos back and forth. As many things as possible will be developed online and will be kept online instead of printing them on paper. This aspect is already

being accomplished in respect to documentation that previously was filed in the Documentation Library but is now stored online. As previously mentioned under the task forces, the library is being eliminated. The documentation required for the QI reviews is now created online and transmitted to the reviewers for their review instead of sending them paper copies.

There are many benefits from using a workbench. Primarily it is more productive because the tools needed to perform the analyst/programmer's job are immediately available on their terminals. Other benefits include simplifying the training of new hires, easier introduction of new tools by incorporating them in the appropriate functions and a significant reduction in paper handling and storage.

Training

Training is the third "T" identified by Girish Parikh[3]. Since both the development of an active training program and the implementation of a DP human resource management program were described in the Growth Need Strength Section, they will not be described again here.

CHAPTER V

MEASURING PRODUCTIVITY

There is no easy way to measure productivity. Productivity, as it applies to the application development and maintenance environment, might best be defined as "producing and maintaining better applications at a declining cost"[9]. Another measurement of productivity defined by Mr. Albrecht of IBM is expressed as a ratio of value divided by cost. To increase the value of that ratio, the quality of systems must increase more than the cost of producing those systems increases, or system quality (value) must decline at a slower rate than the cost of maintaining them, or finally, the most probable indication of increased productivity, quality increase and costs decline.

Mr. L. T. Herrmann of Shell Oil Co. in a paper entitled "Productivity and Performance Measurement in Systems Development"[10] described many of the problems we have experienced in measuring productivity. Three items, quantity, cost, and quality, must be measurable. Using the three measures, a productivity ratio of output quantity to input quantity can be calculated. The ratio can then be compared to a standard. Quantity, such as lines of code, number of programs, jobs, etc, and cost are directly measurable. Quality measurement is more difficult and most likely will include some subjective ratings. It is also difficult to get agreement on a standard.

A common measure that has been used by the DP industry as a measure of productivity is lines of code. The number of lines of code produced by each project and the cost of the project is collected. By dividing the number of lines of code by the cost, an average cost of each line of code can be calculated. On the positive side, lines of code are easy to count. But, there are several problems with using lines of code as a measure of productivity. The measure does not account for differences in language, technology, or complexity. CSD has collected lines of code data on projects, but the management recognizes the problems with using it as a measure of productivity.

The major effort of CSD, to date, to measure productivity has been to collect budget and actual data for all projects. Using the criteria for a successful project defined earlier, completing a project on time and within budget, the performance of CSD can be tracked from 1981 thru 1984.

Analysis of Project Data

Data on CSD normal completion projects in three size categories has been collected and analyzed. The three size categories are:

- projects with costs less than $50,000
- projects with costs from $50,000 to $100,000
- projects with costs greater than $100,000.

The types of data compared are:

- actual project dollars to budget dollars
- actual project hours to budget hours
- actual project days to budget days.

The number of projects completed in each size category has remained relatively constant from 1981 - 1984 as shown in the following table:

Year	LT 50K	50-100K	GT 100K	Total
1981	194	23	28	245
1982	180	27	28	235
1983	200	33	34	267
1984	171	22	24	217

An improvement from 1981-1984 in the percentage of completed projects by the percentage variance of actual project dollars to budget project dollars for projects in each size category is shown in the following tables:

Year	+ -10%	+ -25%	+ -50%	+ -75%	+ ->75%
1981	36%	32%	16%	6%	10%
1982	46%	26%	18%	4%	5%
1983	45%	29%	16%	5%	3%
1984	51%	27%	16%	4%	2%

Projects LT $50,000
Actual Project Dollars to Budget Dollars

Year	+ -10%	+ -25%	+ -50%	+ -75%	+ ->75%
1981	17%	39%	13%	30%	0%
1982	22%	33%	30%	4%	11%
1983	52%	24%	9%	0%	15%
1984	64%	18%	9%	0%	9%

Projects $50,000 - $100,000
Actual Project Dollars to Budget Dollars

Year	+ -10%	+ -25%	+ -50%	+ -75%	+ ->75%
1981	36%	29%	21%	7%	8%
1982	50%	21%	11%	7%	11%
1983	41%	29%	26%	0%	3%
1984	54%	25%	13%	8%	0%

Projects GT $100,000
Actual Project Dollars to Budget Dollars

Improvement is also shown from 1981-1984 in the percentage number of completed projects by the percentage variance of actual project hours to budget project hours for projects in each size category as shown in the following tables:

Year	+ -10%	+ -25%	+ -50%	+ -75%	+ ->75%
1981	47%	31%	13%	2%	6%
1982	54%	22%	17%	5%	3%
1983	59%	20%	13%	4%	5%
1984	57%	29%	9%	2%	3%

Projects LT $50,000
Actual Project Hours to Budget Hours

Year	+ -10%	+ -25%	+ -50%	+ -75%	+ ->75%
1981	9%	45%	9%	36%	0%
1982	29%	14%	36%	7%	14%
1983	32%	32%	4%	8%	24%
1984	44%	22%	11%	11%	12%

Projects $50,000 - $100,000
Actual Project Hours to Budget Hours

Year	+ -10%	+ -25%	+ -50%	+ -75%	+ ->75%
1981	33%	25%	8%	0%	33%
1982	38%	31%	6%	6%	19%
1983	33%	39%	22%	0%	6%
1984	52%	29%	14%	0%	5%

Projects GT $100,000
Actual Project Hours to Budget Hours

Likewise an improvement is also shown from 1981 - 1984 in the percentage number of completed projects by the percentage variance of actual project days to budget project days for projects in each size category as shown in the following tables:

Year	+ -10%	+ -25%	+ -50%	+ -75%	+ ->75%
1981	41%	14%	15%	5%	25%
1982	45%	13%	11%	7%	24%
1983	49%	13%	13%	8%	16%
1984	51%	16%	15%	5%	14%

Projects LT $50,000
Actual Project Days to Budget Days

Year	+ -10%	+ -25%	+ -50%	+ -75%	+ ->75%
1981	43%	26%	22%	9%	0%
1982	37%	26%	19%	4%	14%
1983	33%	21%	18%	9%	18%
1984	52%	14%	14%	5%	14%

Projects $50,000 - $100,000
Actual Project Days to Budget Days

Year	+ -10%	+ -25%	+ -50%	+ -75%	+ ->75%
1981	50%	29%	4%	14%	4%
1982	50%	29%	14%	4%	4%
1983	65%	9%	12%	12%	3%
1984	65%	13%	9%	9%	4%

Projects GT $100,000
Actual Project Days to Budget Days

The graphs of this data in Appendices II-VIII, shows that there has been an improvement, as measured by the actual to budget variance, for the three types of project data for all size projects.

Future Measures of Productivity

Since budget versus actual data only shows part of the picture and can be misleading because it is based on estimates and agreements, an Application Productivity Measurement Program is being developed. The program is based on "Function Point Analysis",[9] developed by Mr. Albrecht of IBM. The process is currently employed by IBM and is being adopted for use by other companies such as Shell Oil Co., American Airlines, Exxon Chemicals, Standard Oil of Indiana, and Hallmark Cards, Inc.[11]

Function Points are calculated for an application by listing and counting the major data or control types:

- External inputs such as screens or keyed inputs,
- External outputs such as batch reports or screen reports,
- Logical internal files - logical groups of data not physical files,
- External interface files - files passed or shared between applications, and
- External inquiries that come from users or from other applications.

To yield a function point number, the counts of the major data or control types are adjusted for processing complexity and the degree of influence, from no influence to strong influence, of fourteen general project characteristics defined by Albrecht. Additionally, several attributes or factors that are expected to influence productivity such as the application size, customer maturity, development environment, project team maturity, whether the code is reused, modified or newly written, the tools that are available, and the techniques used will be recorded for projects in addition to their cost and schedule data.

The function point number is used as a measure of the work-product. The work-effort is measured by the cost of the project. The work-product divided by the work-effort is called "productivity". This trend should be up. The work-effort divided by the work-product is called the unit cost. Its trend should be down. By using function points as a measure, it is expected that productivity trends will be determined and the attributes or factors in the producing environment that have both a positive and negative impact on productivity will be identified. With data on many projects over time, comparisons will become increasingly meaningful.

According to Steve Drummond, Hallmark Cards, Inc.,[11] function points indicate that prototypes appear more productive than the traditionally developed applications; purchased packages appear to provide more function per man-day invested than do in house developed systems; less experienced staff often require more time to complete tasks than more experienced staff requires; revisions to existing systems require more manpower per function delivered than new application development; and large projects appear less productive than small projects.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Based on this case study of the Commercial Systems Development Division of Phillips Petroleum Company, several factors should be considered when making changes in a Data Processing organization in order to increase productivity. As shown by the project completion data, there has been an improvement in performance from 1981 - 1984. Since this is not a controllable environment, it is not possible to prove the casual relationship each program has had on the improved performance. I believe the 1982 reorganization and all the programs that have been implemented since that time are responsible for the improvement.

Based on my fifteen years experience in the data processing industry, the results of Cougar and Zawacki's research are observable in the data processing environment. DP professionals do seem to have a high Growth Need Strength, a relatively low Social Need Strength, and data processing jobs and the profession do provide an opportunity for the growth needed. Additionally, the three T's, techniques, tools, and training are needed by data processing professionals.

Even though some progress has been made in measuring DP productivity, there needs to be more development in this area. Function Point Analysis does seem to be the best method available. As more companies start using this method and as they share their results, I believe function points will become the standard productivity measure in the DP Industry.

I strongly recommend that any future changes in the environment consider all the factors outlined in this paper, Growth Need Strength, Social Need Strength, Motivating Potential Score, Techniques, Tools and Training.

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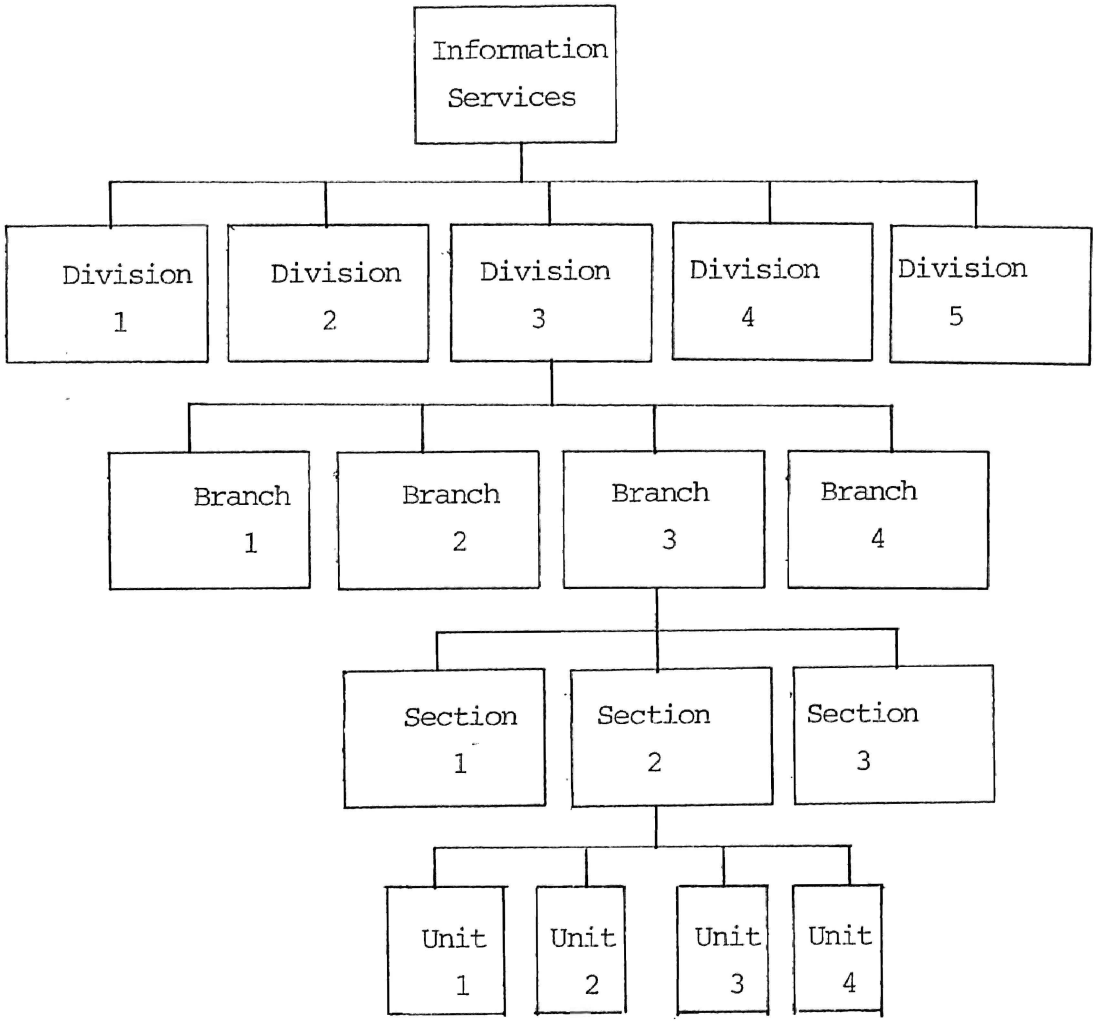
Appendix I

Organization Chart



ACTUAL PROJECT DOLLARS TO I.S. BUDGET DOLLARS
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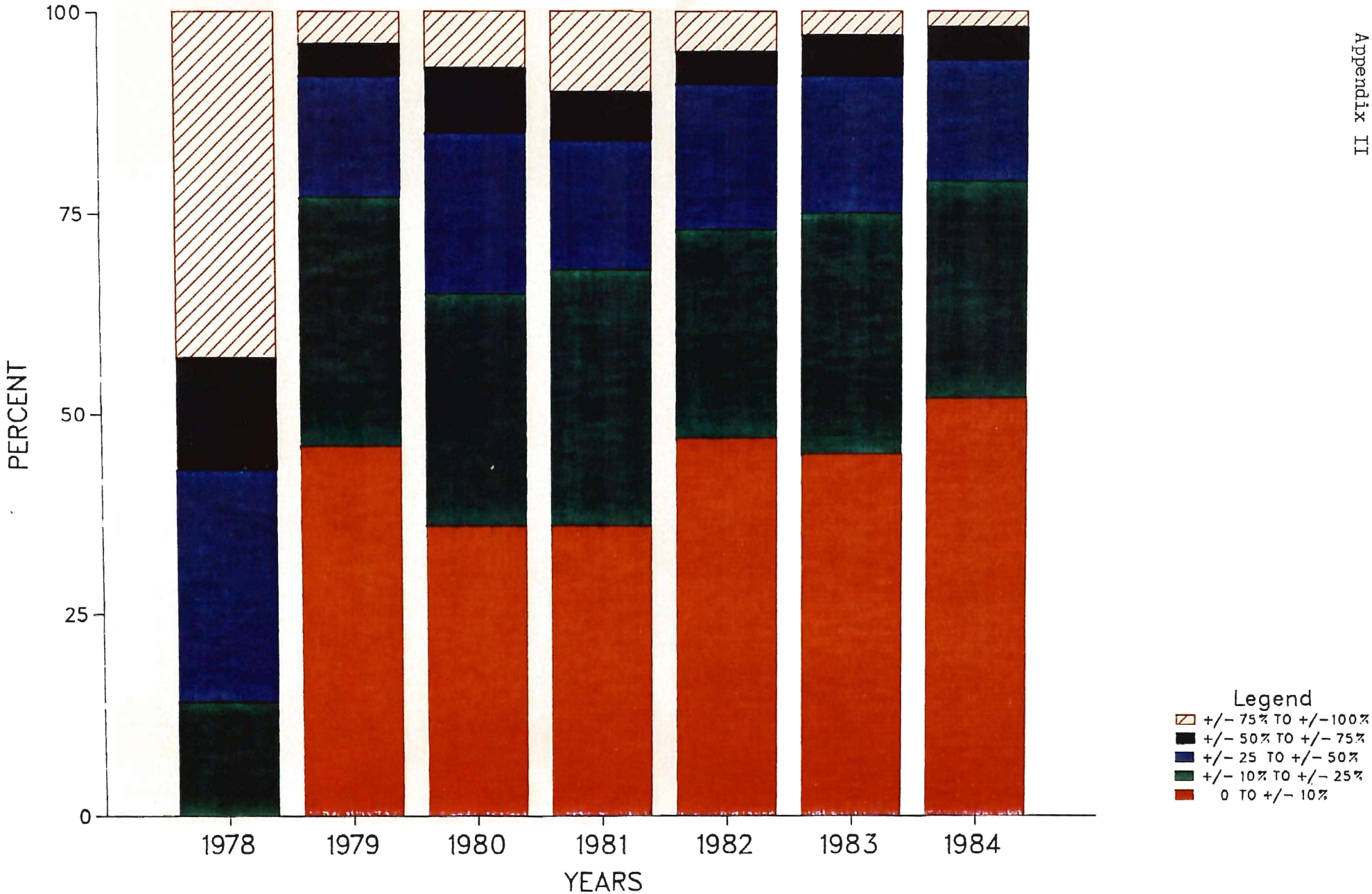
TERMINATION INDICATOR: 1 NORMAL COMPLETION
DIVISION: CSD FOR YEARS 1978/79/80/81/82/83/84



ACTUAL PROJECT DOLLARS TO I.S. BUDGET DOLLARS
PROJECT SIZE: $50,000 TO $100,000
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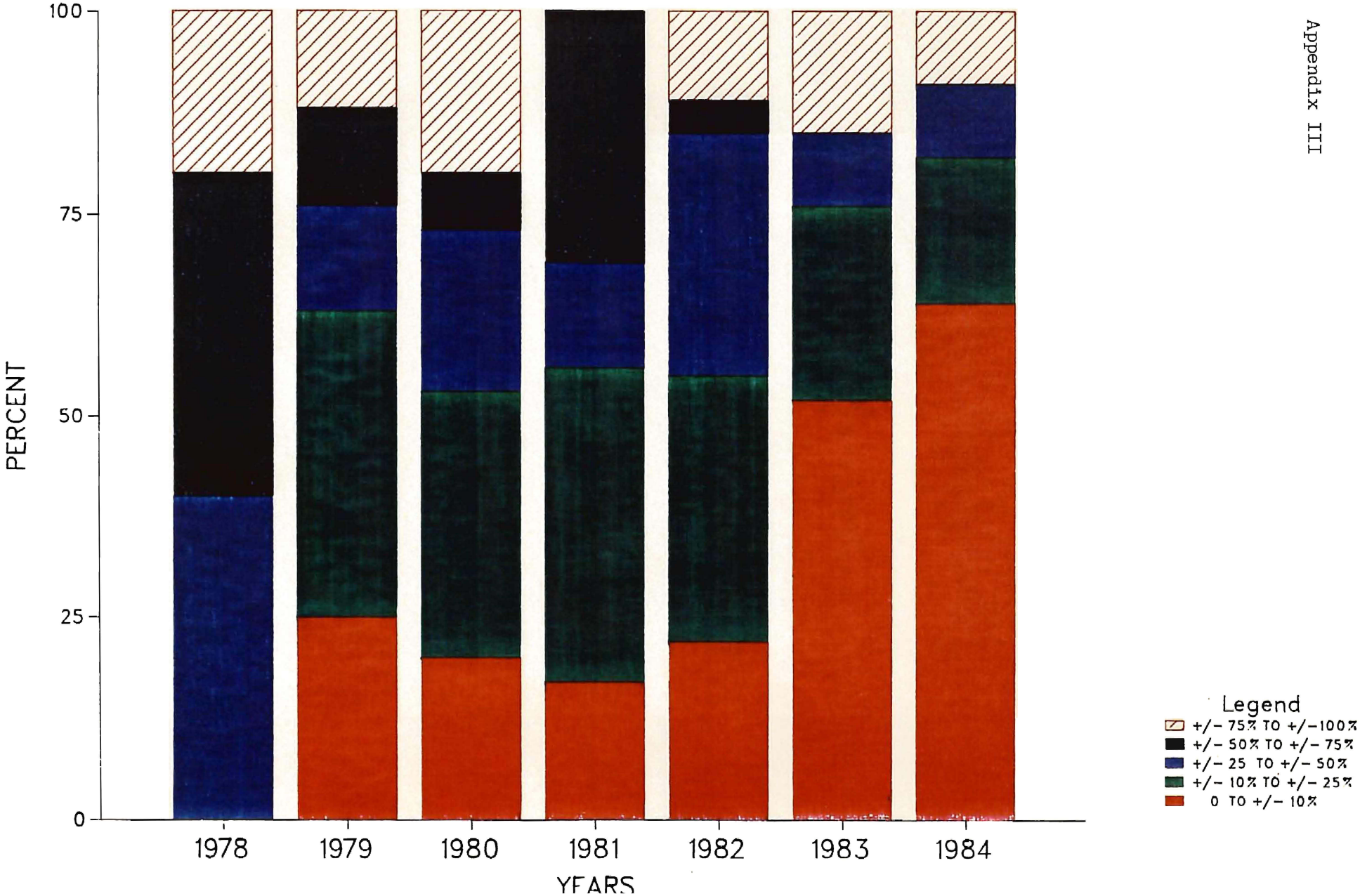
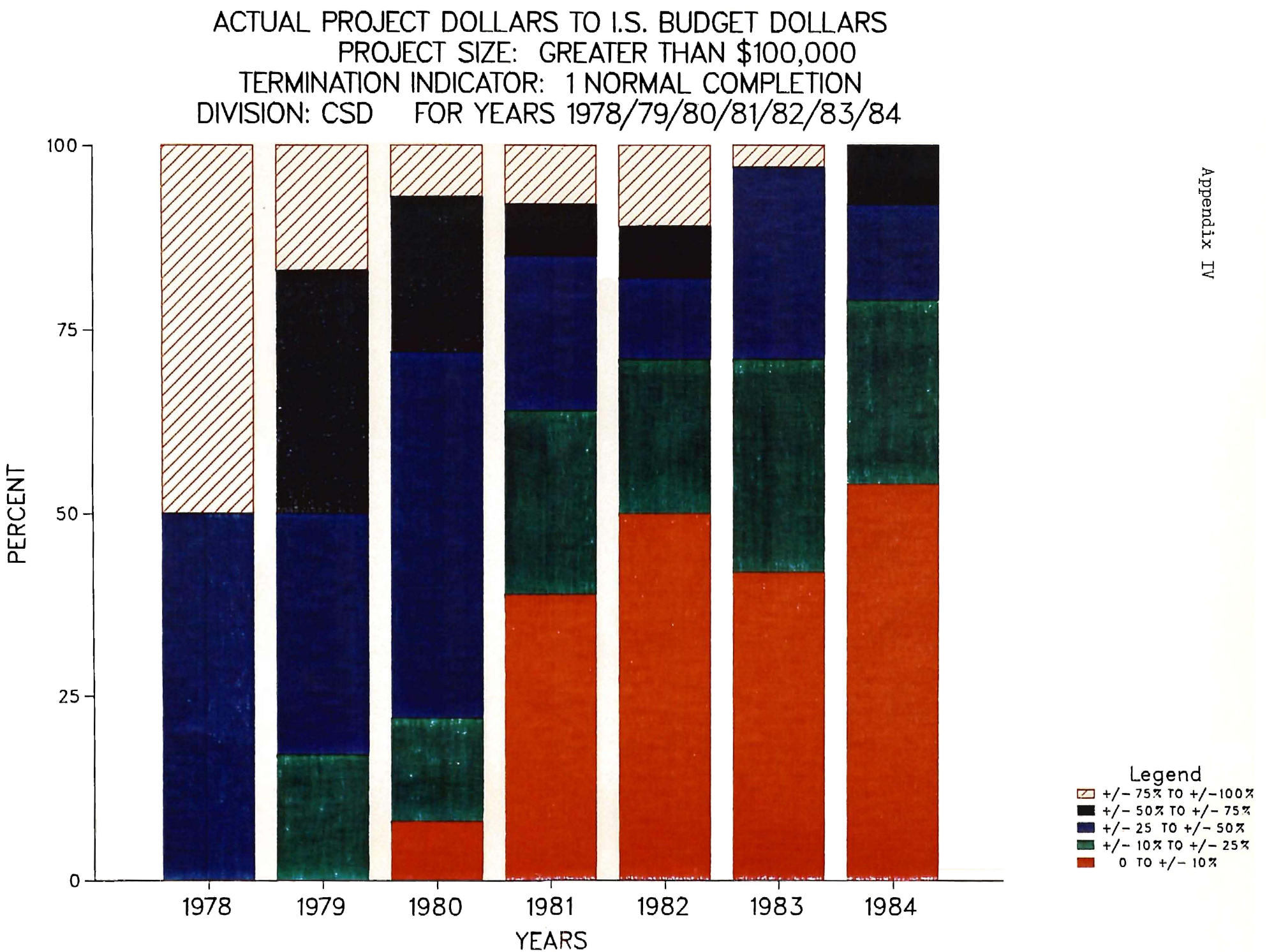
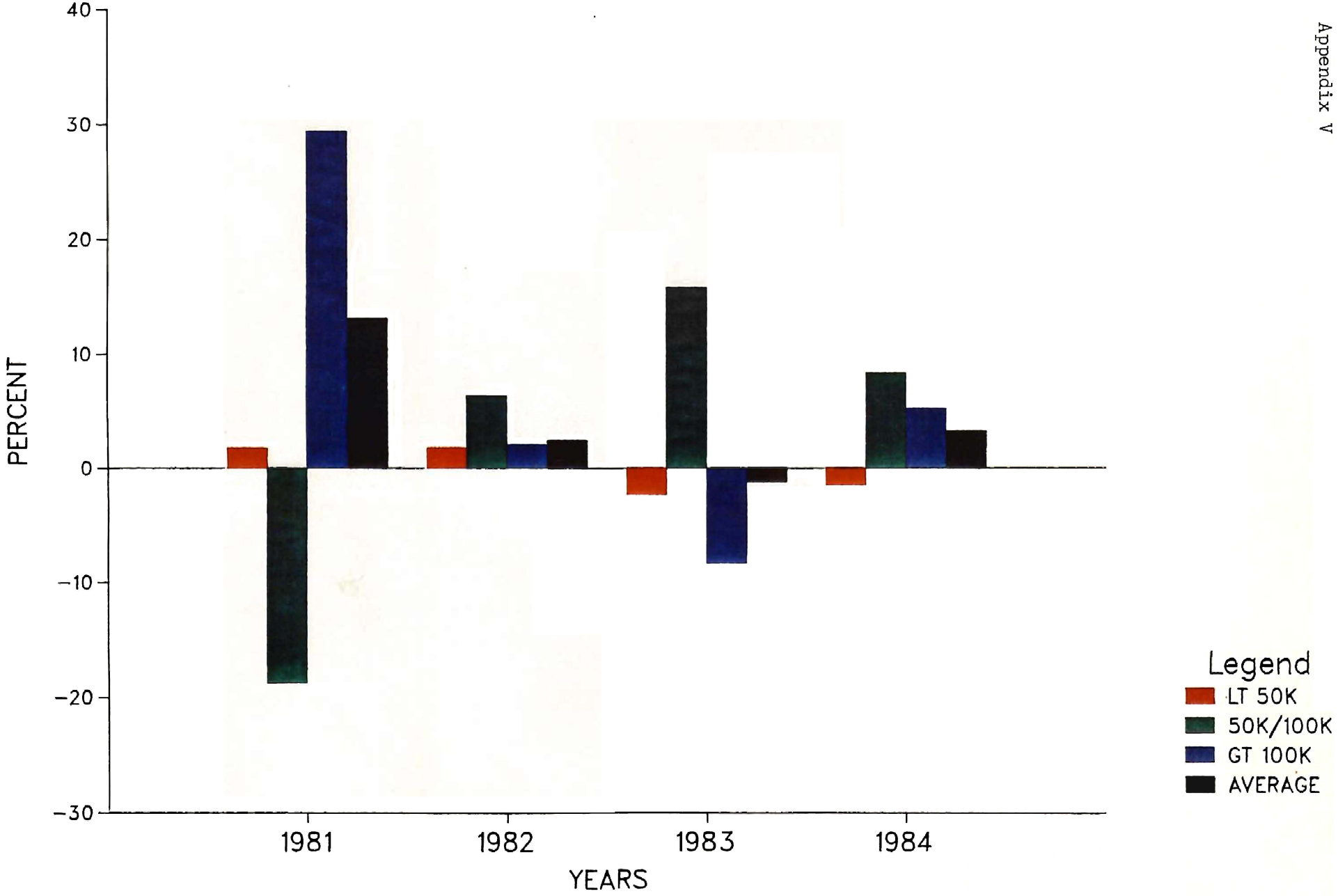
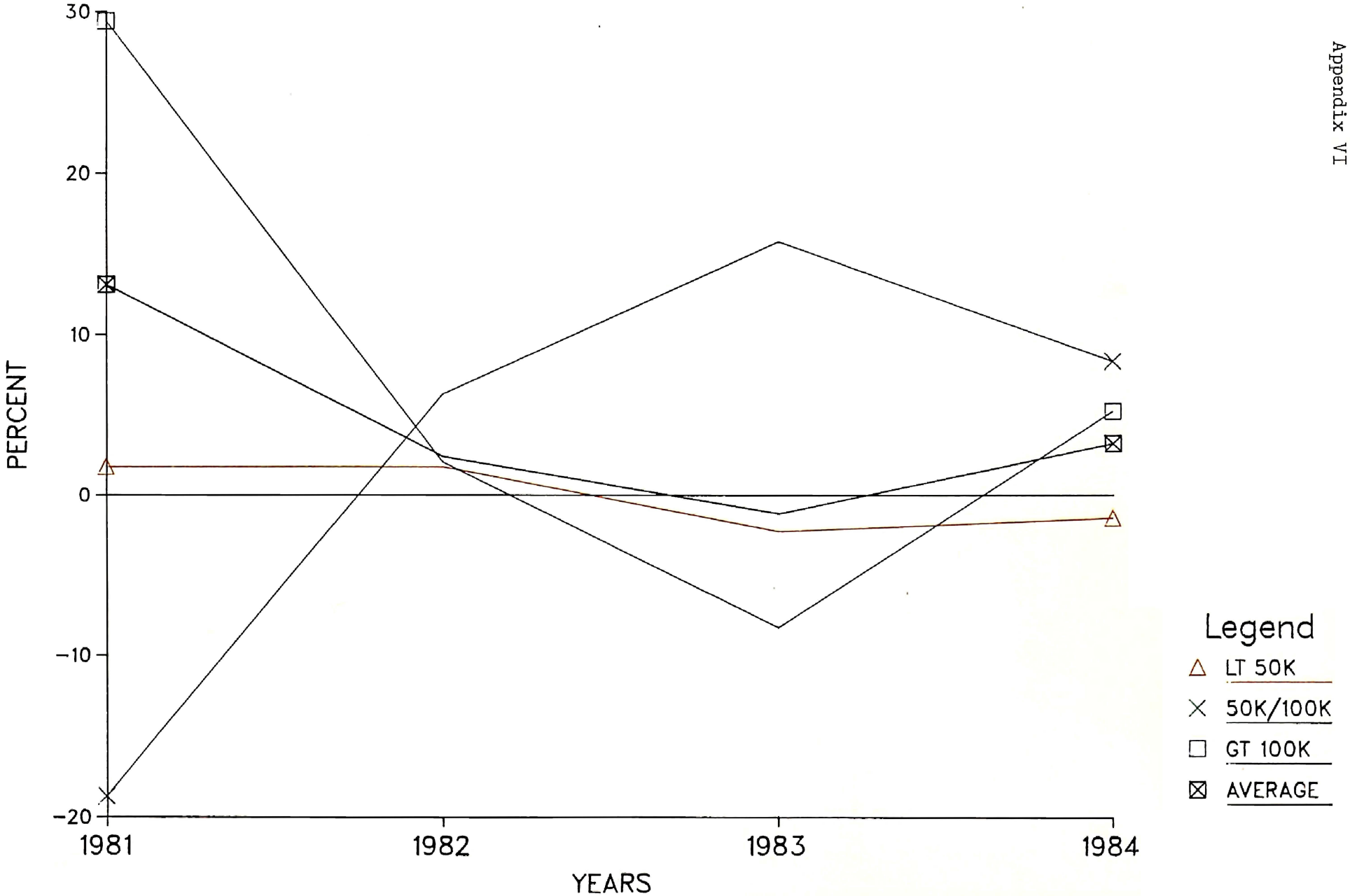



ACTUAL PROJECT DOLLARS TO I.S. BUDGET DOLLARS
PROJECT SIZE: GREATER THAN $100,000
TERMINATION INDICATOR: 1 NORMAL COMPLETION
DIVISION: CSD FOR YEARS 1978/79/80/81/82/83/84
PERCENT
100
75
50
25
0
1978
1979
1980
1981
1982
1983
1984
YEARS
Legend
+/- 75% TO +/-100%
+/- 50% TO +/- 75%
+/- 25 TO +/- 50%
+/- 10% TO +/- 25%
0 TO +/- 10%

ACTUAL PROJECT HOURS TO I.S. BUDGET HOURS
TERMINATION INDICATOR: 1 NORMAL COMPLETION
DIVISION: CSD FOR YEARS 1981/82/83/84



ACTUAL PROJECT HOURS TO I.S. BUDGET HOURS
TERMINATION INDICATOR: 1 NORMAL COMPLETION
DIVISION: CSD FOR YEARS 1981/82/83/84



ACTUAL PROJECT DAYS TO I.S. BUDGET DAYS
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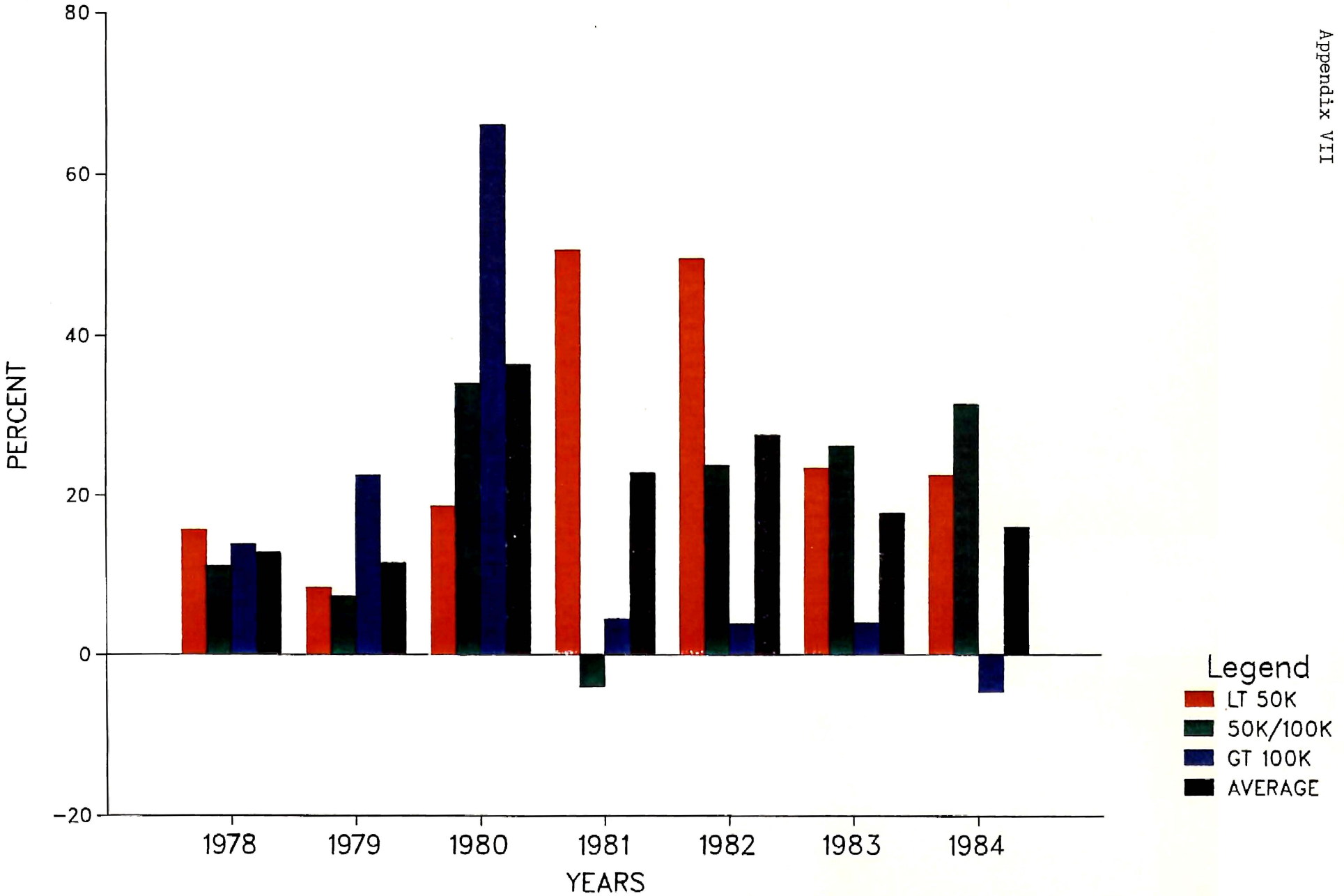
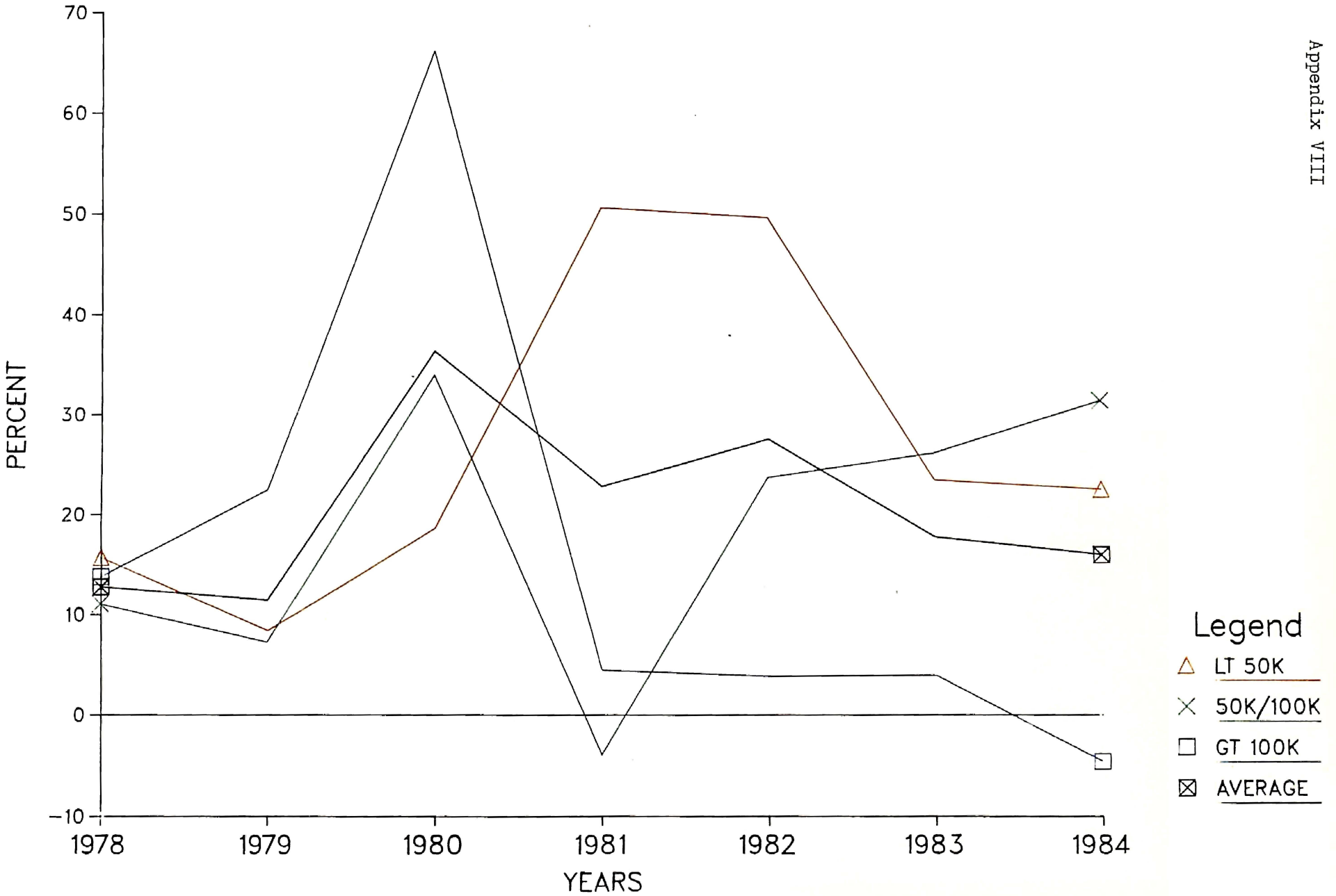


ACTUAL PROJECT DAYS TO I.S. BUDGET DAYS
TERMINATION INDICATOR: 1 NORMAL COMPLETION
DIVISION: CSD FOR YEARS 1981/82/83/84



Appendix VIII

VITA

Roseann Karen Kubicek

Candidate for the Degree of

Master of Business Administration

Report: MEASURING AND IMPROVING PROGRAMMER PRODUCTIVITY AT PHILLIPS PETROLEUM COMPANY

Biographical:

Personal Data: Born in Alva, Oklahoma, January 13, 1944, the daughter of Sol and Rosemary Bouziden

Education: Graduated from Alva High School, Alva, Oklahoma, May, 1961; received the Bachelor of Science degree from the University of Oklahoma, Norman, Oklahoma with a major in Math, May 1965; completed requirements for the Master of Business Administration degree at Oklahoma State University, July, 1985.

Professional Experience: Employed as a data processing professional by Phillips Petroleum Company 1965-1970 and 1974 to the current time. At present, Commercial Systems Development Division Section Supervisor